Understanding how the incorporation of indigenous knowledge (IK) enables or constrains the teaching and learning of alcoholic fermentation in Life Sciences in Grade 11

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DECLARATION

I, the undersigned, hereby declare that the work contained in this thesis is my own original work and has not been in its entirety or in part been submitted for any degree at any university. Where I have drawn on the words and ideas of others, these have been acknowledged by using references according to the Rhodes University Education Department Guide to Referencing.

Signature: **Mutanho Chrispen** Date **19/03/2016**

DEDICATION

This project is dedicated to my late (paternal) grandmother whose life, indigenous knowledge and teachings inspired me to want to do this research. It has been more than twenty years since she passed away, but I still find a lot of wisdom that is applicable to modern science in her teachings and practices. I always wish that I had been wise enough to document what I learnt from her while she was still alive.

ABSTRACT

There is growing interest in the role of indigenous knowledge (IK) in science education in many parts of the world. In South Africa, this comes against the backdrop of a long history of cultural alienation, neglect and suppression of the IK of the indigenous people by colonial governments. Hence, the first post-independence National Curriculum Policy Statement (Curriculum, 2005) and its subsequent modified versions emphasised the need to redress the imbalances of the past so as to make science accessible to learners from diverse cultural backgrounds. However, literature reveals that the efforts to implement an IK-based curriculum are constrained by the lack of clarity, knowledge and skills on how to effectively make use of IK in the classroom situation so as to bring about effective teaching and learning. Against this background, this study sought to understand how the incorporation of IK enables or constrains the teaching and learning of alcoholic fermentation.

Underpinned by an interpretive paradigm, a qualitative case study was conducted at a high school in Mthatha District in the Eastern Cape Province of South Africa. The study comprised of a sample of ten Life Sciences teachers from four neighbouring high schools, two Grade 11 Life Sciences teachers and their classes and two focus groups of six learners from each class. Convenience and purposive sampling were used to select the participants and the research site. The study made use of a questionnaire, document analysis, lesson observation, stimulated recall interviews and focus group interviews to generate data. The questionnaire sought to get an overview of Life Sciences teachers' attitudes, opinions and experiences on incorporating IK in science teaching. The data gathered were then used as baseline information to inform the main study. The lesson observations, stimulated recall interviews and the focus group interviews sought to understand how the incorporation of IK enables or constrains the teaching and learning of alcoholic fermentation.

Document analysis, lesson observation, stimulated recall interviews and focus group interviews were conducted to understand the experience of incorporating IK in a real life classroom situation. The study was informed by Vygotsky's socio-cultural constructivism and Shulman's pedagogical content knowledge (PCK) theory. From Vygotsky's theory I borrowed the idea of mediated learning, scaffolding (Bruner, 1986), zone of proximal development (ZPD), as well as the use of language and cultural artefacts as tools of analysis of the classroom interaction between the teacher and the learners during the teaching-learning process. Shulman's theory of PCK was also used to analyse how teachers apply IK in teaching Science. The data obtained were coded inductively and presented in tables, graphs and thick descriptive texts to make it easy to understand.

The findings of this research show that incorporating IK improved the teaching-learning process by arousing learners' interest in science, increasing learners' participation and motivation, meaning making, language use, questioning and engagement in the learning

process. Teaching became learner-centred, for it was directed by learners' questions. Collaborative learning through group discussions, debates, arguments and brainstorming emerged to be an effective way of engaging learners in learning. The teachers used probing to encourage critical thinking before scaffolding learners.

However, even though teachers generally accept IK as valuable in their teaching they lack the pedagogical content knowledge to effectively incorporate it into meaningful teaching and learning. Furthermore, teachers viewed cultural diversity as a constraint to their efforts to incorporate IK in teaching science. On the contrary, their learners held the view that having cultural diversity in classrooms created an opportunity to learn from other people's cultures. Variables such as experience and difference in the cultural background of learners and teachers alike, tended to affect the teachers' ability to incorporate IK.

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LIST OF FIGURES AND OR ACRONYMS

CAPS - curriculum Assessment Policy Statement

CCK - cultural content knowledge

IK - indigenous knowledge

NMMU - Nelson Mandela Metropolitan University

PCK - pedagogical content knowledge

SAARSTE - Southern African Association for Research in Mathematics, Science and Technology

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CHAPTER ONE

SITUATING THE STUDY

1.1 Introduction to the study

In this chapter I briefly outline the background to the study. The chapter commences with a brief discussion of the background to the problem before proceeding to the statement of the problem, aims and objectives of the research, research questions and rationale for the study, significance of the study, delimitations, research design, methodology, and limitations of the study and the definitions of key terms.

1.2 Background to the study

This study sought to understand how the incorporation of indigenous knowledge enables or constrains the teaching and learning of alcoholic fermentation to grade eleven learners. It was conducted at a high school in Mthatha District of the Eastern Cape Province of South Africa. The school is situated in a *Xhosa* community just outside the Mthatha town and is populated by *isiXhosa* speaking learners, a few learners from other countries, a few Coloureds, Indians and Whites. The learners who are not *Xhosa* constitute less than ten percent of the student population at the school.

In this study I chose to study alcoholic fermentation because I observed that learners struggle to understand this concept yet it is one of the concepts where teachers could take advantage of learners' indigenous knowledge. Learners come to school having experienced to practices such as the making of *umqombothi* and *marhewu*, steam bread and many other traditional foods. According to Hanisi (2006), such practices are common among the *Xhosa* people. This implies that many rural learners stand a chance of coming to school with an idea of such indigenous knowledge.

The research was done at a time when there is growing interest in the role of indigenous knowledge (IK) in Science education. Shava (2013) attributes this renewed interest in IK to the anti-colonial agenda to reclaim identity by the indigenous people and to the realisation that Western Science has no solutions to some problems that confront us as humans. In South Africa, like in any other Southern African country, this renewed interest in IK does not come as a surprise, given the historical imbalances of the colonial era which suppressed nearly all forms of indigenous knowledge. Vhurumuku and Molekeche (2007) observe that the acceptance of IK in the mainstream curriculum is an ongoing international trend which culminated in the incorporation of IK in Science curricular in many post-colonial states.

In this study I wanted to find out how the incorporation of IK enables or constrains the teaching and learning of alcoholic fermentation. My curiosity to do this research was triggered by both my personal experiences and professional interests. As a child I grew up in Zimbabwe during the colonial era when the IK I brought from home as an African child was treated as inferior, unscientific and was side-lined. At that time I found Science very difficult.

As a Life Sciences teacher, I noticed that although IK is now accepted as part of the mainstream curriculum many teachers tend to struggle to link the scientific concepts taught in school Science and learners' IK. As a result, many learners still struggle to understand abstract biological concepts such as photosynthesis and respiration and so forth. This left me curious to know if teachers possess the necessary skills to effectively incorporate IK in their teaching and how the incorporation of IK enables or constrains the teaching and learning of Life Sciences.

In South Africa, the interest in IK comes against the backdrop of a long history of colonial education that side-lined and denigrated the culture of the indigenous people. Mothwa (2012) argues that during the colonial era in South Africa, any form of indigenous knowledge or civilisation was discarded at face value as unscientific and therefore not worth knowing. Inevitably, this led to the loss of a substantial amount of knowledge as it could not be passed on from one generation to the other.

Soon after independence, Bantu education was abandoned because it negated the democratic principles of equality and inclusivity underpinned in the National Constitution of South Africa (DBE, 2011). Vhurumuku and Mokeleche (2007) identify three factors that influenced the incorporation of IK in the South African curriculum. These are: "the need to correct the injustice and inequities" of apartheid education, the "influence of pluralism and multiculturalism" in education and the "belief that IK is essential for sustainable development" (p. 99).

Drawing from the above arguments, one can safely conclude that the interest in IK in South Africa is part of the rapid socio-political transformation that characterises the post-colonial era. After independence, the government was faced with the daunting task of constructing a democratic society from the debris of apartheid, in which every citizen enjoys equal rights. Mapara (2009, p. 139) describes it as a way of "reclaiming identity and asserting visibility by the once oppressed people". As a result the incorporation of IK is seen as an essential step towards redressing the injustices of the colonial era and bringing about the essential social transformation that is necessary for the mutual co-existence of all members of post-apartheid South Africa (DOE, 2005; DBE, 2011).

1.3 Ontological and epistemological justification for the incorporation of IK

The arguments raised above tend to imply that the incorporation of IK in the mainstream curriculum was largely influenced by political justification. However, literature reveals that

the incorporation of IK was also necessitated by the need to make education accessible to all learners (Aikenhead, 1996; Van Wyk, 2006). Hodson (1998) postulates that, the work of constructivists such as Piaget and Vygotsky led to an epistemological revolution in science education. This led to a shift from the traditional teacher-centred methods of teaching to child-centred education.

These international trends in science education also influenced educational policy in South Africa. The shift from the traditional methods of teaching led to the adoption of constructivism as a theoretical framework informing Science education in South Africa (Vhurumuku & Molekeche, 2007; Aldous & Rogan, 2009). According to Hodson (1992), learner-centred education places emphasis on building upon the learners' needs and what they already know as opposed to what the teacher needs the children to know. Hence, the Curriculum Assessment Policy Statement (CAPS) emphasises the need to incorporate IK to make Science accessible to learners from diverse socio-economic and cultural backgrounds.

In the following section I take a look at curriculum requirements with regards to the incorporation of IK.

1.4 Curriculum requirements

This section briefly outlines the requirements of CAPS with regards to the incorporation of IK in science teaching and learning in South Africa.

It has already been pointed out that, although South Africa has experienced many educational changes since independence, the interest in IK has remained as reflected by the following broad aims of the CAPS curriculum:

- To value the indigenous knowledge systems and acknowledge the history and heritage of this country;
- To promote social transformation by addressing the educational imbalances of the colonial past and promoting equal educational opportunities for all sections of society; and
- To promote the constitutional principle of human rights, environment and social justice and issues of diversity, poverty, inclusivity, inequality, race and other factors.

These broad aims reflect a commitment to promote the incorporation of learners' cultural capital into education (Mkwambo, Ngcoza & Chikunda, 2014). Bourdieu (1986) equates the learners' cultural capital to the knowledge funds that enable them to understand what is taught in the school curriculum. Therefore, science teaching should take into cognisance the cultural capital that learners from diverse home backgrounds bring to school. It should not be confined to teaching scientific concepts only, but needs to embrace ideas from other cultures.

To this end, the DBE (2011, p. 16) states that "learners must be exposed to the history of science and indigenous knowledge systems from different times and other cultures". In other words learners are expected to understand the relationship between school science and their everyday lives to broaden their understanding of not only science, but also their indigenous knowledge systems and that of other cultures.

To achieve these goals teachers are expected to adopt a learner-centred approach in teaching science (DBE, 2011). Meiers (2007) describes a learner-centred approach to education as one that places emphasis on the learners' needs as opposed to what the teacher needs to accomplish. A learner-centred approach to teaching caters for the learners' individual learning styles and needs and uses their experiences as the foundation upon which new knowledge is built.

Thus, teachers are expected to make use of learners' IK so as to increase their access to science education. It is presumed that by incorporating the cultural capital of all learners, teachers will make it much easier for learners from different socio-cultural and economic backgrounds to understand science. Accordingly, Kraak (2001) advises that educators need to adopt a cross-fertilisation perspective and ensure that the learning contexts share a resemblance with what learners experience at home. In essence, this means that teachers should make use of learners' prior knowledge, including IK, to help them understand science.

Mothwa (2012) adds to this argument by observing that the principle of inclusivity embraced in the CAPS curriculum, dictates that all learners should be actively involved in learning science. Therefore, teachers are expected to familiarise themselves with the culture of their learners so that they are able to incorporate their IK into their teaching of science. The CAPS document stipulates that inclusivity should become the central part of the organisation, planning and teaching at each school. Hence, teachers are expected to have a sound understanding of how to recognise and address barriers to learning and how to plan for diversity (DBE, 2011). Corollary, incorporating IK in science education requires teachers with proper training and necessary expertise. The CAPS document states that the realisation of an IK based-curriculum is only possible if teachers have sound knowledge of how to recognise and incorporate IK to address barriers arising from cultural diversity and different ethnic backgrounds (DBE, 2011).

However, Mothwa (2012) observes that many teachers in South Africa lack the training and knowledge to effectively incorporate IK into meaningful learning. She partly attributes this to the fact that South Africa still has many teachers who received Bantu education that was not only Eurocentric but also despised African civilisation. Similarly, Shizha (2007) also found out that teachers acted as gatekeepers, protecting Western civilisation from contamination by and erosion from other civilisations. Such attitudes do not promote the implementation of an IK-based curriculum.

Mothwa's (2012) study revealed that although teachers understood the importance of IK in improving learners' performance, they had limited cultural content skills and the pedagogical knowledge to incorporate IK effectively. She observed that the teachers in her study just paid lip-service to IK. They just mentioned in passing as they explained concepts in the conventional way. Mothwa argues that their use of IK is superficial and is therefore of little value to effective teaching and learning of Science. Le Grange (2007) adds that teachers' understanding of learning areas and teaching methods is of paramount importance to effective teaching. Therefore, teachers need to critically reflect on their teaching to enable them to effectively incorporate IK. Mothwa's (2012) study reveals that teachers lost a lot of golden opportunities to incorporate IK into meaningful learning.

In light of the above arguments, Aldous and Rogan (2009) conclude that the policy to incorporate IK was hurriedly done without proper consideration of how it could be implemented. It lacks details on how IK could be incorporated into meaningful teaching and learning. For instance, at the school where I am currently teaching there are no books (among the textbooks we use and the school library) that explain how IK can be incorporated in teaching Science to promote meaningful learning. Vhurumuku and Molekeche (2009) attribute this lack of information on how to incorporate IK to lack of research to ascertain the feasibility of incorporating IK in Science education.

The observations above raise important questions that need to be answered. In light of the arguments raised, one is left wondering how teachers are incorporating IK in the absence of curriculum guidelines, support or proper training on how to incorporate IK in Science education as alluded to by Vhurumuku and Molekeche (2009). Do teachers have adequate skills and the cultural content knowledge (CCK) to enable them to incorporate IK meaningfully? And lastly, are they using IK in ways that support teaching and learning? These are the compelling questions at the core of this research. They triggered my curiosity to find out how the incorporation of IK enables or constrains the teaching and learning of alcoholic fermentation and the sub-concepts embedded in it. In the following section I briefly outline the problem addressed by this research.

1.5 Problem Statement

The problem is that, although government policy emphasises the need to incorporate IK, the current situation makes it difficult to incorporate IK into the science curriculum. This study sought to understand the enabling and constraining factors and how they impact on the teaching and learning of alcoholic fermentation.

1.6 Significance of the study

This study contributes to the ongoing debate on the role of IK in Science education. It seeks to shed light on how the incorporation of IK in Science education enables or constrains the

teaching and learning of alcoholic fermentation. It responded to the call to find out how best IK can be incorporated in Science teaching. It sought to understand how the incorporation of IK enables or constrains the teaching and learning of alcoholic fermentation. By so doing it would contribute to improve Life Sciences teaching by highlighting the advantages and disadvantages in incorporating IK in Life Sciences lessons.

The findings of this research are of potential value to a number of stakeholders such as curriculum developers, material developers, textbook writers, Life Sciences educators and learners.

The gap that this research seeks to fill

This study is not the first one of its kind. Similar studies were conducted by Mothwa (2012); Khupe (2014) and Uushona (2013) in South Africa and Namibia respectively. However, these studies tend to treat teaching and learning as if they were independent processes by studying them separately. In contrast, this study sought to understand how the incorporation of IK enable or constrain both the teaching and learning of alcoholic fermentation. By so doing, the study sought to build a deeper understanding of how the incorporation of IK enables or constrains the teaching and learning of alcoholic fermentation.

1.7 Research Goals

The main goal of this research was to understand how the incorporation of IK enables or constrains the teaching and learning of alcoholic fermentation.

This goal was achieved by answering the main question in the section below.

1.8 Main Question

- How does the incorporation of IK enable or constrain the teaching and learning of alcoholic fermentation?

To provide answers to this question, I had to find out the effect of incorporating IK during mediated learning and sense making. I also had to find out the kind of training that teachers received to enable them to incorporate IK and their experiences and attitudes towards the incorporation of IK in Science education. To get a full picture of how IK enables or constrains the teaching and learning process, I had to find out learners' interpretation of the experience of incorporating IK in the teaching and learning of Life Sciences.

1.9 Key concepts used in the thesis

It is important for the reader to understand the meanings of the main concepts used in this study because their contextual meaning might be slightly different from their everyday use. Understanding these concepts will enable the reader to understand what this research is all about.

The following main concepts were used in this study, namely, indigenous knowledge, alcoholic fermentation, *umqombothi,* meaning making and learner-centred teaching and learning.

1.9.1 Indigenous knowledge

Indigenous knowledge can be defined as knowledge that originates from a particular locality or region that has been passed on from one generation to another as traditional wisdom used to make important decisions necessary for survival (Kibirige & Van Rooyen, 2006).

1.9.2 Mediated learning

According to Vygotsky (1978), mediated learning refers to the way the teachers assist learners to make the transition from tasks they can solve on their own to those that they can only solve with the assistance of the teacher. In this study, I would have wanted to treat mediated learning as a synonym of teaching but I realised that not all teaching can be described as mediated learning. In this research mediated learning refers to the way the teacher assists learners to develop their own understanding of scientific concepts on fermentation in particular.

1.9.3 Alcoholic fermentation

According to Campbell (1990), alcoholic fermentation can be defined as a metabolic process whereby yeast converts glucose $CH_{12}O_6$ to ethanol (CH_3CH_2OH) and carbon dioxide gas (CO_2), in the absence of oxygen.

1.9.4 Sense making

Uushona (2013, p. 5) describes meaning making as a process whereby "learners are able to make sense of the new concepts emerging in the topic being taught. It deals with the issue of whether learners are able to relate a particular situation to what they know or experience". In this research meaning-making is treated as synonymous to sense making. Thus in this context sense making refers to the process whereby learners build their own understanding of the concepts taught.

1.9.5 *Umqombothi*

Umqombothi is a traditional beverage among the Xhosa people in the areaa where this study was undertaken. Hanisi (2006) defines *umqombothi* as a traditional beer usually made from fermentation of the cereals sorghum, millet or maize. Uushona (2013) observes that *umqombothi* is a popular traditional beer among the people of Southern Africa. It is known by different names by different ethnic groups in this region. For instance, the Zulus call it

utshwala, the Shona [Zimbabwe] *hwahwa* and *joala* in seSotho [Lesotho] (Hanisi, 2006). These people use *umqombothi* as a drink in many traditional ceremonies and rituals.

1.9.6 Learner-centeredness

A learner-centred approach to education is where the teaching and learning is structured and conducted in such a way that it caters for the needs of the learner. In this regard, a learner is regarded as an individual capable of constructing his or her own understanding of the phenomenon under study. According to Uushona (2013, p. 5), in learner-centred education "teaching is planned in such a way that new knowledge is based on refining the prior knowledge of learners to create new understanding. A learner can construct meaningful and coherent representation of knowledge when supported and given instructional guidance as time goes on".

1.9.7 Scaffolding

Scaffolding refers to a concept in social constructivism where the teacher or knowledgeable other assist the learners to complete tasks and gradually withdraws as the learners gain the ability to complete the tasks on their own Vygotsky (1978).

1.9.8 Pedagogical content knowledge (PCK)

According to Shulman (1987) pedagogical content knowledge refers to the teacher's knowledge of the content of the subject and a deep and flexible understanding of teaching and learning theories and how to apply them to effectively bring about learning. PCK is a combination of the knowledge of what to teach and how to teach it.

1.9.9 Cultural content knowledge

Cultural content knowledge refers to a person's knowledge of the culture of a particular group of people. In this study it refers to the teachers' knowledge of how, when and why things are done in the *Xhosa* community. This knowledge includes how *umqombothi* is made.

1.10 Thesis outline

This section briefly outlines the components of this study conducted at a high school in the Mthatha District of the Eastern Cape Province of South Africa. The thesis is made up of six chapters outlined below.

Chapter One: This chapter introduces the study. It outlines the contextual background to the study, rationale for the study, the significance of the study, research goals and the questions that the study sought to answer as well as the main concepts underpinning the study.

Chapter Two: For this study to be successful it had to be informed by what already exists in literature. Thus in Chapter Two, I reviewed the literature that is relevant to this study. The chapter starts by defining indigenous knowledge before it proceeds to discuss the benefits of incorporating IK, challenges faced in incorporating IK and the findings from similar studies.

Chapter Three: In Chapter Three, I present the research methodology. The chapter discusses the research paradigm, the research design and outlines the research goal, objectives, main research question, the sub-questions, the population, sampling procedure, contextual background of the research site, the data gathering techniques that were used, ethical considerations, validity and the limitations of the research.

Chapter Four: Chapter Four presents the data gathered from the different research instruments. It starts with the data gathered from the questionnaire before proceeding to the lesson plans, the observations, the interviews with the teachers and the focus group interviews done with learners.

Chapter Five: In Chapter Five, I analyse and interpret the data presented in Chapter Four in light of the themes that emerged from the data that enabled me to answer my main research question. The analysis and discussion of the data is done in comparison with the findings of similar research mentioned in the literature review chapter.

Chapter Six: Chapter Six summarises the findings, makes recommendations, takes a critical reflection of the journey throughout this study and afterwards draws a conclusion.

1.11 Concluding remarks

This chapter outlined the background/context of this research. It looked into the important aspects of the research such as: the background to the study, the questions to be answered by the research, the key concepts, as well as the research method and design. This research draws ideas from earlier studies on the role of IK in Science education.

In the next chapter I review the literature relevant to this study.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This research sought to understand how the incorporation of IK enables or constrains the teaching and learning of alcoholic fermentation in Life Sciences. To fully comprehend this phenomenon, there was a need to review literature on IK. In this chapter I review the literature on the role of IK in Science education.

The literature review seeks to understand the following aspects:

- What is indigenous knowledge?;
- The role of IK in Science education;
- The challenges faced by teachers in incorporating IK in Science education;
- The influence of teaching experience on the teacher's ability to incorporate IK; and
- The role of pedagogical trans-languaging in Science education.

2.2 What is indigenous knowledge?

As far as Vhurumuku and Molekeche (2007) are concerned, it is difficult to come up with a comprehensive definition of indigenous knowledge that is universally agreed upon by all. This is because scholars do not agree as to what qualifies as 'indigenous' or what constitutes 'knowledge'. They argue that both terms are illusive concepts that need unpacking. For instance, Loubser (2005) observes that the word 'indigenous' is a generic term associated with a list of words such as traditional, vernacular, native, or population and can be confined to a particular geographical area. In some cases it is associated with races such as Black Africans, Aborigines, Japanese or any other non-Westerners. However, applying the concept indigenous exclusively to non-Western societies erroneously implies that Europeans have no indigenous knowledge. Vhurumuku and Molekeche (2007) argue that the ownership of indigenous knowledge "should never be considered the preserve of African, Aboriginal or Indian" societies because even the so called 'European societies' are also proud owners of IK (p. 98).

In addition to this confusion, there is no general consensus on the definition of knowledge. While Westerners view knowledge as scientifically gathered and proven information, most definitions of indigenous knowledge encompass beliefs, superstitions and science

(Vhurumuku & Molekeche, 2007; Shava, 2013). For instance, in most African societies the concept of knowledge is intertwined with the concept of '*Úbuntu*' or 'being humane' (Mkwambo, Ngcoza & Chikunda, 2014). Thus, a person is knowledgeable if they know how to conduct themselves properly, in a manner that dignifies other human beings.

According to Shava (2013, p. 284), IK is transgenerational because it is passed on from one generation to the other - orally, symbolically or through dance and cultural practices such as the making of *umqombothi*. Similarly, Kibirige and Van Rooyen (2006) elaborate that indigenous knowledge (IK) is a legacy of traditional wisdom passed on from one generation to another in a particular society. Both definitions emphasise that IK is knowledge that is cumulated over a long period of time and is preserved from one generation to another. This implies that IK is knowledge for survival. Vhurumuku and Molekeche (2007) define IK as an information base for a society, which facilitates communication and decision-making. Odora-Hoppers (2002, p. 8) also view IK as the "wealth of knowledge in a particular group", which distinguishes it from other groups and is not easily accessible to other groups from different cultural backgrounds.

The above definitions tend to revolve around the idea that IK encompasses a broad spectrum of knowledge within a particular society which is unique and is often used as a point of reference in making important decisions. IK is holistic in nature and is gathered through human experiences over many generations. Accordingly, Ogunniyi (2007, p. 965) describes IK as "a conglomeration of knowledge systems, which is redemptive, holistic and transcendental of human experience with the cosmos". In other words, IK encompasses science, technology, religion, language, philosophy, politics and other socio-economic systems within a particular geographical locality. The definitions also encompass the ontology and epistemology of IK. Kibirige and Van Rooyen (2006) add that IK is traditional wisdom derived from the practical engagement with the environment for survival that is local, tacit, orally transmitted, based on experience, learned through repetition and constantly changing.

Amidst this confusion alluded to earlier on, the term indigenous knowledge is also conflated with ethno-science, traditional ecological knowledge, indigenous science and local knowledge. These terms tend to localise IK to particular geographical areas or ethnic groups. Vhurumuku and Molekeche (2007) contest this localisation of knowledge and argue that some knowledge considered to be 'indigenous' to given communities, within specific geographical localities, was transported from other regions through human interaction and have become ingrained in the cultural matrixes of the recipient communities with time.

In addition, the terms 'indigenous knowledge' and 'indigenous knowledge systems' (IKS) are often used interchangeably (Kibirige & Van Rooyen, 2006; Mkwambo, Ngcoza & Chikunda, 2014). However, in this research, IKS refers to the broader cultural matrix within which IK is found. Vhurumuku and Molekeche (2007, p. 98) postulate that IKS is the much broader

system, encompassing both IK and the understanding of the nature of science (NOS). In other words, while IKS refers to the cultural matrix within which IK is found, IK refers to the traditional wisdom that distinguishes one society from another.

However, some IK are common among many societies – this then raises the question of whether IK can be described as universal (Vhurumuku & Molekeche, 2007). Moreover, if IK is universal, does it still qualify to be called IK? While there are no clear cut answers to these questions, it is important to note that part of what is called IK in any society might have originated elsewhere and been spread, adopted, assimilated and ingrained into other societies due to the human interaction alluded to above. This challenges the idea of localising IK and confining IK to a particular geographical area and ethnic group.

In this research, IK is understood to be knowledge that is gathered through trial and error, observation, experimentation innovation and application over many generations of intelligent reasoning and that informs a society's engagement with the environment for survival (Kibirige & Van Rooyen, 2006).

However, I am aware that not all IK is compatible with western science and to this end Horsthemke (2008) posits that our quest to incorporate IK should not blind us to the point of accepting and legitimatising beliefs, opinions and superstitions that do not meet the criteria of knowledge. This view places Western science in a privileged position where it is seen as pure knowledge that is free of cultural beliefs and biases. Such a stance attracts contestation as some scholars argue that the so called 'modern science' represents European beliefs and value systems (Aikenhead & Ogawa, 2007).

Notwithstanding, I take a broad-minded view in acknowledging that IK benchmarks the limitations of Western science. Aikenhead and Ogawa (2008) argue that IK should not be regarded as the binary opposite of Western science. Instead, we need to realise that the two knowledge systems complement each other. Shava (2013) contends that Western science is no longer the only source of solutions to the problems facing humanity. In some cases, science has failed us by providing the wrong answers to problems. Shava has a valid point especially when one considers that answers to issues such as global warming, Ebola and AIDS are yet to be found.

The above arguments left me interested in knowing how teachers make use of scientific facts in IK and deal with the misconceptions, myths and beliefs that are inherent in it. This draws the focus of this chapter to the role of IK in Science education.

2.3 The role of indigenous knowledge in Science education

Many educational researchers argue that incorporating indigenous knowledge in Science teaching facilitates learning (Aikenhead, 1996; Ogunniyi, 2007; Le Grange, 2007). These authors argue that as part of learners' prior knowledge, IK is the window through which

learners are able to understand the outside world. According to McRobbie and Tobin (1997), knowledge is not only personally constructed; it is also socially mediated through interactions with other members of the same cultural group. Therefore, learning is a collective endeavour in which learners acquire knowledge through active involvement and interaction with knowledgeable others to build knowledge (Stears, Malcolm & Kowlas, 2003). These arguments emphasise the need to engage learners in group work in which they actively participate in debates, discussions and arguments so as to create knowledge. Thus, learners need to be involved in what Stears et al. (2003) describe as a community of practice in which they actively participate in constructing knowledge.

IK provides a cultural context through which learners view the world. It acts as a springboard upon which new ideas are built. Stears et al. (2003) call IK the lens through which learners view the world. It is the foundation upon which new knowledge can be built.

In the same vein, Le Grange (2007) warns us of the dangers of ignoring learners' IK. He argues that ignoring learners' IK leads to a 'cognitive dissonance' as the learner tries to reconcile Science and IK. In other words, learners experience a cognitive conflict within their minds as they try to reconcile conflicting ideas from Science and IK. Aikenhead and Jegede (1999) equate the experience of learning abstract and de-contextual school Science to border-crossing between home and school. They argue that incorporating IK enables learners to bridge the gap between what they learn in school and their IK. Thus, any curriculum that ignores learners' IK risks destroying the framework through which learners are likely to interpret the scientific concepts (Le Grange, 2007; Aikenhead, 1996). These arguments clearly illustrate that IK plays an important role in determining how learners acquire and understand Science.

In this regard, Aikenhead (1996) equates the non-Western learners' experience of learning Science to border-crossing between the Western and the non-Western world views. Thus, incorporating IK enables the learners to link what they know with the new information. Bouillion and Gomez (2001) concur that if IK is ignored, learners become frustrated and regard Science as a subject that is too difficult to understand. Basu and Barton (2007) also point to the gap between Western sciences and IK as one of the major reasons why learners fail Science. The above arguments alert us to the danger of ignoring learners' prior knowledge in the form of IK. Ignoring learners' IK leaves them anxious, confused and de-motivated. Such teaching dehumanises learners and alienates them from their culture by destroying the framework through which learners are likely to interpret the world (Le Grange, 2007).

In light of the above arguments, many researchers argue that Science education should build on learners' prior knowledge, cultural experiences and interests (Basu & Barton, 2007; Aikenhead, 2007; Le Grange, 2007). In this regard, Ogunniyi (2007) identifies four reasons why IK should be part of the Science curriculum and these are:

- To preserve IK from extinction;
- To rediscover the wisdom in IK and use it to solve the problems we encounter;
- To make Science more accessible to all learners; and
- To redress the social injustice of the colonial era.

Similarly, a study conducted by Stears, Malcolm and Kowlas (2003, p. 109) in the Cape Flats in South Africa revealed that incorporating learners' interests and prior knowledge "promoted deeper engagement for the children with each other and the content". In other words, the incorporation of IK improves the quality of classroom interactions between the teacher and learners and among learners themselves.

In research conducted in Namibia by Uushona (2013), he concluded that incorporating IK enhanced learner engagement and conceptual development. He also found out that it improves the teacher-learner interaction through brainstorming and discussions. These findings resonate with the claim made by Shizha (2007) that incorporating IK motivates learners and improves their participation in Science lessons. Stears et al. (2003) also conducted a similar study in the Cape Flats in Cape Town and found out that incorporating learners' everyday experiences into Science education increased the level of learner engagement. It also drew learners into deeper thinking thereby improving the degree with which they engaged with one another, their teacher and the content.

The findings build a strong case in favour of IK. However, research shows that achieving an IK based curriculum is not an easy task because it is riddled with many challenges such as lack of documented knowledge as to how IK can be incorporated into effective teaching and negative attitudes towards the incorporation of IK (Mothwa, 2012; Khupe, 2014). The section below discusses the challenges encountered by teachers in incorporating IK in science education.

2.4 Challenges in incorporating IK in Science education

Section 2.3 above, highlighted that scholars see the incorporation of IK in Science education as a positive move towards making Science easier to understand thereby making it accessible to all learners. However, critics argue that these scholars overlook the challenges inherent in incorporating IK (Aikenhead & Ogawa, 2007; Shizha, 2007). In this section I look at the challenges faced in incorporating IK.

According to Aikenhead and Ogawa (2007), the conventional school Science in South Africa is not conducive to the incorporation of IK. Abd-El-Khalick and Ledderman (2000) also observe that Science teaching continues to side-line other forms of knowledge by treating them as 'myths' and 'half-truths' that do not conform to the positivist perspective implied in conventional science. Many argue that this is largely because not much has been done to change the mindset of teachers and ensure the successful incorporation of IK in school

Science (Vhurumuku & Molekeche, 2007; Ogunniyi, 2005; Shizha, 2007). This is confirmed by the findings of research conducted by Dziva, Mpofu, Kusure, Muvindi and Munodavafa (2012) in Zimbabwe which revealed that the teachers in their study had a negative attitude towards IK and had limited understanding of IK. They lacked the pedagogical knowledge to effectively incorporate IK into effective teaching and learning. They attributed this to the fact that, although the Zimbabwean curriculum clearly states that IK should be incorporated in Science teaching, not much has been done to educate teachers to prepare them for the new curriculum changes.

However, although this study was done in Zimbabwe, the outcome of this research also applies in South Africa because of the similarity in the historical and socio-political status of these countries. This is confirmed by Mothwa's (2012) study conducted in Gauteng in South Africa, in which she found out that teachers had a negative attitude towards IK because they had insufficient training on how to incorporate it into meaningful teaching and learning. The teachers lacked the pedagogical knowledge to teach Science using the inquiry-based approach propounded by the curriculum. Most teachers in Mothwa's study only 'paid lip-service' to the use of IK without properly engaging in any meaningful detail that would bring about effective learning. Mothwa (2012) attributes this to lack of training. She also concluded that most teachers in South Africa trained during the colonial era when IK was either despised, side-lined or dismissed as unscientific.

Delpit (1995, p. 141) also adds weight to the above views by saying that teachers tend to "feel as if they are losing control if learners do not fit in with their traditional teaching methods". These findings and sentiments imply that teachers' attitudes towards IK are a major challenge to the success of incorporating IK in the Science curriculum. Ogunniyi (2005) observes that teachers are strategically placed so that they can jeopardise the success of any curriculum innovation if they are not taken on board. Hence, Science teachers need to undergo a paradigm shift (Kuhn, 1962) in the way they perceive IK. There is a need to restructure their mind-set to suit the needs of an IK-based curriculum and fulfil their new role as cultural brokers (Aikenhead & Ogawa, 2007).

To Ogunniyi (2005), changing teachers' mind-set is not an easy thing to do. It is a daunting task which requires long-term training and mentoring in which teachers and curriculum developers engage in constructive dialogue aimed at finding ways of incorporating IK. In South Africa, teachers are often given short, in-service training when new curriculum innovations are made. Ogunniyi (2007) argues that such training is insufficient. It does not guarantee the incorporation of IK. In many cases the knowledge gained does not translate into curriculum practice and hence there is tension between curriculum formulation and implementation.

In her study, Mothwa (2012) found out that during the teaching-learning process teachers failed to recognise and seize golden opportunities that arose to infuse IK. She attributed this

failure in part to the fact that many teachers in South Africa were trained during the colonial era. During that time, the IK of the indigenous people was ignored, denigrated or dismissed at face value as superstitious and unscientific.

Mothwa (2012) argued that such teachers are not well equipped to implement the child-centred NCS curriculum because their pre-service training prepared them for the old methods of teaching. In Mothwa's view, such teachers are not the best technocrats needed for the successful implementation of an IK based curriculum.

The above arguments left me wondering if the level of teaching experience that one has, has a bearing on one's ability to infuse IK in teaching Science. The following section looks at the alcoholic fermentation and the theoretical frameworks informing this study. It briefly discusses socio-cultural constructivism before turning to Shulman's pedagogical content knowledge.

2.5 Fermentation

According to Campbell (1990), alcoholic fermentation can be defined as a metabolic process whereby yeast converts glucose $CH_{12}O_6$ to ethanol (CH_3CH_2OH) and carbon dioxide gas (CO_2), in the absence of oxygen. During this process adenosine tri-phosphate (ATP) (from glycolysis) provides energy to break down the two pyruvate molecules (formed during glycolysis) into ethanal which is later converted to ethanol (CH_3CH_2OH). Ethanol is the alcohol in traditional fermented beverages such as *umqombothi*.

In the process of fermentation CO_2 is given off as a by-product. It is released during a process called decarboxylation. It escapes from the ferment as a gas and forms the bubbles and froth that is seen on top of traditional beverages such as *umqombothi*. According to Campbell (2000), CO_2 provides beer with its taste, aroma and carbonation. Alcoholic fermentation is a complex chemical process which can be summarised by the following chemical equation:

In words: Glucose ==> Ethyl Alcohol + Carbon dioxide (gas) + Energy
In symbols: $C_6H_{12}O_6$ ==> $2(C_2H_5OH)$ + $2(CO_2)$ + ATP

According to Uushona (2013), traditional beverages such as *umqombothi* are prepared in many African societies using cereal grains such as maize, sorghum, *rapoko* and millet. In her study, Hanisi (2006), found out that making and drinking *umqombothi* is a common practice among the *Xhosa* people in the Eastern Cape because it is considered as non-alcoholic beverage due to its low alcoholic content. It could be argued that these studies suggest that many learners come to school with prior knowledge of alcoholic fermentation which teachers can make use of in their teaching.

2.6 Theoretical framework

It is important to understand the theoretical frameworks informing this study. This section discusses the two theoretical frameworks informing this study, which are Vygotsky's socio-cultural constructivism and Shulman's pedagogical content knowledge. The discussion commences with a brief definition of a theoretical framework, turning to the theoretical framework used in this study.

According to Merriam (2009), a theoretical framework is like an architectural plan upon which a research project is built. It informs every aspect of the research process and is the lens through which the research is viewed. This study is informed by Vygotsky's socio-cultural constructivism and Shulman's (1989) pedagogical content knowledge (PCK).

Each one of these theories is briefly discussed in the sections below.

2.6.1 Socio-cultural constructivism

Constructivism is a theory based on the view that learners construct their own understanding of phenomenon through interaction with their physical and social environment (Hodson, 1990). This view represents a direct contrast to the traditional view that knowledge can be transmitted from the teacher to the learner. Constructivism regards learning as a process whereby the learner builds their own understanding of phenomenon as they engage with their physical or social environment.

Although there are many theorists associated with constructivism, its major proponents are Jean Piaget and Levy Vygotsky whose theories came to be known as cognitive and socio-cultural constructivism respectively (Hodson, 1992). This study was informed by Vygotsky's socio-cultural theory.

According to Vygotsky (1978), learning is a socially mediated process in which learners construct meaning of their environment with the assistance of more knowledgeable others. McRobbie and Tobin (1997, p. 194) clarify this by pointing out that while knowledge is socially mediated, meaning making is a personal experience in which knowledge is constructed as the new information "interacts with the extant knowledge". This emphasises the importance of group work so as to assist learners to construct their own understanding of phenomenon. In a socio-cultural classroom set up, the role of the knowledgeable others in scaffolding other learners cannot be over-emphasised.

Bruner (1986) describes the role of the knowledgeable other as that of scaffolding learners from one level of understanding to another. This idea ties in very well with the idea that learning takes place within the zone of proximal development (ZPD). According to Vygotsky (1978, p. 86), the ZPD is the "distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or collaboration with more capable peers".

According to McRobbie and Tobin (1997, p. 196), "social constructivism highlights the role of active involvement in tasks associated with making connections between everyday experience and extant knowledge". Thus, the learning process involves making use of the everyday cultural tools such as language, artefacts and other aspects of culture to make sense of scientific phenomena. In this way learners put to the test their ideas by discussing, arguing, questioning and testing their understanding of concepts against their peers' views. It is through listening to themselves and others that learners are able to refine their understanding of phenomena (McRobbie & Tobin, 1997).

From these arguments it can be seen that language is a critical tool in the teaching and learning process. According to Zhang (2008) the learner's ability to use the language of instruction affects his or her ability to access education. In a classroom situation, language is the medium through which ideas are exchanged between the teacher and the learners and among learners. The socio-cultural theory, with its emphasis on social interaction places value on language. Zhang (2008) argues that it is "through talking that learners become actively involved in learning and the teacher constructively intervenes".

It is interesting to note that while language is such an important mediational tool, many learners in Africa access education in a second language, which is usually English (Zhang, 2008; Probyn, 2009). The plight of these second language speaking learners is well articulated by McDonald (1990) who equates learning through a second language to swimming up a waterfall. In South Africa the language problem is compounded by the fact that the preferred language of teaching and learning is English despite the fact that only a very small percentage of learners speak it as a home language (Probyn, 2009). Probyn identifies this scenario as one of the reasons why many learners fail Science. This finds support in Obanya (1999) who argues that having to access the curriculum in a second language that they do not fully understand is the greatest challenge that African children face.

In Science classes the language problem is compounded by the fact that Science is a cognitively demanding and lexically dense subject (Probyn, 2009). In addition, many English words assume a different meaning when they are used in Science. For instance words like *work*, *energy*, and *power* are used in Science to mean different things from their daily meanings. For Science teachers, learners' poor proficiency in the language of instruction poses a big challenge, for they have to teach both the English language and the scientific content.

It is important to note that the ability of teachers to effectively incorporate learners' IK is highly dependent upon what they know. Therefore, it is necessary to review literature on the teachers' knowledge of not only the content of the subject but also how to teach the subject. The following section discusses literature on PCK, starting with a brief definition of PCK before turning to the importance of PCK.

2.6.2 Pedagogical content knowledge

According to Shulman (1989), pedagogical content knowledge (PCK) refers to the way that teachers integrate their knowledge of theories of teaching and learning and the knowledge of the subject matter to bring about effective teaching and learning. In other words, PCK refers to the teachers' knowledge of both the subject content and the effective methods of teaching the subject. One can also clearly see that PCK is a combination of the knowledge of the content, theories of teaching and learning and the methods of teaching. Content knowledge, which refers to the knowledge of the subject matter, can be acquired through studies while PCK is acquired through both studies and experience.

According to Meyer (1999), PCK is the most important determinant of how one teaches. This finds support in the numerous studies cited above that point to the fact that many science teachers find it difficult to incorporate IK into meaningful and effective instructional practices (Aikenhead, 1996; Ogunniyi, 2007; Mothwa, 2012). Similarly, Meyer (1999) argues that the most important single factor determining the effectiveness of a teacher is what he or she knows.

Flowing from the above arguments one can easily see that PCK is the practical knowledge that teachers use to bring about effective teaching and learning. It embraces both the knowledge of the content of the subject and the methods used to bring about effective teaching and learning. Clearly, PCK is more than the mere knowledge of the subject content or the general philosophies of teaching. It also embraces the teacher's ability to present the subject content in a manner that makes it easier for learners to understand (*ibid*.).

Shulman (1989) observes that teachers' PCK depends on their age and experience in teaching. This implies that elderly, experienced teachers are more skilful than their younger counter-parts. In other words, the process of learning to teach is complex (Meyer, 1999). Experience builds up over the years as the teacher engages with different groups of learners in their specific socio-political and cultural environment.

What stands out from these assertions is that there is a difference between the way an inexperienced teacher and an experienced teacher teaches. Accordingly, a study conducted by Meyer (1999) found that novice teachers were unable to effectively incorporate IK into their teaching. They relied on unmodified subject matter extracted directly from the textbooks or the curriculum. Their use of IK was limited to the superficial level, directly related to simple factual knowledge.

Meyer (1999) concluded that this was because the novice teachers lacked the framework to understand what was happening in the classroom. He argued that novice teachers have limited PCK. Their knowledge base is restricted and poorly organised. They lack the experience to organise their thinking in order to accommodate other knowledge domains outside science. Grossman (1989) observes that these teachers struggle in applying PCK

despite their vast knowledge of the subject content. It could be argued that it is not enough to know what to teach but also to know how to teach it.

2.7 Concluding remarks

This chapter reviewed related literature that is relevant to this study. It looked into the debate around the role of IK in science education and the challenges faced by teachers in trying to implement an IK based curriculum. It was argued that the incorporation of IK makes it easy for learners to understand the subject. As such, IK should be incorporated in Science education not only to increase access to Science education, but also to make Science easier to understand. Thereafter, the review focused on the socio-cultural theory and the pedagogical content knowledge theory as the theoretical frameworks informing this study.

In the next chapter I discuss the methodology that I used in this study.

CHAPTER THREE

METHODOLOGY

3.1 Introduction

In this study I sought to understand how the incorporation of IK enables or constrains the teaching-learning process in Life Sciences. This chapter outlines the procedure that was followed in conducting this research. It starts by outlining the research goal and objectives, after which it turns to the research procedure followed. It then briefly discusses the research paradigm underpinning the research, the research design, sampling procedure, data gathering techniques, data gathering procedure, data presentation and analysis as well as the validity and ethical considerations undertaken in conducting this research.

3.2 Research paradigm

According to Denzin and Lincoln (2008), a paradigm is an overarching philosophy guiding practice in research. Cohen, Manion and Morrison (2011) add that a paradigm is a set of assumptions or beliefs about the nature of knowledge and how the knowledge is acquired. Hence, a paradigm refers to the general understanding of what knowledge is and how it is acquired, which guides the researcher's action. Furthermore, a paradigm informs the nature of inquiry and influences the kind of data that a researcher can collect, the data gathering techniques, the data presentation and analysis and the kind of conclusions that the researcher can arrive at (Denzin & Lincoln, 2008).

Cohen et al. (2011) argue that although there are many research paradigms from which a researcher can choose, they can be placed on a continuum ranging from positivism to the interpretive paradigm. This study was underpinned by the interpretive paradigm and informed by constructivism as the theoretical framework [see Section 2.5]. According to Denzin and Lincoln (2000, p. 31), the constructivist-interpretivist paradigm is based on the assumption that "there are multiple realities" and that "the knower and the respondent co-create understandings". Thus, human behaviour can best be understood not only by observing it but also by listening to its actors.

Lending support, Maree (2008) argues that the interpretive paradigm is based on the assumption that the human mind is so complex and purposive, that human behaviour can only be understood from within. In other words, it is only by exploring the richness, depth and complexity of human interaction that we are able to understand the meaning attached to human behaviour. Maree places emphasis on studying people's lived experiences. That is, it is only by understanding the social context within which meanings are constructed that we are able to understand human behaviour (*ibid.*).

With this in mind, I set out to study teachers and learners in their real life classroom situations in order to understand how the incorporation of IK enables or constrains the teaching and learning of alcoholic fermentation. I observed and listened to their interpretation of their experience of teaching and learning through the incorporation of IK. As already pointed out in the research procedure, obtaining the opinions of both the teachers and learners enabled me to understand the lived experiences of incorporating IK not only from my own perspective, but also from the perspectives of those directly involved in implementing it. Herein lies the importance of the interpretivist paradigm in this study.

Miles and Huberman (1994) argue that the greatest advantage of the interpretive paradigm is that it gives the researcher an opportunity to study phenomenon and ordinary events, in their natural setting. Thus, the researcher is able to obtain information directly from the participants without having to rely on secondary sources. Denzin and Lincoln (2008) add that interpretive research is "inherently multi-method" in its approach to data gathering. In this research I used the case study research design which enabled me to use different data gathering techniques and come up with thick descriptive data that captured the richness, depth and complexity of the phenomenon under study (Denzin & Lincoln, 2008; Miles & Huberman, 1994).

The following section discusses the case study research design. The discussion defines a case study, before looking at its advantages, limitations and application to this study. While the discussion justifies the case study as the most suitable design for this study, I was nonetheless not blind to its limitations.

3.3 A case study

According to Creswell (2007), a case study is a comprehensive study of a confined system centred on extensive collection of data. Merriam (1988, p. xiv) also describes a case study as "an intensive, holistic description and analysis of a bounded phenomenon such as a program, institution, person or process, or unit of study".

From these definitions it is clear that a case study is a systematic inquiry aimed at gaining thorough understanding of a phenomenon under investigation. It seeks to understand phenomena in their natural state and capture the uniqueness of the event. In this study I intended to gain an in-depth understanding of how the incorporation of IK enables or constrains the teaching and learning of alcoholic fermentation. My case was a group of grade eleven Life Sciences teachers and learners, at one high school in Mthatha who were engaged in the teaching and learning of alcoholic fermentation.

I chose a case study as my research design because it would enable me to thoroughly investigate how the incorporation of IK enables or constrains the teaching and learning of alcoholic fermentation (Miles & Huberman, 1994; Cohen et al., 2011). To achieve the above mentioned objectives I had to narrow my focus to smaller units which would inform my

analysis of the data collected at a later stage. Thus, my units of analysis were the benefits and constraints of incorporating IK. In other words, it was through studying the benefits and constraints of incorporating IK that I would be able to understand how it enables or constrains the teaching and learning of alcoholic fermentation.

Merriam (1988) sees a case study as a holistic approach to understanding phenomena which uses a wide range of data gathering techniques. Unlike quantitative methods, a case study enables the researcher to scrutinize phenomena from different angles (Cohen et al., 2011). Yin (2009) adds weight to this assertion by claiming that triangulation of data gathering techniques enables the researcher to have a multi-dimensional view of the phenomenon under study.

Cohen et al. (2011) advise that educational researchers working with children be sensitive to the power dynamics that exist between them and learners. Learners may feel intimidated or coerced to provide information. This suggests that the researcher must create a relaxed environment that is free of anxiety in which learners can give information freely. With this in mind I decided to use a focus group interview technique to interview learners. Cohen et al. (2011) suggest that learners feel more secure to provide information when interviewed as a group than when confronted individually.

Although the focus group interview is often criticised for the fact that it can be dominated by the extroverts, I made sure that all learners had an opportunity to express themselves. I allowed learners to openly respond to questions and gave introverted learners a chance to speak as well. I allowed the extroverts to speak freely so that I would get as much information from them as possible and to avoid embarrassing them. In this way I was able to see the phenomenon under study from different angles, through the eyes of different learners. Luckily all learners were able to express themselves well in English during both the interviews and the lessons since the school is an English medium school. This saved me the trouble of having to use an interpreter.

The section below discusses in detail the sampling procedure and each one of the above mentioned data gathering techniques.

3.4 Research goal

The main goal of this study was to understand how the incorporation of IK enables or constrains the teaching and learning of alcoholic fermentation.

This goal was achieved by addressing the following objectives:

- To find out how the incorporation of IK enables or constrains the teaching/mediating/ learning of alcoholic fermentation;

- To find out how the incorporation of IK enables or constrains learners' understanding of the concept of alcoholic fermentation;
- To find out if teachers have the necessary skills and knowledge to enable them to incorporate IK in their teaching; and
- To find out teachers' experiences, attitudes and opinions about incorporation of IK in teaching Life Sciences.

The main purpose of pursuing these objectives was to answer the following main question:

- How does the incorporation of IK enable or constrain the teaching and learning of alcoholic fermentation?

1. To answer the main question, the following sub-questions were asked: What are teachers' perceptions, attitudes and experiences towards the incorporation of IK? [*To answer this sub-question I used questionnaires and stimulated recall interviews*].
2. How does the incorporation of IK enable or constrain mediated learning of alcoholic fermentation? [*This was answered using the lesson observation and stimulated recall interviews*].
3. How does the incorporation of IK enable or constrain learners' understanding of alcoholic fermentation? [*This was answered using the lesson observation and stimulated recall interviews and focus group interviews*].
4. What are learners' attitudes, opinions and experience towards the incorporation of IK in learning Life Sciences? [*To answer this sub-question I used the focus group interviews*].

Answering these questions required a flexible approach that enabled me to be open-minded and study the phenomena under investigation from different angles. This approach included the research paradigm informing the study, the research design, methodology and data gathering techniques, data presentation and analysis. The following sections describe how the research was conducted. It looks at each one of the above listed aspects in detail.

3.5 Population

According to Cohen et al. (2006), a population is the entire group of persons that the researcher is interested in. Such a group is chosen because it possesses the characteristics that the researcher is interested in investigating. Yin (2009) suggests that after identifying the population the researcher chooses the target population. They define the target population as

only those members of the entire population who meet a certain criteria set by the researcher in accordance with his/her research interests.

In this research I was interested in finding out how the incorporation of IK enables or constrains the teaching and learning of alcoholic fermentation in Life Sciences. This limited my target population only to Life Sciences teachers and their learners. Of these, I was only interested in those teaching and doing Grade 11 because the concept of alcoholic fermentation is taught in this Grade.

Maree (2008) argues that because it is usually nearly impossible to study the entire population because of time and financial constraints, the researcher has to resort to sampling. In this study it would have been impossible for me to study the entire population of Life Sciences teachers and learners in South Africa, so I confined my research to the Eastern Cape Province. I further confined or limited my interest to Mthatha District in order to cut out on time and travel costs. Since this was a case study, I was not interested in coming up with a sample that would be representative of the entire population. Instead, I wanted a sample that would enable me to gain an in-depth understanding of how the incorporation of IK enables or constrains the teaching and learning of alcoholic fermentation. Thus, I further narrowed my research focus to the school where I am teaching so as to gain an in-depth understanding of how its contextual uniqueness enables or constrains the incorporation of IK. To understand the peculiar circumstances under which this study was conducted there is need to have a contextual analysis of the school.

3.6 Research site

In this section I discuss a contextual analysis of the research site. I thus looked at the geological and socio-cultural location of the school, the demographic composition of its learners and the ethnic background of the teachers. This information is essential as it enabled me to understand the contextual factors enabling or constraining the teaching and learning of alcoholic fermentation at this school in particular.

3.6.1 Geographical location

The school where this study was conducted is a peri-urban high school with a student population of 1535 and 52 teachers. It is located within a *Xhosa* community in Mthatha District of the Eastern Cape Province of South Africa. This school is a Roman Catholic institution although it enrols learners from different socio-cultural and religious backgrounds.

It is interesting to note that the community is comprised of people from different religious and cultural backgrounds. Among these people are church-goers from different Christian denominations, those who practise African Traditional religion, Hinduism and many other religions. The implication of this cultural and religious diversity is that the learners found in our classes have a wide diversity of IK and beliefs associated with it. There are chances that

these learners experience tension in their homes because of the conflicting religious and cultural practices. Therefore, it was interesting to find out how this tension affects the incorporation of IK in a multicultural classroom. Although I initially had set out to investigate the impact of cultural diversity on the incorporation of IK, I realised that not all learners in the classes I observed were *isiXhosa* speaking. In Teacher A's class there was a coloured girl who spoke *Afrikaans* at home as her home language. Although the rest of the learners were *isiXhosa* speaking, three were of a *Sotho* origin and one had a *Zulu* background.

The teachers at this school were from different ethnic groups. Thus, it is important to have a look at the demographic composition of the teachers and learners in this study so as to understand the influence of their ethnicity on the outcome of this research.

3.6.2 Demographic composition of teachers

The school is comprised of 52 teachers from different countries such as Cameroon, India, Nigeria, South Africa, Uganda and Zimbabwe.

The Principal and one of the two Deputy Principals of the school are Indian. The teaching staff consists of nine Indians, seven Zimbabweans, three Nigerians, two Ugandans, one Cameroonian, and two white and 28 black South Africans, mostly of Xhosa origin. It is interesting to note that the foreign teachers together constitute forty-six percent (46%) of the teaching staff at this school. This statistic is very important as it projects a vivid contextual profile of the factors enabling or constraining the incorporation of IK at this school.

The Life Sciences department at the school consists of three South African teachers, one Zimbabwean, one Nigerian and one Ugandan. All these teachers teach Grade 11, except the Ugandan because there are only five Life Sciences Grade 11 classes at the school.

The demographic composition of the school made it an interesting case to study as it reflects the cultural diversity found in the South African classroom after independence. It would be interesting to see whose IK teachers use as they mediate learning and how they deal with the issue of cultural diversity as they incorporate such IK.

3.6.3 Demographic composition of the learners

The student population consists of learners from different ethnic, national and racial backgrounds. Although the majority of learners are *Xhosa* speaking South Africans, there are a few coloured South Africans, black Zimbabweans and *Sotho* speaking learners. This means that there is diversity in the classrooms in terms of learners' cultural backgrounds.

3.7 Sampling

Cohen et al. (2011) define sampling as the process of picking research participants from a given target population. Miles and Huberman (1994) add that sampling is a very crucial

element of research. It determines the quality of information that can be obtained and the ultimate result of the research.

According to Cohen et al. (2011), there are so many sampling techniques that a researcher can use and these can broadly be classified as probability and non-probability sampling techniques. Cohen et al. (2011) observe that the decision to select either probability or non-probability sampling techniques is determined by the nature of the study and the purpose of the sample.

Since my study was a qualitative case study, I used non-probability sampling techniques to choose the participants and research site. I was not interested in coming up with a sample that would be representative of the general population. Instead, I wanted a sample that would fully capture the uniqueness of the case under study. This enabled me to understand the intricacies involved in incorporating IK and how the incorporation of IK enables or constrains the teaching-learning process in a real life classroom situation. I used purposive sampling and convenience sampling to select both the teachers and the learners. As explained earlier on, my target populations were Life Sciences teachers and learners from the school where I am currently teaching.

3.8 Purposive sampling

According to Cohen et al. (2011), purposive sampling is used in qualitative research to deliberately choose only those participants who possess the characteristics that are relevant to the study. Unlike probability sampling where the researcher strives to eliminate researcher bias by selecting a sample that is representative of the target population, in purposive sampling the researcher uses his or her discretion to select participants that best illuminate the case under study. To Cohen et al. (2011), the prime purpose of purposive sampling is to come up with a sample that will enable the researcher to gain deeper insight into the phenomena under study.

In this research I used purposive sampling to decide who would be eligible as potential participants and who would not. My target populations were the Life Sciences teachers and learners at the school where I am teaching because alcoholic fermentation is taught in Life Sciences at Grade eleven. The sample automatically excluded all the other teachers and learners not teaching and learning Life Sciences. According to Cohen et al. (2011), comprehensive information can only be obtained from those who possess it. In my case, the teachers I chose had been directly involved in mediated learning in the lessons observed. This made them the best positioned people to tell whether the incorporation of IK enabled or constrained their efforts to make learners understand the process of alcoholic fermentation.

3.8.1 Criteria for selecting teachers

The two teachers who participated in this research were selected using convenience and purposive sampling. Their selection was largely based on the fact that they were easily available and that they were Life Sciences teachers at the school where I am currently teaching. Thus, both purposive sampling and convenience sampling were used to decide who would be a candidate participant and who would not. According to Cohen et al., convenience sampling and purposive sampling can be used by the researcher to select the most easily accessible candidates possessing the desired characteristics.

In this research, my target population were Life Sciences teachers only because I was investigating how the incorporation of IK enables or constrains the teaching and learning of alcoholic fermentation. In South Africa, this concept is taught in Life Sciences in Grade 11. This automatically excluded teachers of other subjects and Life Sciences teachers who taught other Grades. Therefore, I was only interested in those teaching Life Sciences in Grade 11.

The two teachers that I selected were polar opposite cases in terms of their experience. Teacher A was a seasoned teacher with more than ten years teaching experience. In contrast, Teacher B was a novice with less than five years of teaching experience. Both teachers were *isiXhosa* male teachers who grew up in the Eastern Cape. Initially, I wanted to observe lessons from all the four teachers in our Department but I could not because the other two teachers turned me down in the final stages of the preparation. I could not force them as this would be unethical and a violation of their right to withdraw from the project at any time (Cohen et al., 2011).

Selecting teachers with different levels of experience enriched my insight into how the incorporation of IK enhanced teaching. Although it was out of the scope of my study, observing teachers with different levels of teaching experience enabled me to draw comparisons between the way a newly trained teacher perceives and incorporates IK and how an experienced teacher makes use of IK in his/her teaching. In this way I was be able to find out how experience influences the way teachers incorporate IK. Having said this, I now turn to the research site.

3.8.2 Criteria for selecting learners

I also used purposive sampling to select the six learners who constituted the focus group in this study. These learners were selected on the basis of their level of participation in the lessons observed. To avoid choosing only the extroverts and the highly motivated learners, I purposively selected the most active learner from each class, a moderately active learner and the least active learner from each class. My intention was to come up with a sample that would depict the wide range of opinions towards the incorporation of IK in learning Life Sciences.

My assumption was that their different levels of enthusiasm, excitement and engagement were possible indicators of how the incorporation of IK benefitted or constrained their learning. Thus, by selecting learners who responded differently to the lessons, I wanted to eliminate bias within the sample that would be brought about by selecting learners with the same characteristics. I assumed that this sample would fairly represent those who viewed the incorporation of IK as beneficial and those who viewed it as constraining. Denzin and Lincoln (2000) justify the use of purposive sampling by pointing to the fact that it enables the researcher to select the typical traits within a sample. In other words the researcher is able to pick groups or individuals with the desired characteristics.

However, Yin (2009) argues that the greatest weakness of purposive sampling is that it is subjectively done and is prone to researcher bias. To avoid picking only those learners who confirmed my preconceived ideas, I asked a workmate to watch the videos of the two lessons observed and pick the learners whom he viewed as most active, moderately active and those whom he perceived as passive. Although the sample was subjectively done, at least the selection was done by someone who was not an interested party to this research. Cohen et al. (2011) emphasise the need for rigour to ensure that the results of qualitative research are trustworthy and credible.

3.8.3 Research site

This study was conducted at the school where I am teaching for convenience purposes. The school is located in a peri-urban area of Mthatha town of the Eastern Cape Province of South Africa. It has a student population of 1578 learners and 52 teachers. The majority of these learners come from a Xhosa community where cultural practices such as the making of *umqombothi*, preparing *amasi* and many others are common. Hanisi (2006) postulates that practices such as making *umqombothi* and *marewu* are common among the Xhosa people.

I decided to conduct the research at a school where I am teaching to cut on travelling costs. I had limited time and financial resources to fund my research since I had to divide my meagre salary between my studies and my family. Travelling to other schools to conduct the research would also mean wasting learners' precious learning time. This would be unethical and unfair to the learners I teach. The nearest high school was ten kilometres away. Being a full time employee and part-time Rhodes University student, my day was divided between my studies and my work.

Having said this, I now turn to the data gathering procedure that was followed in conducting this research.

3.9 Data gathering procedure

The nature of this study required that I use data collecting procedures that would enable me to understand the lived experiences in relation to the incorporation of IK. To get a deeper insight

into this experience I needed to have an overview of what is happening not only at the school where I am teaching but also in other schools.

Hence, I divided my data gathering procedure into two phases. In phase one I wanted to get a general picture of how teachers are incorporating IK in the absence of proper curriculum guidance as pointed out by Rogan (2007). The data obtained in phase one was used as baseline information to answer sub-question one and to guide the research procedure in phase two.

The data gathering procedure is discussed in detail in Sections 3.9.1 and 3.9.2 below.

3.9.1 Phase one

Rogan (2006) observes that the policy of incorporating IK was adopted without proper consideration of how it could be done. This left me curious to know how teachers are incorporating IK in their classrooms in the absence of curriculum guidance.

The information obtained from phase one would inform my lesson observations and interviews in phase two.

I gave a questionnaire to ten Life Sciences teachers from four neighbouring schools. The questionnaire explored the following themes arising from the first two sub-questions in Section 3.3.1 above:

- Teachers' level of training on how to incorporate IK;
- Teachers experiences in incorporating IK;
- Their attitudes, opinions and perceptions of IK; and
- The challenges they encounter in incorporating IK.

The data collected was used as baseline information that informed the second phase of this research. According to Cohen et al. (2011), questionnaires are often used to survey peoples' attitudes, opinions or knowledge about a particular subject or phenomenon. In this research a questionnaire provided information that enriched my understanding and sharpened my insight and focus during the lesson observations and interviews in phase two. It also enabled me to draw comparisons between the observed teachers' lived experiences and what teachers had said in the survey.

According to Cohen et al. (2011), the multi-method approach to research enables the researcher to come up with data that is trustworthy. This resonates with an observation made by Yin (2009) that triangulation of research instruments enables the researcher to build a better picture of the phenomena under study by consolidating different sets of data obtained from different sources. In other words, triangulation makes the data collected more valid. In this study, four data gathering techniques were triangulated, namely: a questionnaire, lesson observation, personal interviews with teachers and focus group interviews with learners. This

helped me to consolidate different sets of data from different sources. The section below discusses the second phase of the data gathering process.

3.9.2 Phase two

In phase two I conducted two lesson observations with the two Grade 11 classes after which I conducted stimulated recall interviews with the teachers and focus group interviews with the learners. Each lesson was a double lesson lasting for an hour. I wanted to observe four separate lessons but unfortunately the management of the school could not allow me to do so as this would take up much of my teaching time and disturb the smooth running of the school. I then persuaded the teachers to allow me to combine the lessons into double lessons. As a result I ended up having to observe two double lessons - one double lesson for each teacher.

The lesson observations focused on how the incorporation of IK enabled or constrained the teaching-learning process. My focus was on how the teachers incorporated IK into mediated learning and how it helped them to make sense of alcoholic fermentation. I wanted to witness the lived experience of incorporating IK in the teaching and learning of alcoholic fermentation so as to answer the following sub-questions:

- How does the incorporation of IK enable or constrain teaching of alcoholic fermentation?
- How does the incorporation of IK enable or constrain learners' understanding of the process of alcoholic fermentation?

Arrangements were made prior to the lesson observations to ensure that both teachers were teaching the same concepts. I ensured that they would incorporate IK by asking them to draw up lesson plans prior to teaching in which they would carefully consider how they would incorporate IK. After the lesson observation I conducted stimulated recall interviews (Lyle, 2003) with each teacher while watching the videos, as well as focus group interviews with the learners. During the stimulated recall interviews, I could pause the video to seek clarity and this in itself became a validation process [see Section 3.14]. In this way I was able to understand the teachers' intentions and interpretation of their own behaviour.

However, although observation is applauded for enabling the researcher to gather first-hand information, it is often criticised for being intrusive. Cohen et al. (2011) argue that people tend to adjust their behaviour when they know that they are being observed. This coupled with the subjective nature of observation can reduce the validity of the data obtained. Moreover, it is difficult to observe and write everything that occurs during a lesson observation. In this study I had to stop jotting down notes while I observed the lesson in Teacher A's class because I noticed that it made learners anxious and caused them to adjust their behaviour.

To address the above-mentioned challenges, observed lessons were video-recorded. Thus, my interest in the observation was limited to understanding how the incorporation of IK enables

or constrains mediated learning. Cohen et al. (2011) alert us to the fact that although observations are a valuable tool in qualitative research one can easily get carried away and lose focus as there are many things to observe. For this reason, I made use of an observation schedule that helped me to stay focused. The data obtained was transcribed and a colleague checked for ambiguities and accuracy. Thereafter the transcribed data was given to the two teachers for validation purposes. The section below gives a detailed account of the data gathering techniques that were used to gather data in this research.

3.10 Data gathering techniques

According to Yin (2009), the success of research depends on the researchers' ability to choose the most appropriate data gathering techniques that will enable them to gather data that will help them to answer their research question(s). Similarly, Cohen et al. (2011) point out that the most important consideration in selecting research instruments is their ability to yield the most appropriate data that meet the needs of the research.

Taking into consideration the advice from these authors I chose a document analysis, a questionnaire, stimulated recall interviews, focus group interviews and lesson observations as my research instruments in this study. These techniques were selected for triangulation purposes. The weakness of one data gathering technique was complemented by another.

The following sections discuss each instrument in detail - justifying its appropriateness to the study.

3.10.1 Questionnaires

Questionnaires are commonly used in survey research to get an overview of the phenomenon under study (Wilson & McLean, 1994). Cohen et al. (2011) add that questionnaires are used to find out the general opinions and attitudes about the phenomenon under study.

Questionnaires may take different forms ranging from structured questionnaires to open-ended questionnaires (Cohen et al., 2011). In this study, I used a structured questionnaire with closed and open-ended questions (see Appendix H) to get an overview of teachers' experiences, attitudes and opinions about the incorporation of IK in teaching science. The data obtained would act as baseline information that would inform my understanding of how IK enables or constrains mediated learning.

The questionnaire was given to ten Life Sciences teachers from the four closest neighbouring schools. According to Cohen et al. (2011), although a questionnaire may take long to prepare, it can be economical in terms of the researchers' time since it can be answered in their absence. In my case a questionnaire enabled me to get information from teachers who were geographically spaced. I had no time to travel to the four neighbouring schools to gather

information, so I hand posted the questionnaires through other teachers working in the schools. This saved me both travel costs and time.

Wilson and Mclean (1994) point out that another advantage of a questionnaire is that it gives respondents the opportunity to answer questions freely in the absence of the researcher. This makes their answers more truthful as they will not be influenced by the presence of the researcher as is the case with interviews. In this study I gave the questionnaire to the teachers to answer in their own spare time. According to Cohen et al. (2011), giving respondents a questionnaire to complete in their own spare time, reduces the pressure of having to provide immediate answers to questions.

However, questionnaires are often criticised for not giving the researcher the opportunity to clarify questions that may not be clearly understood by the respondents (McMillan & Schumacher, 2010). Cohen et al. (2011) advises that the researcher needs to set questions in simple language that is likely to be understood by respondents.

In this research I piloted the questionnaire by giving it to a colleague. This helped me to check for accuracy, grammatical errors, ambiguity and spelling mistakes (Cohen et al., 2011). In addition, I also answered the questionnaire before giving it to the respondents to check if it still enabled me to answer my research questions. Although my respondents were teachers who would have understood English, answering the questionnaire enabled me to get the feel of the questionnaire. The questionnaire was used in conjunction with video-taped lesson observations, stimulated recall interviews with the two teachers at our school and focus group interviews with the six participant learners mentioned in the data collection procedure section above.

The section that follows explains how observations were conducted.

3.10.2 Observation

According to Marshall and Rossman (1950), an observation is a systematic look by the researcher at peoples' behaviour, events, settings or artefacts with the intention of systematically noting something of interest or relevance to the research. McMillan and Schumacher (2010) also posit that an observation involves carefully examining particular human behaviour or phenomena that is of special interest to the researcher.

Analyses of the above definitions show that during an observation the researchers selectively focus on behaviour or traits that are of interest to them. McMillan and Schumacher (2010) argue that the distinct advantage of observation is that it involves gathering live data from naturally occurring social situations. The researcher does not have to rely on secondary sources of information. They are directly involved in seeing, hearing and recording information from a naturally occurring event.

In this study I conducted two lesson observations. The purpose of my observation was to find out how the incorporation of IK enables or constrains the teaching and learning of alcoholic fermentation. Originally, I had intended to observe lessons from all four Life Sciences teachers at the school. However, two of the teachers turned me down at the last minute and for ethical reasons I had to respect their decision. Cohen et al. (2011) emphasise that the researcher should respect the rights of the participants to withdraw or withhold information they may not be willing to share.

Both the teachers who participated in this study had teaching qualifications but had different levels of teaching experience. For ethical reasons I called them Teacher A and Teacher B to protect their identities. Teacher A was an experienced teacher with more than ten years teaching experience while Teacher B was newly qualified with less than five years teaching experience. Selecting teachers with different levels of experience enabled me to observe whether experience had an effect on the way teachers incorporated IK into their teaching.

To get a fair result from the observations, I made arrangements prior to the lesson observations to ensure that the teachers would be teaching the same topic and same content. Each teacher was asked to prepare a lesson plan in which he/she would incorporate IK when teaching alcoholic fermentation. This would enable me to draw fair comparisons between the two lessons so as to gain a deeper understanding of how the incorporation of IK enables or constrains the teaching and learning of alcoholic fermentation.

I then observed each teacher using mediated learning when instructing learners about alcoholic fermentation. Each lesson was a double period that lasted for one hour. This lesson observation in phase one was meant to see how teachers were incorporating IK in the absence of curriculum guidelines. According to Robson (2002), what people do often differs from what they say. Thus the data obtained in these preliminary lesson observations acted as a reality check. It enabled me to draw comparisons between teachers' responses to the questionnaire mentioned above and what actually happens during the teaching-learning process.

The second set of lesson observations were done in phase two of the study after exposing the teachers to the module on incorporating IK. The objective was to see if the incorporation of IK embedded in the making of *umqombothi*, enables or constrains the mediated learning of alcoholic fermentation. However, observations have some limitations. The presence of the researcher may alter the behaviour of participants. As a result, the data collected by this method can be biased (*ibid*.). Cohen et al. (2011) also notes that it is very easy to lose focus in a lesson observation as there are many variables to be observed. In addition, a researcher may not be able to observe, listen to and write everything that occurs in the classroom during a lesson observation.

To compensate for the above stated shortcomings, I video-recorded the lessons I observed and conducted some stimulated recall interviews as well as taking field notes. Leedy and

Ormrod (2014) posit that field notes may not sufficiently capture all the data as it unfolds, hence the need for recording. Video-recording enables one to capture events as they occur (Merriam, 2009). It also allows for capturing of other non-verbal communication such as movements and facial expressions (*ibid*.). I video recorded all the lessons and was assisted by the same colleague who had helped me before.

Cohen et al. (2011) postulate that video recording is intrusive in that it involves having to physically attend the lesson that you are observing which can disturb the natural flow of events thereby denying the researcher access to reality. Naturally, when someone is aware of the fact that they are being observed, they change their behaviour to suit the situation. In a classroom situation, both the teacher and the learners can alter their behaviour to impress the observer.

To minimise the impact of my presence I assumed the role of a non-participant observer. The use of stimulated recall interviews also enabled me to probe and seek clarification in order to understand the motives behind the teachers' actions. The section below discusses interviews as a research technique.

3.10.3 Interviews

According to Cannell and Kahn (1968), an interview is a conversation between the interviewer and interviewee in which the interviewer seeks to obtain research-relevant information. Similarly, Kelly (2006) defines an interview as a conversation between two or more people used to understand peoples' thoughts and feelings, opinions, perceptions and attitudes in order for researchers to answer their research questions.

Both definitions tend to emphasise that an interview involves a direct conversation between individuals so as to gain an insight into the interviewee's thoughts. Tuckman (1972) supports this by arguing that the greatest advantage of an interview is that it "provides access to what is in the interviewee's head". Maree (2008) adds that an interview has the advantage that it gives the researcher access to both the verbal and nonverbal communication. The researcher may observe such things as frowning, change of tone and other gestures which enable the researcher to understand how the interviewee feels. Thus, an interview provides the researcher with first-hand information that comes directly from the participant's mouth and non-verbal actions. Such information might not be obtainable through indirect data gathering techniques such as questionnaires.

In this study I used semi-structured interviews with both teachers and learners. Two sets of interviews were conducted, namely, the stimulated recall interviews with the teachers and focus group interviews with the learners. I conducted the stimulated recall interviews with the two teachers whose lessons I observed interviewed. Three learners from each class were interviewed in focus group interviews to find out what they felt about the incorporation of IK.

3.10.4 The stimulated recall interviews with the two teachers

According to Lyle (2003, p. 861), a stimulated recall interview is "an introspective procedure in which (normally) videotaped passages of behaviour are replayed to individuals to stimulate recall of their concurrent cognitive activity". In other words a stimulated recall interview enables both the researcher and the respondent to relive the recorded experience and review and analyse it as it occurs.

In this research, I wanted to find out how the teachers interpreted the lesson observed. My main focus was to understand how the incorporation of IK enabled or constrained their efforts in the mediated learning of alcoholic fermentation. To achieve this, I watched the video of the observed lesson with each of the two teachers. This made it easier to reflect upon the lesson and discuss the critical moments. In this way I was able to understand the motivation behind their actions, their attitudes, opinions and the challenges they faced in incorporating IK using mediated learning to teach about alcoholic fermentation. All these were important aspects in answering my main research question.

However, the greatest challenge I faced with this method was that of limited time. Teachers were busy marking June examinations and trying to wind up the term. This made it very difficult to have time to watch the videos and conduct the interviews. One teacher was very uncomfortable with the idea of having to watch the lesson he taught with me. I had to explain to him the purpose of the stimulated recall interview and allay his fears.

3.11 Data analysis

Data analysis was done using content analysis. According to Maree (2008), content analysis is a "systematic approach to qualitative data analysis aimed at identifying, summarising and understanding the message content of written documents, audio-visual media, open-ended survey questions and interviews". In this study, content analysis enabled me to identify trends, summarise and understand data from the questionnaires, lesson plans, lesson observations, stimulated recall interviews and focus group interviews.

Data were coded and placed into categories according to themes that enabled me to answer my research questions. In some cases data were tabulated or presented in graph form to provide visual pictures. This made it easier to see trends in the data.

3.12 Validity

Lincoln and Guba (1994) point out that one of the major challenges in qualitative research is how to ensure validity. As already mentioned above, in this research, triangulation in the data gathering process was used so as to improve the trustworthiness of the data obtained (Cohen et al., 2011). Thus, the questionnaire, interviews and the lesson observations accompanied by field notes and video recordings, were done to improve the trustworthiness of the data

obtained. King, Morris and Fitz-Gibbon (1987) advise that it is important to design research instruments that are easy to understand, with clear instructions. Cohen et al. (2011) also point out that research instruments should be written in simple language that is easily understood by the respondents. In light of the above views the interview schedules and questionnaire were given to a friend to critically validate them.

3.13 Ethical considerations

According to Cohen et al. (2011), a researcher has no right to conduct research in any organisation without the permission of those in authority. Bell (1991) advises that such permission should be sought well before conducting the research. For this study, I sought permission to conduct this research from the Mthatha District Office, Principals of the schools involved, the participating teachers and the parents of the learners.

Because I was dealing with minors, letters were written to the Principal of the school concerned, and the teachers to be observed. Participants were assured that participation in this research would be strictly voluntary and that their identities would be concealed and remain anonymous. They were also informed of their right to withdraw at any time.

3.14 Limitations of the study

The findings of this study cannot be generalised because it is a case study confined to studying only two teachers at one high school and ten teachers from the neighbouring schools in Mthatha District. A larger and more representative sample would allow for more generalization. Additionally, the use of recording devices such as a video camera may have caused the teachers and learners to alter their behaviour. Cohen et al. (2011) postulate that, people tend to alter their behaviour if they are aware that they are being observed.

3.15 Concluding remarks

This chapter outlined the procedure undertaken in conducting this research. It looked into the paradigm underpinning the study, the research design, data gathering and analysis procedure undertaken. A questionnaire, document analysis, lesson observation, stimulated recall interviews and focus group interviews were used as data collecting procedures. The chapter also discussed the validity, the ethical consideration and limitations of this research.

In the next chapter I present and analyse my data in relation to the research questions.

CHAPTER FOUR

DATA PRESENTATION AND ANALYSIS

4.1 Introduction

In this chapter, I present the data collected in this research. I start by presenting the data obtained from the questionnaire given in phase one. Although this is predominantly a qualitative research, data from the questionnaire are presented in frequency tables and graphs so as to provide visual pictures of the phenomena under investigation.

For phase two, I present data from the lesson plans, lesson observations, the stimulated recall interviews and the focus group interviews. Data are ordered, categorised, coded and presented according to the themes that emerged from the data. Each section of data is discussed in descriptive narrative form.

Data presentation is sequentially done according to when it was collected. To make it easier to understand, data is presented according to themes that emerged from the data.

4.2 Phase one: Survey on teachers' attitudes, opinions and perceptions

In this phase, I present the data obtained from the questionnaire [see Section 3.3.1]. The questionnaire answered sub-question one, which reads as follows:

- What are teachers' attitudes, opinions and experiences with regards to the incorporation of IK?

To address this question, the questionnaire explored the following themes:

- Teachers' training;
- Teachers' experiences in incorporating IK;
- Their attitudes, opinions and perceptions of IK; and
- Challenges encountered in incorporating IK [see Section 3.9.1].

The data obtained in this phase are presented in frequency tables and graphs to provide a visual picture and make them easier to understand. The presentation starts with the teachers' demographic data to set the context of the study.

4.2.1 Teachers' demographic data

4.2.1.1 Teachers' age groups

Table 1: Teacher's Age groups:

Teachers' ages (in years)	20-30	31-40	41-50	51-60	Above 60
Number of teachers	1	5	3	1	0

From this table it can be seen that 60% of the teachers were below 41 years of age, while only three out of the ten teachers were in the age group 41-50 years and no one was above 60. In essence this means that the respondents to the questionnaire were relatively young even though only one of the participants was below 30. Half the sample is within the age range of 31-40 years.

4.2.1.2 Professional qualifications

On the question of qualifications, the teachers indicated that they had the following qualifications:

4.2.1.2 Teacher's qualifications

Qualification	**Number of teachers**
Bachelor of Education and Advanced Certificate in Education (ACE) (Natural Sciences)	2
Bachelor of Sciences with Honors;	2
B.Ed. Honors Commerce	2
Higher National Diploma and Post Graduate Certificate in Education (PGCE	3
Advanced Certificate in Education	1

From this data it is clear that not all the teachers had the necessary qualifications that would enable them to become effective Science teachers. For instance, 20% indicated that they had Bachelor of Commerce Degrees (B. Com) which is a commercial qualification. It is a not an educational degree which prepares someone to teach science. These teachers did not indicate whether they got any in-service training which may suggest that they did not receive any training.

It is also interesting to note that, of the remaining 80%, only 30% had teaching qualifications. In other words, even though educational qualifications such as a Bachelor of Science might have equipped the teachers with the necessary subject content knowledge, it is not a teaching qualification designed to equip teachers with pedagogical knowledge. It is also interesting to note that all those who had teaching qualifications had entry level qualifications such as an Advanced Certificate in Education (ACE) or Post graduate Certificate in Education (PGCE). This may suggest that they may have initially trained for other professions, only to find themselves in the classroom due to circumstances.

The teachers were asked to indicate their teaching experience and their responses were tabulated in the frequency table below:

Table 2: Teachers' years of service and their frequency:

Years of service	**Number of teachers**
0-5	2
6-10	4
11-30	3
21-30	1
More than 30	0

The data from this table shows that 90% of the teachers who responded to the questionnaire had not more than 20 years of teaching experience. This implies that they started teaching after 1994. Another 60% of the teachers had experience of ten years or less.

4.2.1.4 IK training

Teachers were also asked to indicate if the incorporation of IK was part of their pre-service or in-service training. They had to indicate the type/nature of training they received and the results were recorded below:

Table 3: Teacher Training:

Training	Number of teachers
Part of my university training	4
Short course/In-service training	4
School based training	2

The picture painted by the data is encouraging. All the respondents received some kind of training in how to incorporate IK. 40% of the teachers indicated that incorporating IK was part of their university studies, while the other 60% indicated that they had received some in-service training on how to incorporate IK in Science teaching. However, what is of concern is that 50% of those who received pre-service training rated their training as inadequate. One respondent wrote that, "*IK was just mentioned in passing"*. The teacher went on to recommend that teachers should be properly trained on how to incorporate IK to assist them to incorporate IK.

The teachers said they received district-based training by Subject Advisors. However, only 20% of the respondents received school-based training. All of the teachers who received school-based training had also received in-service training. What is worrying is the fact that 30% percent of the teachers commented that their training did not equip them with enough skills to enable them to incorporate IK into meaningful teaching and learning as can be seen from the comment from one of the teachers who wrote: "*Yes, IK was incorporated but the lecturers only paid lip-service to IK. No detail was given. We were just told to incorporate IK in our teaching".*

On the question of how often they incorporate IK in their teaching, it is encouraging to note that all the teachers indicated that they incorporated IK. However, only 20% of them indicated that they always use IK, while 50% indicated that they sometimes incorporate IK in their teaching. Only 10% said they rarely incorporate it.

4.2.3 Teachers' attitudes, perceptions and experiences on incorporating IK

On the question of exploring teachers' attitudes, perceptions and opinions about IK, the data obtained shows that the teachers were positive about the incorporation of IK. All of them commended the idea of incorporating IK. Their views are summarised as followings:

- It creates more clarity and understanding of Science as a subject and enables learners to quickly grasp concepts;
- It makes Science teaching and learning more interesting;

- It helps learners to link their studies with everyday life;
- It helps to make Science relevant to learners' lives;
- It encourages learners to know and preserve indigenous knowledge;
- Learners can know that the knowledge from the past is useful and can be used to solve problems we face at school and in society in general;
- To teach learners to be responsible citizens who respect their cultural heritage;
- To enable learners to make use of knowledge within our culture to solve problems such as climate change and loss of biodiversity or environmental damage due to pollution; and
- To let learners realize that science is not new, it has always been part of people's lives.

However, when the teachers were asked if they found it easy to incorporate IK in their teaching, most of them said that they do not always find it easy to incorporate IK. They cited the following as the challenges they face in their efforts to incorporate IK:

- Linking IK to science;
- Lack of cultural knowledge by both the teachers and learners;
- Cultural differences between them and their learners and among learners;
- Lack of training;
- Not all topics link with IK; and
- No time to incorporate IK as they try to race through the syllabus to keep pace with the CAPS curriculum requirements.

Some of the teachers argued that they find it difficult to translate ideas expressed in vernacular languages (*isiXhosa*, *isiZulu* or *seSotho*) to English. For instance, one teacher wrote *"IK is in vernacular so translating it is not easy" [see Appendix I]*. She argued that not all concepts or ideas expressed in *isiXhosa* or *isiZulu* can be easily translated into English.

Of the teachers who indicated that they rarely incorporate IK, 40% said that they are not always confident in incorporating IK because both their training and upbringing did not give them enough knowledge to enable them to do so. One teacher wrote: "*I do not have enough knowledge of IK or enough knowledge of Xhosa traditions because I grew up in town and I am from a Christian background*". This teacher's response may be an indication of the cultural dilemma found in some multicultural classrooms. One respondent from Nigeria admitted that she lacked knowledge of Xhosa culture because she was a foreigner. She said that she often found it difficult to link her IK to learners' knowledge.

4.2.4 Link between science and IK

The teachers were asked to indicate the extent to which they agree with the statement that there is a link between IK and Western science. Their responses were recorded and plotted on the pie graph below.

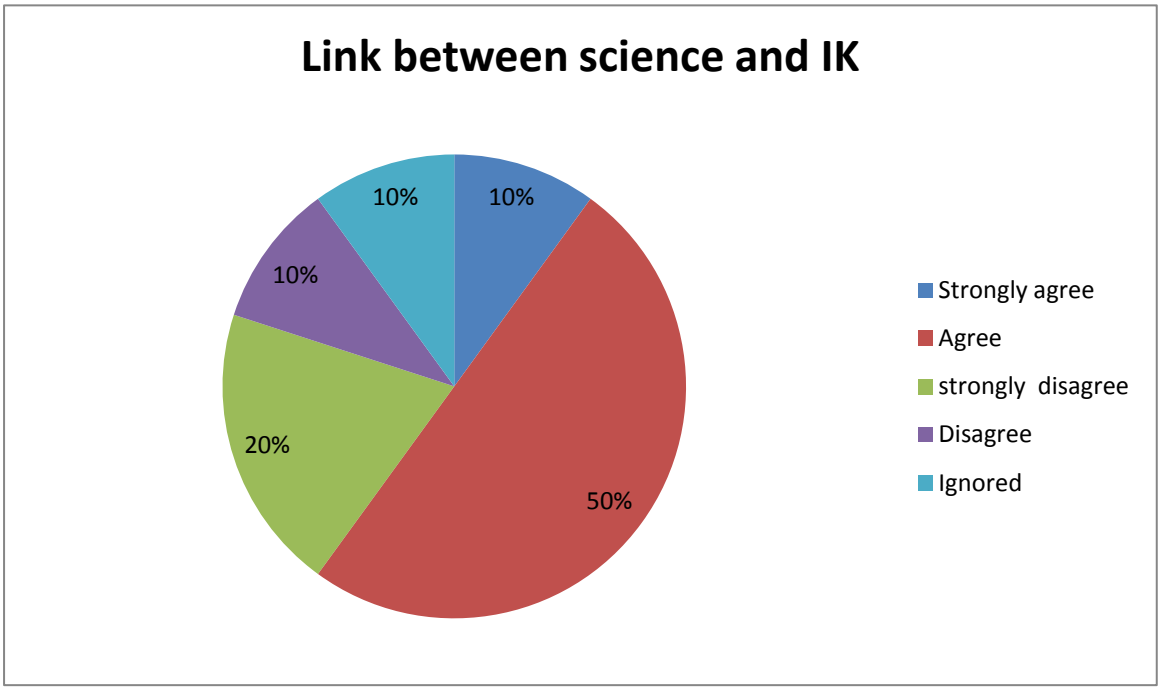


Figure 1: Link between Science and IK

The pie graph shows that 60% of the respondents felt that there was a link between IK and Science while 40% felt that there is no link between IK and Science. Of these, 10% strongly agreed that there is a link between IK and Science while the remaining 50% simply agreed that there is a link between IK and Science. Another 10% did not respond to the question and left it blank. On the other hand 20% strongly disagreed that there is a link between IK and Science while 10% simply disagreed. This makes a total of 30% of the entire population of respondents who disagreed with the view that there is a link between IK and Science.

4.3 Phase two

In phase two, I present the data obtained from document analysis, lesson observations, stimulated recall interviews (with the teachers) and the focus group interviews.

4.3.1 Document analysis: Lesson plans

Prior to the lesson observations, I asked the two teachers to prepare lesson plans in which they would incorporate IK. They then used these lesson plans to teach. Each lesson was a double lesson lasting for an hour. To understand what happened during the lessons observed, I had to analyse the lessons in conjunction with the lesson plans that informed them. The

following is a content analysis, scrutinizing the lessons plans used by Teachers A and B respectively. The lesson plans were analysed in terms of their objectives, lesson activities, and assessment techniques.

The following table presents a comparative analysis of the lesson plans given in Appendices E and F.

Table 4: Comparison between Teacher A and Teacher B's Lesson plans

Lesson plan aspect	Teacher A	Teacher B
Objectives	Objectives clearly stated	Not very clear
Teacher activities	Precise action to be taken by the teacher stated	Teacher to explain all concepts
Learner activities	Learner activities focussed on *umqombothi* Clearly learner centred	Learner activities focused on getting to understand concepts from the book. Focus is on understanding the content.
Assessment strategy	Written activity	Written work
Lesson evaluation	Teacher evaluated the lesson as very exciting	Teacher reported that he did not enjoy the lesson much but feels that he managed to make learners understand.

An analysis of the two lesson plans revealed that Teacher A had a clear plan of how he was going to use IK. He had objectives and activities stating what he wanted to achieve and what he wanted done. For instance, one objective was stated as follows: *By the end of the lesson learners should be able to use their indigenous knowledge to explain the process of alcoholic fermentation.*

On the other hand, Teacher B stated that learners should be able to understand alcoholic fermentation by using IK. There is no elaboration as to how this could be achieved. In his activities he stated that he would use IK to explain the process of alcoholic fermentation. The teacher does not mention what IK would be used or how it would be used. This makes it difficult to follow exactly what he intended to do during the lesson.

What stands out from the two lesson plans is the fact that although both teachers intended to use IK in their teaching their approach to the use of IK were different. Teacher A adopted a learner-centred approach and was clear on what he wanted to do and how he intended to use IK. Teacher B tended to use IK only as a point of reference from which learners could draw

examples that would enable them to understand the process of alcoholic fermentation. His plan did not give him much freedom to or create space for the creative use of IK.

On the contrary, Teacher A had a concise plan of what he wanted to do. He based his lesson on IK surrounding the preparation of *umqombothi.* He clearly stated how he would engage learners in using IK. The following table draws a comparison between the lesson plans presented in Appendices E and F from Teacher A and Teacher B.

Having looked at the lesson plans, it is necessary to turn to what happened during the lessons.

4.4.2 Lesson observations

This section presents the data obtained from lesson observations. The lessons were double lessons lasting for an hour each. The lessons were informed by the lesson plans discussed above.

4.4.2.1 Lesson 1: Teacher A

Teacher A started the lesson by cracking a joke about *umqombothi* before turning to facts of anaerobic respiration learnt in the previous lessons. Learners laughed and he smiled. I also could not avoid a smile. Teacher A then introduced the lesson by saying, "*Today we are going to learn about anaerobic respiration that occurs during the preparation of umqombothi. This process is called alcoholic fermentation".* A learner raised a hand and asked the question, "*Why is it called alcoholic fermentation?"*

I was fascinated by this child's question and immediately I decided to include him in my sample. I shall refer to the learner as Ln A1. The teacher asked the class to clap hands for him for asking such a brilliant question and said "*However, I am not going to tell you the answer because it is what I want you to find out in this lesson*". He went on to explain to the class that they were going to learn about alcoholic fermentation in traditional practices such as the preparation of *umqombothi*.

The learners became excited and alert. The teacher divided the class into groups of four and asked the learners to discuss how *umqombothi* is made. Each group had a scribe who recorded what the group members said. The teacher then moved around listening to the discussions taking place in individual groups. He sat among the learners and participated in the group discussions as a group member.

In this study I narrowed the focus of my observation to a focus group of six learners. For convenience purposes, I named the learners in this group as Ln A1, Ln A2, Ln A3, Ln4, Ln A5 and Ln A6.

Ln A1 explained using both *isiXhosa* and English saying: "*You take water and put it in a big pot/ container. Then you ugalele (pour) imealie meal. Then upheke isidudu (cook porridge) or something like porridge. When it is ready you take it off the fire uyipolise (cool it down)".*

Ln A2 interjected and added "*Then if the umqombothi is cooled down ufake imthombo (add sorghum)...".* I could see that Ln A2 had forgotten the word because he kept flapping his hand, eyes tilted upward and face turned sideways, trying to remember the name of the substance added and Ln A1 interjected by saying "*Are you talking of amabele". "Ewe-ee! (Yes)"* remarked Ln A2. Meanwhile the other learners just nodded their heads or smiled as they listened to the conversation. Ln A1 continued by saying "*Then you add warm water uhluze, uhluze (sieve) and let the mixture stand until it iyabila (ferments)".*

Then the teacher said "*So how do you know that umqombothi is ready?*" The teacher then gave Ln A3 a chance to speak and he explained that if *umqombothi* is ready the elders taste it and they know that it is ready for drinking, to which everybody in the group laughed. The teacher then shared his own experience of preparing *umqombothi* by explaining that his grandmother used to put a burning match above a container of the *umqombothi.* "*Ewe sir!"* interjected Ln A4. He then explained that the same process is also done in their home and that sometimes they cover the container with a blanket to keep it warm or place it on cow dung to keep it warm. All the learners laughed except Ln A6 who just smiled.

The teacher asked them to think of possible reasons why the *umqombothi* should be kept warm. The learners discussed, debated, laughed and challenged each other's views as they tried to work out the possible reasons why a match stick is used to test if *umqombothi* is ready, the essence of putting the container on top of dry cow dung or covering it with a blanket and many other traditional practices. The learners tried to work out the answers by brain storming. They debated, laughed and referred to their textbooks to find out more about fermentation. The teacher then reminded them of the conditions that are favourable to the thriving of fungi by referring them to what they had learnt about bread mould. He then explained that *"yeast is fungus that also requires dark, warm and moist conditions to thrive*".

A child in another group raised her hand and that said they were failing to find a scientific explanation as to why a burning matches is used to test if *umqombothi* is ready. The teacher nodded his head and redirected the question to the class. He asked the members of the focus group to give others a chance to work out a possible explanation. This was followed by silence as learners tried to work out possible reasons. I observed with keen interest how some learners squinted their faces as they entered into deep thinking. Finally, one learner said *"I think Sir, the fire iyacinywa [Translated:* ***is extinguished****] by the smell or the bubbles of the beer"* and everybody laughed. I also could not avoid a smile. After many attempts to answer this question, the teacher asked the members of the focus group to give details to the class. Ln A1 explained by reminding the other learners that one of the products of respiration is carbon dioxide which does not support combustion. The class clapped hands.

Another learner then asked "*Does it then mean that the beer produces carbon dioxide just like we breathe out carbon dioxide*?" The teacher responded by redirecting the question to the class. Ln A3 answered the question by referring to the answer given by Ln A1 above. These

and many other questions kept on arising. Some of the questions asked to various groups during the course of the observation are tabulated below.

Table 5: Questions and answers used during Teacher A's lesson

Question	**Answer by learners**	**Explanation by the teacher**
What substances do we mix and why?	Mealie meal, *amanzi*, [*amabele*, *imithombo*]	Teacher refers them to the equation $C_6H_{12}O_6 \rightarrow 2C_2H_5OH+2CO_2$ on the chalkboard and asked them to analyse the requirements for anaerobic. The cereal grains (mealie meal, amabele) or any other cereal grains used in making *umqombothi* are rich in glucose which is broken down during anaerobic fermentation.
Why is the porridge cooled down before adding malt/yeast?	Because yeast is a living organism which would die because of the heat.	Agrees with learners and reminds them of their prior knowledge on microorganisms [fungi].
What will happen if the yeast is added while the porridge is still hot? Why?	*Umqombothi auzikubila* [*umqombothi* will not ferment] because heat kills the yeast.	Yeast like any other organism cannot withstand extremely high temperature. He also reminds learners that enzymes denature under extreme temperature.
Why do we cover the container with a blanket?	To keep it warm. Learners listened attentively.	He also explained that anaerobic respiration takes place in the absence of oxygen because the yeast that causes fermentation respires anaerobically.
What type of containers do we use and why?	We use *umpande* made of plastic to make umqombothi not to lose its taste.	Umqombothi is acidic because of the presence of carbonic acid created by the reaction of CO_2 and water. Acids cause metals to corrode. That is why *umqombothi* loses its taste. In the olden days they would use clay pots. Clay has no metal and is a poor conductor of heat. This keeps the temperature of *umqombothi* within a range that is favourable to fermentation.

The table above clearly illustrates how the teacher used the technique of scaffolding to help learners understand. What I also found very interesting in this lesson is the fact that although the general rule at this school emphasises the use of English in all subjects except *IsiXhosa*, both the learners and the teacher were code switching. Group members discussed and argued in their own language and one learner would help the scribe to translate their answers into English. They asked each other questions in their own language and challenged one another

to clarify or explain concepts. Learners became fully engaged in discussions, expressing what they knew about the process of making *umqombothi*. This underlines the role of using one's mother tongue and code switching in Science education. I also observed with interest that learners were excited as they used gestures, traditional artefacts such as the calabash, and indigenous knowledge to explain the scientific concepts.

4.4.2.2 Lesson 2: Teacher B

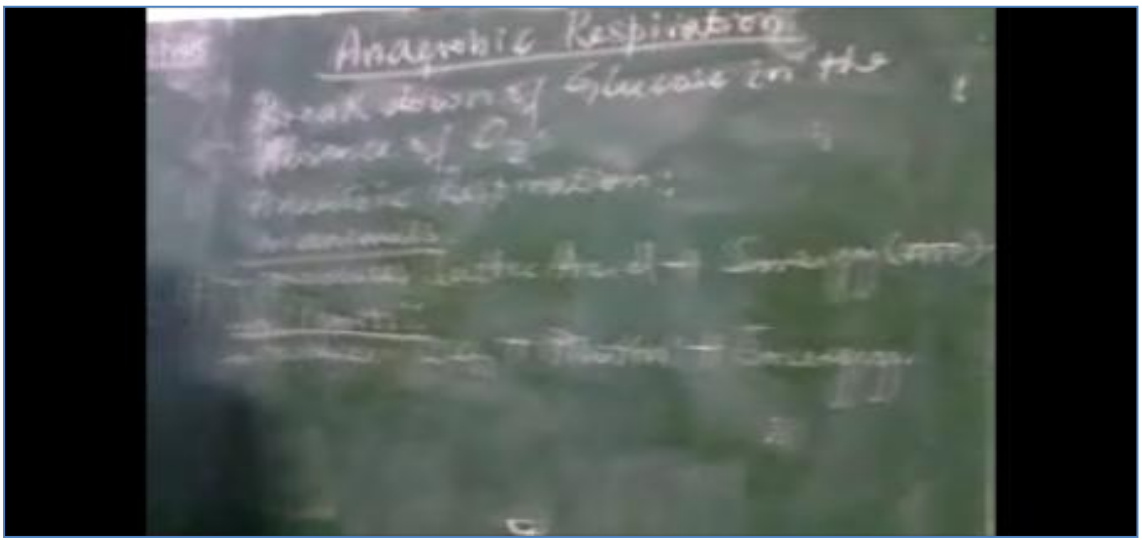
This teacher started the lesson by writing the topic anaerobic respiration on the chalkboard. He then went on to say "*Today we are going to learn about anaerobic respiration*". Thereafter, he defined anaerobic respiration as the chemical breakdown of the glucose molecule which happens in plants and animal cells so as to provide them with energy.

Learners were asked to read from their books the process of anaerobic respiration. Using a PowerPoint presentation the teacher explained the main concepts involved in learning about alcoholic fermentation. He then went on to say "*I am sure most of you have some idea on how to make umqombothi"*.

Teacher B then asked a learner to stand up and explain to the class how *umqombothi* is made. By that time I could see a lot of uneasy fidgeting among learners. A learner raised her hand to explain the process and a few learners interjected by shouting chorus answers and words like *umbona* [maize] to fill in words as she explained. The teacher silenced the class and emphasised that one speaker should speak at a time while others listen.

He then instructed the learners to discuss other ways that they use the process of fermentation at home. Because the learners were not grouped they broke into uncontrolled talking. The teacher ignored the chaotic situation for some time before saying "*Alright! Alright! I can see that some of you are taking this as playing time. Let me explain to you the use of fermentation in our everyday lives"*. He then used the illustration on his PowerPoint presentation to explain how beer is made. "*Fermentation is the scientific process used to make cheese and bake bread"* explained the teacher.

A learner asked the question *"Why don't we get drunk after eating bread, since you said that alcohol is produced?"* The class laughed and the teacher was not happy with the noise made. He looked uneasy. He then explained by saying, "*During baking, the yeast is killed by the*



heat and the little alcohol produced evaporates due to the heat in the oven". He reminded learners that ethanol which is the chemical substance in beer evaporates quickly because it has a low boiling point. The teacher went on to explain using the PowerPoint presentation how alcohol is produced in industry use. He summarised his presentation on the chalkboard as shown in Fig 2 below:

Figure 2: Chalkboard Summary

Teacher B explained using the following words:

"*In the final application which is the production of beer and wine, air must be excluded. During fermentation the breaking down of the glucose molecule in plants produces carbon dioxide and ethanol in plants. Remember that in animal cells it produces carbon dioxide and lactic acid which accumulates in our muscles*". Learners were then asked to answer questions in groups using the information presented during the lesson and what is in their book.

4.4.3 Analysis of the lessons one and two

To clearly understand how the incorporation of IK enabled or constrained the teaching and learning of alcoholic fermentation it was necessary to systematically analyse the two lessons. The following table was drawn up to analyse aspects of the two lessons observed that would enable me to judge whether the incorporation of IK positively or negatively impacted on the process of mediated learning.

Table 6: Instructional strategies and behaviours observed in Teacher A and B's lessons

Teaching technique	**Observation in teacher A's lesson**	**Observation in teacher B's lesson**
Introduction of IK	Starts by arousing learners' interest by pointing out that they are going to learning about *umqombothi.*	Concept focussed (teacher starts by defining anaerobic respiration and fermentation
Presentation of information	IK precedes scientific facts.	Facts presented before IK is introduced.
Concept-building techniques	Concepts built through discussions, debates, probing, and critical analysis of traditional practices.	Teacher explains concepts.
Teacher talk	Dominated by questioning. Explanations are brief and aimed at scaffolding.	Explanation dominated.
Student engagement	Participation encouraged. Thought provoking questions asked. Arguing, discussion, debating and explaining to one another. Evidence of critical thinking.	Little room for participation. Only one learner explained the process of making *umqombothi* while the others listened. They shouted answers. I could see signs of frustration.
Teacher-learner interaction	Teacher was a listener, co-learner, participant and knowledgeable other. There is a sense of collegiality among learners and teacher.	Teacher dominated. Long explanations. Teacher constantly asked learners to be quiet. Teacher seemed nervous and frustrated or embarrassed by learners' behaviour.
Learner-learner interaction	Collaborative learning with: debates, arguments, discussions, laughter. Learning atmosphere was relaxed.	Little effort made to allow teacher - pupil interaction. Learners shouted chorus answers.
Motivation and sustenance of learners interest	Clapping hands, encouraging comments.	No comments made after learner contributions.
Communication and classroom control	Warmth. No need for reprimands. Everyone seemed to be enjoying him/herself.	Reprimanded learners who were making noise.

This table shows that the two teachers approached the incorporation of IK differently. Teacher A took a child-centred approach to the incorporation of IK and all his teaching revolved around IK. In a Vygotskian socio-cultural style, he engaged his learners in group discussions on how to prepare *umqombothi*. From the discussions arose debates, more

discussions, arguments and clarification as learners tried to explain how *umqombothi* is made. Learners automatically switched from English to *isiXhosa* as they tried to engage deeply in discussions.

It was clear that some learners were not familiar with the process of making *umqombothi*. The teacher allowed those that were familiar with the making of *umqombothi* to explain to the others. His lesson presentation always moved from an exploratory stage where learners engaged in free discussions, debates and arguments to a presentational or expository stage where the teacher helped learners to understand the science behind the phenomenon. The learners were excited by this experience. They became enthusiastic to learn and started asking interesting questions. The teacher-learner relationship was characterised by warmth. There was no need to reprimand the learners as they were meaningfully engaged in their learning.

On the contrary, Teacher B used a teacher-centred approach in which his use of IK was teacher initiated. His lesson was content-based and the teacher only used IK as a point of reference as he explained concepts. There was little room for learners to explore their own IK. Instead, that teacher made reference to IK as he tried to clarify the concepts in his explanations. When one learner was given an opportunity to explain how *umqombothi* was made, the other learners interjected and shouted out chorus answers to fill in words as she explained. This irritated the teacher.

4.4.3.1 Findings

A comparison of the two lessons gives the impression that, when properly used incorporating IK improves the quality of classroom interaction that takes place between the teacher and the learners and among learners themselves. Flowing from the above observations and narratives, it is clear that although the two teachers used IK differently, the incorporation of IK increased learner participation. Learners from both classes were excited with the incorporation of IK in their learning. Although Teacher B did not create much room for learner participation, his learners were enthusiastic to share their IK and they turned to shouting chorus answers.

The learner-centred approach where the teacher elicited learners' IK was more effective in arousing the learners' interest, enabling them to understand the concepts taught. It created a relaxed learning atmosphere conducive to learning, in which both the teacher and the learners engaged in collaborative learning.

The benefits of IK from Table 5 can be summarised as follows:

- It enables the teacher to use a learner-centred approach to teaching;
- It made learners to participate;
- It improved teacher-pupil rapport;
- It deepened learners understanding

- It roused learner interest, curiosity and enthusiasm to know more about their IK and science;
- It improved learner engagements with content and with one another; and
- It enabled the teacher to scaffold learners from the known to the unknown.

These findings are discussed in detail in the discussion of findings in Chapter Five. Having said this, I now turn to the interviews.

4.5 Interviews

This section presents the data from the interviews starting with the stimulated recall interviews. Much of the data is presented in a summary form as it is not easy to present everything verbatim.

4.5.1 Stimulated recall interviews

In this study, stimulated recall interviews were conducted with Teacher A and B [after each lesson observation] so as to understand their interpretation of the experience of incorporating IK into mediated learning of alcoholic fermentation. It was necessary to find out the teachers' interpretation of the lessons as this would enable me to make a comparison between what the teachers said and what I observed. Cohen et al. (2011) postulate that people do not usually do what they say, thus human behaviour is best understood by synchronising what we observe with the participant's interpretation of his/her actions. Stimulated recall interviews with the teachers gave me an opportunity to listen to the teachers' interpretation of the experience of incorporating IK and compare it with what I observed within the lesson.

I was not able to interview the teachers immediately after observing their lessons because of our busy work schedule. The stimulated recall interview was chosen so as to remind both the interviewer and interviewee of what happened during the lessons.

4.5.1.1 Teacher A

The first stimulated recall interview was done with Teacher A, two days after the lesson observation. The purpose of this interview was to see the lesson through the eyes of the teacher so as to understand the meanings he attached to the experience of incorporating IK as he interpreted the lesson. It sought to understand the teacher's evaluation of the lesson. Therefore, the questions asked sought to find out what the teacher interpreted as the benefits and disadvantages of incorporating IK in this lesson.

I would have wanted to conduct the interview soon after the lesson but I could not find an appropriate time to do so due to our busy work schedule. The stimulated recall interview helped us to re-live the observed lesson and saved us the pain of having to recall everything that occurred during the lesson. Because there was so much to observe, I had to restrict the

focus of my stimulated recall interviews to the themes that would enable me to answer the main question. The data obtained is presented in the table below.

Table 7: Questions, responses that arose from the stimulated recall interviews with Teacher A

Question	Response	Codes	Theme
Now that we have watched the video together what would you say were the benefits of incorporating IK in your teaching? [***I had to probe him to elaborate***] What else? [***I kept nodding my head to encourage him to elaborate***] You were moving around participating in group discussions. May you explain why? How?	*As far as I am concerned the incorporating of IK helped me a lot. In the first place learners were very excited. You see, these learners enjoy talking a lot, so when I grouped them and asked them to discuss they were happy. You see, even some learners who do not usually talk in my lessons were active today.* *In addition learners were asking relevant and exciting questions, like the one asked about 'Why we call the process alcoholic fermentation?' In trying to answer that question I wanted everyone to be part of the lesson, so I* ***redirected*** *it to the class, so that they can think.* *I was helping learners to understand what they did not understand.* *I listened to what learners said, asked questions that helped them to realise what they left out in their explanations.*	Learner motivation Instructional congruency [Child-centred approach, DBE, 2011] Increase in learner participation Increase in curiosity to know more about the Science behind the making of ***umqombothi*** Mediated learning through the use of the knowledgeable others Scaffolding through the ZPD Promoting critical thinking Interrogating IK	**How IK enables mediated learning**

Why did you choose to teach about *umqombothi*?	*Initially I wanted to use many examples of alcoholic fermentation but I realised that many concepts can be taught through umqombothi.*		Link between IK and Science
What would you say worked in this lesson? Why? What would you say didn't work for you? So would you say everything went on perfectly well? What else?	*I think the lesson was successful.* *Learners participated. They were asking relevant questions and discussing and not making a noise like they usually do.* *For me? Nothing? Well, to some extent. In fact what was not right was that some learners got excited and ended up discussing some things outside Science.* *Some things in isiXhosa were not easy to translate or explain in Science/ English.* *Like ukubila which means boiling but in this case was referring to fermenting.*	Teacher attitude	Learner engagement
Your learners were code switching, why?	*They were discussing a tradition - the making of **umqombothi** which is a cultural practice. I think it would be unfair to ask them to discuss it in English because they would not be able to express themselves.*		Language use
Why did you put learners in groups?	*I wanted every learner to have an opportunity to talk.*		Participation
In what way was the use of IK helpful to you as a teacher in this lesson	*It helped me in many ways. For instance I was able to cover a lot of stuff which I would not be able to cover in a normal lesson. Using examples from IK helped me to identify the mistakes in the way learners understand Science. Learners were enjoying what they were doing. It was easy to link what they were learning to what they were doing.*	Content coverage and learner motivation IK as a source of misconception	

What would you have done differently? And how did you deal with that? [**Follow up question**]	*Maybe I would need to ask learners to research IK prior to the lesson so that every learner comes with the same knowledge. As it is, some learners had more knowledge than others.* *I asked the learners who knew what they were doing to explain to others so that the other learners could also know how umqombothi is made.*	Lack of time	
Not all your learners come from the same cultural background. How did you deal with cultural diversity?	*No these one are all Xhosa Sir. These children know the Xhosa culture.*	Lack of cultural diversity	
Was IK part of your studies during your teachers' training?	*When I did my Degree there was not much emphasis on IK. I mean, it was not like it is nowadays. With me, I attended many workshops and with experience you come to realise that what is taught in colleges is only a small fraction of what one needs to know in teaching.*	Lack of training Experience is the best teacher	

4.5.1.2 Teacher B

The stimulated recall interview with Teacher B occurred a day after the lesson. I watched the video of the observed lesson with the teacher and interviewed him. During the interview I would pause the video or replay it so as to focus on a particular incident or event.

The data obtained from the stimulated recall interview was reduced, grouped according to themes that emerged from the data and presented in the table below.

Table 8: Questions, responses, codes and themes from the stimulated recall interview with Teacher B

Question	Response	Codes	Theme
Was PCK part of your training? [What do you mean?]	*Yes it was. But they just mentioned it in passing.* *I mean that they do not teach us in detail. They just mention that we should incorporate IK but no detail is given.*	Lack of training	How PCK constrains teaching
Now that we have watched the video together what would you say were the benefits of incorporating IK? Did you find it easy to incorporate IK? How did you cater for cultural diversity for the learners from different cultural backgrounds? For instance I noticed that there was a Coloured girl and the boy from Lesotho whom I assume come from different cultural backgrounds from Xhosa.	*Well I used it as an example of alcoholic fermentation.* *It was not easy to think of a way to incorporate IK because the text book is not clear on how to use IK, what to do or what to leave out.* *I just assumed that they are staying here among the Xhosa people so they must know how the Xhosa do it.*	Lack of PCK Lack of written material Lack of awareness of cultural diversity	
Did you enjoy the lesson? So would you say everything went on perfectly well? Do you think it was a good idea to incorporate IK?	*Not much. Because the learners were making a noise.* *The problem is, when you ask them to discuss about something that happens in their homes they start discussing something else outside learning.* *Well, maybe in another lesson it would have worked better. In this lesson, I don't think it benefited learners much.* *There was not much to say*	Negative teacher attitudes, opinions and perception of IK Lack of IK content knowledge Lack of written IK content Translation from IK to Western	

Why? [**I kept nodding my head to encourage him to explain further**]	*because IK is not written in books or anywhere. I think it was confusing, because one learner was asking why we don't get drunk after eating bread. You see, it's just to embarrass you or to make others laugh.* *Like ukubila which means boiling but in this case was referring to fermenting.*	Science	
You asked a learner to explain to the class how *umqombothi* is prepared. Why?	*I wanted the learner to explain to the rest of the class so that in the end everyone knows how the beer is made.*	Instructional congruency	
Were you familiar with the process yourself?	*Yes but at home we do not prepare umqombothi because we are Christians.*	Cultural diversity between teacher and learner PCK	
In what way was the use of IK helpful to you as a teacher in this lesson	*Some learners were able to ask and answer questions.*	Participation enhanced learner engagement	How IK enables teaching
What would you have done differently?	*I think I should have asked someone who is more familiar with IK to teach this lesson for me.*	Use of resource person	

4.5.1.3 Findings

The stimulated-recall interviews revealed that both teachers held positive attitudes towards the incorporation of IK. They both argued that IK makes Science teaching and learning easier. However, Teacher B confessed that incorporating IK made him feel uneasy. He pointed out that some of the learners merely wanted to embarrass him by asking silly questions. To him, being asked questions like: *"Why don't we get drunk after eating isonka **[bread]**?"* was silly. It made him feel uncomfortable and he saw it as an attempt to embarrass him. This may suggest that Teacher B lacks the PCK to effectively incorporate IK. In my observation I noted that learners got frustrated by this attitude and this made them noisy. The teacher missed the golden opportunity to help learners discover that although alcohol is also produced during the baking process, it quickly evaporates because of heat.

4.5.2 Focus group interviews

To find out how learners interpreted the experience of incorporating IK, two focus group interviews were conducted separately. Each group consisted of six learners selected from

each of the two classes. I called these interviews focus group interview A and focus group interview B, in which case A and B refer to the classes taught by Teacher A and Teacher B respectively [see Section 4].

As already pointed out in Section 3.3.1, the focus group interviews answered the sub-questions three and four, which read as follows:

3. How does the incorporation of IK enable or constrain learners' understanding of alcoholic fermentation?

4. What are learners' attitudes, opinions and experience towards the incorporation of IK in learning Life Sciences?

To address these sub-questions the following interview questions were drawn up:

- Your teacher used your indigenous knowledge of making *umqombothi* to teach you about IK. Can you describe your feelings during this lesson?
- How did the incorporation of IK help you understand the concept of alcoholic fermentation?
- What challenges did you face?
- What do you think about the incorporation of IK?
- What do you recommend?

4.5.2.1 Focus group interview A

I started the interview by asking the question: "We have attended Teacher A's lesson. How did the incorporation of IK on *umqombothi* make you feel?"

Ln A2 was the first to raise her hand and her response was**:** "*Sir, to me the lesson was very exciting".* Ln A1 said "*I enjoyed the lesson, because it made it easy for me to understand. I think Teacher A should always incorporate IK as it makes it more interesting to learn Science than reading from books".* The other learners were nodding approvingly. Ln A3 just smiled and interjected saying: "*Ewe Sir" [*literally translated to*; Yes Sir]*.

From Ln A1's response I could already pick up that the incorporation of IK made it easier for him to understand the lesson. He felt excited and was highly motivated. This may explain why he was the most talkative learner during the lesson. In his response, he also recommended that Teacher A should always use IK in teaching them Science.

I wanted to hear the opinions of others who had not talked, so I gave a chance to Ln A4. Her response was; "*For me Sir, IK was good. I feel more good. It helps me understand more".* The other learners laughed at her English and she also laughed and I also smiled to create a relaxed atmosphere.

I then asked her what she thought were the benefits of incorporating IK. Her response was: *"I think, Sir, the teacher was using useful examples from home".* The other learners also wanted to express themselves in response to this question, so I allowed them to express themselves in a brief discussion that ensued. Below is a summary of some of the statements said by the learners:

- *It made me happy and wanted to know more.*
- *At least the teacher allowed us to express ourselves in our home language which made it easier for to say what we wanted.*

Ln 5 had this to say: *"IK makes it easy for us to remember what has been taught. In exams you can use your own examples if you have forgotten what is in the text book or what the teacher said".* Ln 1 also added that "*IK is less boring than reading from books. It makes me want to know more".*

I was curious to know why Ln A6 had not contributed much to the conversations that were taking place. She was coloured, shy and timid. I smiled and said to her; "My dear, I am dying to hear from you". Her response was, "*Sir, I do not have much to say because I am not a Xhosa"*. During the lesson the teacher grouped her with three other learners and they were very busy discussing the subject. I noted that most of the time she would just listen and sometimes looked lost. This made me include her in my sample. The teacher seemed unaware of her dilemma and proceeded to teach the class as if it was a culturally homogenous group. He made no reference to other cultural practices or cultural groups.

When I asked her what she felt about the incorporation of IK she said it made her want to learn more and appreciate the culture of others. I asked the other learners what they felt about learning in a multicultural classroom and interestingly they all expressed that it would be a wonderful opportunity for them to learn about other cultures.

The learners went on to recommend that:

- IK should be made part of the syllabus [of which it already is];
- Teachers should use IK more often;
- Teachers should inform them in time and give them time to go and research or ask about IK from their parents before using it in the class; and
- Teachers should not just explain concepts from text books without relating making us understand.

I concluded the focus group interview by thanking these learners. I now turn to focus group interview B.

4.5.2.2 Focus group interview B

As already mentioned, focus group interview B was conducted with learners from Teacher B's class. It is necessary to briefly review what happened during the lesson. In his lesson, Teacher B only made reference to IK. He mentioned that alcoholic fermentation is used in the making of bread, *marhewu* and *umqombothi.* His lesson was done through a power point presentation. Much of it was dominated by teacher talk, even though the teacher made reference to IK. He asked learners in passing to explain what they know about baking, making *marhewu* and making *amasi*. Only one learner was asked to explain the process of making *umqombothi,* while the others listened.

During the focus group, I asked the same questions as in focus group interview A, even though in some cases, I had to slightly rephrase the questions to suit the context. I started the interview by cracking a joke so as to create a relaxed atmosphere. I also assured the learners that the interview would not take long because I could see that they were uneasy and pensive.

On the question of interest, attitudes and opinions, learners expressed a wide range of opinions. Their views were more diverse than those expressed by learners in focus group interview A. They agreed that IK is useful in their learning and expressed almost the same sentiments with the first focus group. However, unlike in focus group A, some learners in focus group B felt that it was not always helpful. For instance Ln B1 said, "*I found it confusing because you find that even the teacher is not sure of IK".*

Ln B1 [the learner who explained how *umqombothi* is made] said, "*The lesson would have been more exciting if the teacher had asked us to go and research first, because not all of us come from rural backgrounds where umqombothi is made*". Although her sentiments largely referred to *umqombothi,* she has a very valid suggestion with regards to how IK can be incorporated into Science education.

These learners' sentiments should be understood in light of what happened during the lesson observed. Not surprisingly, some of them were negative about the role of IK in their learning because the teacher did not create enough space for them to participate.

4.5.2.3 Findings

The narratives from the focus group interviews clearly showed that the incorporation of IK benefitted learners. Incorporating IK made the lesson more enjoyable and easier to understand and remember what was taught. Learners also found it less boring and more relevant than reading books. However some learners found very little value in incorporating IK because Teacher A was not sensitive to cultural diversity while Teacher B did not allow much participation for the learners.

4.6 Concluding remarks

In this chapter I presented and analysed the data obtained from document analysis, the questionnaires, lesson observations, stimulated recall interviews and the focus group interviews. The findings from the above data gathering techniques are interpreted and discussed in detail in the next chapter.

CHAPTER FIVE

DATA INTERPRETATION AND DISCUSSION

5.1 Introduction

In this chapter I interpret and discuss the data gathered in this research. These data were gathered using a questionnaire, document analysis, lesson observations, stimulated recall interviews and focus group interviews as proposed in Chapter Three. To have a full picture of how the incorporation of IK enables or constrains the teaching and learning of alcoholic fermentation, I narrowed the data presented in Chapter Four to four analytical statements in relation to the research questions [see Section 3.3.1]. The analytical statements are:

1. Teachers' attitudes, perceptions and experiences of incorporating IK;
2. Enablements/constraints of incorporating IK in the mediated learning of alcoholic fermentation;
3. Enablements/constraints of IK on learning of alcoholic fermentation; and
4. Learners' perceptions of IK.

Each one of these statements is discussed in detail in the sections below.

Table 9: Themes and analytical statements addressed

Data source	**Themes**	**Analytical statement**	**Research question addressed**
Questionnaire and stimulated recall interviews		Teachers' perceptions of IK	1
Lesson observations	Benefits • Learner-centeredness • Collaborative approach • Teacher-learner relationships • Instructional congruency • Learner directed instruction • Language use • Content coverage • Classroom management	Enablement of IK in mediated learning	2

	• Motivation Constraints • Lack of IK • Lack PCK • IK not documented		
Lesson observations	Enhanced learner engagement • Increased participation • Critical thinking • Interrogating IK to establish the link with Science	Enablement of IK on learning alcoholic fermentation.	3
	Learner motivation • Aroused curiosity, excitement • Interest in Science Curriculum relevance		3
Focus group interviews	Attitudes, opinions and experiences	Learners' perceptions of IK	4

5.2 Analytical statement number 1: Teacher's perceptions, attitudes and experiences

At this point it is important to keep in mind that analytical statement number 1 was derived from the data obtained from the questionnaire given to the ten teachers, from lesson observations and the stimulated recall interviews. My intention was to understand teachers' attitudes, perceptions and experiences with regards to the incorporation of IK. Each one of these aspects is discussed in detail in the following sections. This analytical statement provides answers to sub-question one:

- **What are teachers' perceptions, attitudes and experiences towards the incorporation of IK?**

What emerged from these data were that the teachers who participated in this study perceived the incorporation of IK as beneficial to the teaching and learning of Science. Interestingly, their positive attitudes towards IK tend to contradict the picture painted in literature (Shizha, 2007; Mothwa, 2012; Dziva et al., 2012). These studies claim that teachers hold a negative attitude towards IK. In his study conducted in Zimbabwe for instance, Shizha (2007) found

out that teachers had negative attitudes towards the incorporation of IK in Science education. Instead of assuming the role of 'cultural brokers' as propounded by Ogunniyi (2007), the teachers in Shizha's (2007) and Dziva et al.'s (2012) studies acted as gatekeepers whose role was to protect Western civilisation from contamination from non-scientific IK. Mothwa (2012) also reached a similar conclusion after finding out that most of the teachers in her study conducted in South Africa had a negative attitude towards IK. She attributed the negative attitude towards IK to teachers' limited PCK due to their colonial educational backgrounds. She argued that some teachers who were trained prior to independence seemed to be ill-equipped to implement an IK based curriculum because their education prepared them for Bantu Education which despised IK.

Surprisingly, the teachers in this study commended the incorporation of IK. They argued that incorporating IK benefits both the teacher and the learners. It enables learners to understand Science and develop interest in the subject while it assists teachers in identifying the misconceptions that learners bring from home so that they are able to deal with them. These views resonate with the observations made by Aikenhead (1996) and Le Grange (2007) that incorporating IK enables learners to establish the link between school Science and their everyday life experiences.

The teachers in this study join the vanguard of educators and scholars who argue that IK should be incorporated in science education to increase access to education for learners from diverse socio-cultural and economic backgrounds (Kasanda et al., 2005; Ogunniyi, 2005; Aikenhead & Ogawa, 2007; Shava, 2013). Interestingly, the views expressed by the teachers who participated in the survey were confirmed by the two teachers whose lessons were observed. During the stimulated recall interviews both Teacher A and B appreciated the role of IK in Science education. They were of the opinion that incorporating IK facilitates learning by arousing learners' interest in Science, improving learner engagement and making it easier for learners to understand [see Section 4.5].

The views expressed by both groups of teachers concur with Aikenhead (1996) that incorporating IK enables learners to establish links between their everyday knowledge and school Science. Aikenhead and Jegede (1996) equate the experience of learning Science to border-crossing between home and school. They argue that for many non-European learners whose cultural capital is excluded from the mainstream curriculum, Science is difficult to understand because it sometimes contradicts the knowledge they bring from home.

However, it is important to note that the differences in teacher perceptions noted above may have been caused by the contextual differences between my study and Dziva et al.'s (2012), Shizha's and Mothwa's (2012) studies. For instance, although Dziva et al. and Shizha (2007) also studied teachers in rural set ups, their studies were conducted in Zimbabwe while my study was conducted in the Eastern Cape of South Africa. This means that the socio-economic and cultural contexts of the studies are different. According to Kibirige and Van

Rooyen (2006), IK is culture specific. This means that the difference in teacher perceptions may be caused by the contextual differences within the communities in which the studies were conducted. It is also important to take into consideration the fact that the studies mentioned above were done many years ago. In a world where so many things are rapidly changing, it may also mean that people's attitudes towards IK may be changing.

On the question of how the teachers used IK, the most popular response was that they used IK as a source of everyday life examples. In a similar study, Kasanda et al. (2005) found out that teachers infused IK as a remedial strategy. They fell back on IK, especially where the conventional teacher-centred approach has failed. Half of the everyday contexts used by teachers in Kasanda et al.'s study were introduced after the traditional teaching methods had failed.

During lesson observations, a similar trend was also observed in the way Teacher B [see Section 4.] incorporated IK. Unlike Teacher A, who used a learner-centred approach, Teacher B stuck to the conventional teacher-centred approach and used IK as a 'fall back strategy' to find suitable examples to help him explain concepts. Kasanda et al. (2005) argue that such an approach to the incorporation of IK fails to take into cognisance the curriculum requirements to adopt a child-centred approach in teaching science. Although Kasanda et al. (*ibid*.) were commenting on the Namibian curriculum, their observation also applies to South Africa. The NCS, Life Sciences CAPS document unequivocally stipulates that science teaching should be child-centred to increase access to education to learners from diverse socio-economic and cultural backgrounds (DBE, 2011). However, from my observation IK is not adequately assessed in examinations. This may explain why teachers sideline IK since it is not examinable.

What further emerged in this study points to the dilemma faced by teachers when it comes to curriculum interpretation and the incorporation of IK. Vhurumuku and Molekeche (2007) attribute this problem to lack of research to find out viable ways of incorporating IK into meaningful teaching and learning. From my teaching experience, I noticed that the teachers are often given short in-service training prior to the introduction of curriculum innovations such as the CAPS policy. Ogunniyi (2005) questions the effectiveness of the short courses often given to teachers when new curriculum innovations are made and argues that changing teachers' mind-sets is not an easy task. It requires the curriculum designers and educators to engage in long term skills transfer programmes in which teachers are taught how to incorporate IK.

5.3 Analytical statement number 2: Enablements/constraints of IK in mediated learning

5.3.1 Enablements of incorporating IK in mediated learning of alcoholic fermentation

As already mentioned in Section 5.2 above, analytical statement two sought to provide answers to sub-question two which is as follows:

- **How does the incorporation of IK enable or constrain the mediated learning of alcoholic fermentation?**

This question was answered using the data collected from the lesson observations and stimulated recall interviews.

The data obtained from these instruments show that incorporating IK enhanced the quality of teacher-learner engagement, learner-learner engagement as well as learner-content engagement. In other words, incorporating IK created an opportunity for the learners to engage with the teacher and among themselves at a level that is deeper than would have been possible in an ordinary lesson. According to Vygotsky's socio-cultural theory, knowledge is not transmitted; instead it is constructed through social interaction with others.

Teacher A put his learners in groups to discuss how *umqombothi* is made as explained in Section 4.4.2.1. In accomplishing the task assigned to them, the learners debated, argued, queried one another and clarified issues among themselves. Alexander (2004) views dialogue as the starting point of all learning that occurs in the classroom. Similarly, Zhang (2008) contends that debates, discussions and scaffolded dialogue have higher academic potential than expository methods of classroom talk. This implies that the incorporation of IK through the learner-centred approach used by Teacher A promoted critical thinking as the learners engaged with each other, their teacher and the content.

Incorporating IK also enabled the teacher to apply the technique that Probyn (2009) described as translanguaging where both English and *IsiXhosa* were used for the common purpose of achieving clarity.

This study also revealed that incorporating IK improved aspects of classroom dialogue such as questioning and answering techniques. For instance, Teacher A used techniques such as probing, redirecting questions to the class, and giving clues to promote deeper thinking. Teacher A asked learners questions to stimulate interest and initiate discussion [see Section 4.7]. Zhang (2008, p. 81) posits that authentic questions speed up learning by encouraging learners to deeply engage with content. Teacher A used the following questions to encourage his learners to think.

Table 10: Ranking of the questions used by Teacher A in terms of their cognitive demand

Question	Cognitive demand	Ranking
What substances do we mix? Why?	Recall Application	Simple recall High order
Why is the porridge cooled down before adding malt/yeast?	Application	High order
What will happen if the yeast is added while the porridge is still hot? Why?	Application	High order
Why do we cover the container with a blanket?	Application	High order
What type of containers do we use? Why?	Recall Application	Low order High order
How long does it take for the *umqombothi* to start fermenting?	Recall	Low order

This table clearly shows that Teacher A used high order questions to encourage critical thinking. From this observation it can be argued that the incorporation of IK enabled the teacher to ask challenging questions that helped them to build their own understanding of alcoholic fermentation. Commenting on the importance of questioning techniques, Zhang (2008) contends that cognitively demanding questions stimulate learners' mental activity and promote deep thinking. All the questions asked in the table are thought provoking questions that stimulate interest and promote thinking. In this study, Teacher A created a favourable teaching-learning environment in which he used scaffolding to help learners build their own understanding of alcoholic fermentation.

The teacher grouped learners so that they could discuss the making of *umqombothi.* When I asked him why he used group work [see Section 4] his response was: I wanted learners to share their knowledge of IK. This answer is in tandem with Vygotsky's (1978) idea of using the knowledgeable learners to scaffold the less knowledgeable others. In their study, Stears et al. (2003) found out that learners enjoy learning by interacting with their peers.

This was self-evident in Teacher B's class where learners shouted chorus answers when the teacher asked one learner to explain. I could see that the learners also wanted to actively participate. Stears et al. (2003), propose that learners' everyday knowledge can be used in many ways during the course of teaching and learning. For instance, it can be used as a starting point for learning Science or as a point of reference for thinking or as a context for applying scientific ideas and skills. In this research Teacher A applied all the three levels of using IK while Teacher B used IK at a superficial level.

The study also shows that incorporating IK creates room for the teacher to shift from the traditional role of information dispenser to a colleague, a co-learner and the knowledgeable other. Jegede and Aikenhead (1995) argue that the role of a teacher in a socio-cultural set up is that of "cultural broker" (p. 55). In other words the teacher shifts between giving information and guiding learners to discover knowledge on their own. In Jegede and Aikenhead's opinion, the teacher shifts between being a *travel agent* and a *tour guide* as they help the learners to *cross the bridge* between their home and school experiences.

Teacher A successfully helped his learners to establish links between IK and school Science by asking them probing questions. At times he simply redirected questions back to the class so as to encourage them to think critically. The teacher scaffold them by giving them clues that would enable them to arrive at the right solutions. This created a teaching and learning environment in which both the teacher and learners were freely engaged in collaborative learning. Learners were engaged in group discussions in which they discussed, debated, and argued.

Out of the discussions arose so many questions that required the application of IK to answer them. From this observation one can safely deduce that the incorporation of IK enabled Teacher A to adopt the learner-centred approach advocated by the DBE (2011). Through IK the teaching strategy became learner-directed as learners asked for clarification on the link between their IK and Western science.

5.3.2 Constraints of incorporating IK in mediated learning

Although it was not my original intention to use the two teachers who participated in this study to compare best practice and the not-so-good practice, what emerged in this data compelled me to do so.

Teacher B's use of IK clearly illustrates that if IK is not properly used it can constrain teaching and learning and can frustrate learners. As already mentioned in Section 4.4.3, Teacher B's lesson was content-based. The teacher only used IK as a point of reference to make his explanation clearer and this did not help.

Meyer (1999) as pointed out in Section 2.5.2, found out that novice teachers were unable to effectively incorporate IK in their teaching. They relied on unmodified subject matter extracted directly from the textbooks or the curriculum. Their use of IK was limited to the superficial level, directly related to simple factual knowledge.

Teacher B explained concepts directly from the text book. Even though he attempted to use IK in his explanations, he did not divert much from the documented information. Meyer (1999) concludes that this is caused by the fact that novice teachers lack the framework to understand what happens in the classroom. He argued that novice teachers have limited PCK. Their knowledge base is restricted and poorly organised. They lack the experience to organise their thinking in order to accommodate other knowledge domains outside Science. Grossman (1989) observes that these teachers struggle in applying PCK despite their vast knowledge of the subject content.

My observation of Teacher B left me with no doubt that he understood the scientific facts that he was explaining very well.

5.4 Analytical statement three: How incorporating IK enables learning of alcoholic fermentation

This analytical statement answered sub-question three which is stated as follows:

- **How does the incorporation of IK enable or constrain learners' understanding of alcoholic fermentation?**

This question was answered using the data collected from the lesson observations and the focus group interviews with the learners.

In the following sections I discuss how the incorporation of IK made it easier for learners to understand the process of alcoholic fermentation, as well as its impact on learner engagement, learner interests and motivation.

5.4.1 Making it easier to understand alcoholic fermentation

This study revealed that incorporating IK made it easier for learners to understand the concept of alcoholic fermentation.

This is well captured in Ln A1's sentiments when she said these words, "*I enjoyed the lesson, because the teacher used useful examples and it made it easy for me to understand. I think Teacher A should always incorporate IK as it makes it more interesting to learn Science than reading from books".* During the focus group interviews learners from both classes appreciated the incorporation of IK. They argued that if IK is used they can easily understand what they are taught and can even draw examples from their own experiences.

It is interesting to note that the views of these learners resonate with the assertions made by Ogunniyi (1996), Aikenhead (1996) and Le Grange (2007) that the incorporation of IK makes Science more accessible to learners. According to Ogunniyi (2007), IK is the window or lens through which learners view the world. Le Grange (2007) also refers to IK as the framework upon which learners build new knowledge. In other words, IK provides the foundation upon which new concepts are built. It enables learners to develop their own understanding of concepts as testified by Ln A1 in the excerpt above.

Table 3 above has shown how Teacher A used high order questions to help learners to build their own understanding of alcoholic fermentation. By answering the questions [see Table 3] learners developed the following scientific ideas:

- Fermentation involves the breaking down of glucose in the maize meal and other cereal grains used to prepare *umqombothi*;
- Yeast is a living organism which dies under extremely high temperature;
- Yeast produce enzymes and these enzymes denature under extremely high temperature;
- Yeast respires anaerobically that is why we cover it;
- *Umqombothi* is not put in metals because metals corrode. *Umqombothi* contains carbonic acid produced by the reaction of carbon dioxide and water;
- Enzymes are inactive under low temperatures below 35 degrees Celsius that is why *umqombothi* takes longer to be ready when the weather is cold;
- Yeast is a fungus that thrives under dark, warm and moist conditions.

These answers then made it simpler and easier for learners to understand the following symbolic representation of alcoholic fermentation:

In words: Glucose ==> Ethyl Alcohol + Carbon dioxide (gas) + Energy
In symbols: $C_6H_{12}O_6$ ==> $2(C_2H_5OH)$ + $2(CO_2)$ + ATP

The way Teacher A presented his lesson showed us that he developed concepts from the known to the unknown. By the time he introduced the symbolic equation every learner could understand what he was talking about. It became easier to explain that during alcoholic fermentation yeast converts glucose ($C_6H_{12}O_6$) to ethanol (CH_3CH_2OH) and carbon dioxide gas (CO_2), in the absence of oxygen. During this process adenosine tri-phosphate (ATP) (from glycolysis) provides energy to break down the two pyruvate molecules (formed during glycolysis) into ethanal which is later converted to ethanol (CH_3CH_2OH). Ethanol is the alcohol in traditional beverages such as *marhewu* and *umqombothi*.

Teacher B presented his lesson as explained in Section 4.4.2.1 and the learners were not happy. They later reported that they sometimes find the incorporation of IK confusing.

Jegede (1996) draws our attention to the dangers of ignoring learners' IK by pointing out that it destroys the framework through which learners understand the world.

Basu and Yang (2000) also argue that the lack of curriculum relevance is one of the major reasons why many learners find Science difficult to understand. Bouillion and Gomez (2001) support this by pointing out that if Science is taught in a de-contextualised manner, learners easily get confused, frustrated and anxious. Teacher B's class is a case in point. The learners were not happy with the way the lesson was presented. It was difficult for learners to understand the symbolic equation of alcoholic fermentation because the teacher just started by explaining the chemical equation in abstract terms.

5.4.2 Use of language

Vygotsky (1978) stipulates that language plays a crucial role in shaping the way learners think and understand concepts. Learners understand the outside world by first representing it in their minds.

This study illustrated the importance of language. Learners used their mother tongue to represent concepts. Sections 4.4.2 show that some of the words that were used in the two lessons are:

Table 11: Xhosa terms translated into English

IsiXhosa	**English/Scientific term/equivalent**
Ukubila	Ferment
Ifementesheni	Fermentation
Umlilo uyacima	the fire extinguishes
Ufake imitombo	you put in the malt
Ufake amanzi ashushu	you put in hot water

This table illustrates how the learners' mother tongue was used to lighten the burden of having to master both the English language and the scientific concepts. The teacher used the mother tongue to accommodate learners' poor proficiency in English. Learners first expressed themselves in their mother tongue and one would then translate the statement to English for the group scriber to write it down.

This finding is consistent with the findings made by Probyn (2009) in a similar research where she found out that teachers use code-switching to negotiate meaning. She noted that code-switching is a multipurpose tool that can be used for both affective reasons and for cognitive reasons. In this study code-switching was used mainly for cognitive reasons. Both teachers A and B used code-switching to enable learners to think and express themselves

freely. They would scaffold the learners or allow the other learners to provide the appropriate scientific explanations.

From this exposition it is safe to conclude that the incorporation of IK on the making of *umqombothis* created a conducive environment for learners to make a smooth transition from their IK to scientific concepts. Again, this resonates with Aikenhead's idea of border crossing between home and school science.

However it is important to note that Xhosa words like *ukubila* and *ukutshisa* and others that were used during the lesson may be a source of confusion because they are used to mean a lot of things. For instance, *ukubila* may mean *to boil* as in [***amanzi ayabila boiling water*-the water is boiling].** On the other hand the word *ukutshisa* may mean **hot or burn**.

In this study, both Teacher A and Teacher be did not make references to different meanings of such words. They may have just assumed that learners understood the contextual meaning of these words. Probyn (2009) warns us that science is a lexically dense subject which requires learners to shift from their common sense or everyday reasoning to scientific reasoning. To achieve this learners have to accurately use language and express themselves with precision. Thus, when code switching is used in a classroom situation, it is always important for the teacher to assist learners to understand the scientific meaning of the words used to avoid confusion.

In the following section I discuss how the incorporation of IK affected learner engagement.

5.4.3 Learner engagement

What emerged in this study is that incorporating IK made learners engage deeply with content and with the teacher and one another. This is well captured in Teacher A's response to the question; '*What would you say were the benefits of incorporating IK?*' Teacher A pointed out that incorporating IK made some learners ***who did not usually participate*** in his lessons to be ***active and contribute to the discussion and ask meaningful questions***.

In a similar study conducted in the Cape flats in Cape Town in South Africa, Stears et al. (2003) found out that, incorporating learners' everyday experiences increased learner engagement [see Section 2.3]. The findings of this study tend to confirm this. I noticed that incorporating IK enhanced not only the amount of learner participation but also the quality of teacher-learner engagement. Learners engaged with content at a deeper level than would have been possible in an ordinary lesson.

For instance, an analysis of the questions and the answers given during Teacher A's lesson [as shown in Table 3 above] shows that the incorporation of IK enriched the quality of teacher- learner engagement. It also improved the quality of learner-learner interactions that took place. Mothwa (2012) describes such thinking as intellectual rigour and called the interrogation of IK and the challenging of each other's ideas constructive criticism.

In this study, learners debated, argued and discussed ideas. In other words learners were actively involved in constructing their own knowledge through critical thinking as propounded by McRobbie and Tobin (1997).

What stands out from these narratives and the lesson observations in Section 4.4, is that the incorporation of IK promoted critical thinking. Learners in both lessons asked interestingly thoughtful questions. For instance, in Teacher B's lesson one learner wanted to know why we don't get drunk after eating bread since the process of baking also involves alcoholic fermentation. Similarly, learners in Teacher A's class, were also curious to know what makes *umqombothi* sour and why it looks milky white. The answers to these questions are not in science textbooks. They required the teacher and the learners to critically engage with content and work out the possible answers among many other possibilities. The teacher started by redirecting the question to the class. The learners got into deep thinking.

Through discussions the following facts were established:

- Anaerobic respiration produces CO_2 which then reacts with water to form Carbonic Acid. Acids taste sour.
- *Umqombothi* looks milky whitish because of the presence of CO_2.

These facts gradually helped learners to build an understanding the chemistry of alcoholic fermentation as explained in Section 1.9.3. I could see them nodding their heads to show understanding. The teacher also added that carbon dioxide does not support combustion that's why the matches extinguish. It is my supposition that the questions asked in this lesson would not have been asked in an ordinary teacher-centred lesson aimed at delivering content.

They asked questions that required critical thinking to respond to [see Section 4.4.2.1]. The teacher redirected the questions to the class and everyone receded into deep thinking as they tried to respond to the question. In light of these observations, one can safely argue that the incorporation of IK created an opportunity for learners to critically engage with the content of what they learnt as they tried to make meaning of alcoholic fermentation.

In this research I found out that learners were alert and actively involved in the proceedings of the lesson. The teacher used the technique of redirecting learners' questions to the class so that they could work out answers. He would then reward anyone by asking the class to clap hands for him/her who answers or attempt to answer the question and were inquisitive and curious to know more about their culture and science.

In both lessons learners asked interestingly challenging and thought- provoking questions. For instance, in Teacher B's lesson one learner asked why we do not get drunk after eating bread since there is also alcohol produced during the fermentation of flour. This question reflects critical thinking. There is deeper engagement with content as the learner integrates IK and science. Mothwa (2012) also found out that incorporating IK promotes critical thinking.

It exposes learners to reflective thinking which enables them to construct their own knowledge. Mothwa (2012) describes this as intellectual rigour that is necessary for effective learning.

The above expositions clearly show that the incorporation of IK created a platform for learners to questions that they would not have asked in an ordinary lesson

This finding also resonates with the observation made by Mothwa (2012) in her study conducted in Gauteng. She found out that incorporating IK improved the quality of teacher-learners interaction. In this study the learners engaged in group discussions discussed issues at their level of understanding. They asked each other questions, challenged opinions and attempted to apply science to explain phenomenon. Similarly, Uushona (2013) in his study conducted in Namibia also found out that incorporating learners' IK increased learner participation and engagement.

However, both teachers A and B did not cater for cultural diversity in their classes. They just assumed that all learners were *isiXhosa* and they understood the making of *umqombothi.* Interestingly, in Teacher A there was a Coloured girl sitting among other learners not participating. The child reported that she did not mind learning through IK as long as someone helps her to understand what she might have missed out. From her response one can infer that if the teacher had used the cultural diversity of learners in his class it could have been an opportunity to broaden learners' understanding of other people's cultures.

The study also showed that lack of PCK coupled with lack of CCK made it difficult for the Teacher B to incorporate IK. This constrains the teaching and learning process. Mothwa (2012) made a similar finding in her study and concluded that some teachers in South Africa lack the pedagogical skills that would enable them to implement an IK based curriculum. In this study Teacher B found it difficult to effectively incorporate IK. During the stimulated recall interview he admitted that he had limited knowledge of how *umqombothi* is made because of his urban and Christian family background.

Interestingly, neither Teacher A nor Teacher B showed awareness of the cultural diversity in their classes. Ln A5 was Coloured, but Teacher A just assumed that she would understand the Xhosa culture because she is living among the Xhosa people [see Section 4.4.1]. The CAPS curriculum unequivocally stipulates that teachers should familiarise with the culture of the area that they work in so as to be able to effectively incorporate learners' IK. What is notable in this study is that while the incorporation of IK might have helped some learners it constrained those whose culture was neglected or left out.

5.4.4 Learner interest and motivation

The data obtained from the lesson observation and focus group interviews with the learners revealed that incorporating IK aroused their interest. It made them curious to want to know

the scientific justification behind cultural practices. This is well captured in Ln A1's sentiments when he says: "*I enjoyed the lesson, because the teacher used useful examples and it made it easy for me to understand. I think Teacher A should always incorporate IK as it makes it more interesting to learn Science than reading from books".*

During Teacher A's lesson, one learner remarked: "*Uyazi ndiyathanda lento, especially xa khune hot sitting"* [*Translation: You know, I love what we are doing especially if there is a hot sitting*]. The child was referring to the experience of learning through the incorporation of IK. This learner's sentiments confirm the view held by Basu and Barton (2007) that incorporating IK increases learners' interest in Science. I noticed that learners became excited as soon as the teachers mentioned that they were going to learn about *umqombothi*. Learners were curious to know why the teachers mentioned a traditional practice in a Science lesson. They became alert and attentive. This observation applies to both Teacher A and Teacher B's lessons. Even though Teacher B's lesson was teacher dominated, his learners were curious to participate in sharing their IK. Deprived of the opportunity to actively share their experiences the learners resorted to shouting chorus answers in their desperation to participate as Ln B1 explained how *umqombothi* is made. What is interesting is that Teacher B did not realise this as a golden opportunity to broaden his learners' scope of participation. Instead he was annoyed and asked the learners not to make a noise. However, during the stimulated recall interviews, both Teacher A and B were of the view that their lessons were interesting since learners were participating.

These narratives point to the fact that incorporating IK benefits both the learners and the teacher. This assertion is confirmed by the data from the questionnaires where 80% of the respondents agreed with the assertion that incorporating IK makes learning Science interesting. These teachers' sentiments were confirmed by the learners in their responses in the focus group interviews. Invariably, learners from both classes expressed that they found the lessons interesting.

The study also revealed that IK provides the foundation upon which learners build new knowledge. Learners used IK as the springboard upon which they built new knowledge. The enthusiasm expressed by learners in both lessons bears testimony to the importance of incorporating learners' knowledge funds. According to Aikenhead (1996), IK is the framework within which learners are able to understand the world. He also describes it as the window through which learners peep into the outside world.

This study revealed that incorporating IK helped learners to make sense of the process of alcoholic fermentation. When Teacher A engaged his learners in group discussions, they became totally absorbed in the conversations as they tried to explain the process of making *umqombothi.* They asked each other very interesting, thought provoking questions.

In her study, Mothwa (2012) also found that incorporating IK increased learners' interest in Science. Uushona (2013) also found out that incorporating IK improves not only learner

engagement but also conceptual development. During lesson observations, I noticed that when the teachers asked the learners to discuss how *umqombothi* is made, the learners asked challenging questions that required both the teacher and the learners to use their IK and scientific knowledge in order to come up with appropriate answers.

Jegede (1996) argues that IK is the lens through which learners understand the world. This also finds support in Le Grange (2007), who contends that incorporating IK enables learners to link school Science with their everyday experiences.

5.5 Analytical statement number 4: Learner attitudes, opinions towards IK

This analytical statement summarises the data obtained from the focus group interviews. It provides answers to sub-question four which states as follows:

- **What are learners' attitudes, opinions towards the incorporation of IK in learning Life Sciences?**

The findings in this study revealed that learners view the incorporation of IK in Science as something that benefits them. Their views resonated with that of the teachers. Learners argue that incorporating IK made Science more enjoyable and easier to understand. For instance, one learner from Teacher A's class had this to say: "*It is less boring than reading books"[see Section 4.7]*.

Even though this child sounds like someone who is bored by schooling in general, at least she found the incorporation of IK exciting. Her sentiments draw our attention to the claim made by Basu and Barton (2007) that the gap between Western sciences and IK is one of the major causes of failure and lack of interest in Science. It may be that the child finds reading books boring because she does not fully comprehend what she reads. Thus Science teaching that is de-contextualised risks destroying the framework through which learners understand the world (Aikenhead, 1996; Ogunniyi, 2007; Jegede, 2007).

While their teachers claim that they incorporate IK frequently [Section 4.2.3], some learners felt that teachers do not incorporate IK frequent enough. This contradiction is interesting. It may be an indicator that learners find learning through IK so interesting, that they wish IK would be incorporated more frequently.

In addition to what their teachers said, the learners pointed out that incorporating IK helps them to understand and remember what they are taught. They pointed out that learning through IK enables them to draw on their own examples. This resonates with the social constructivists' claim that the ultimate goal of teaching is to enable learners to construct their own knowledge. In the same vein Staver (1998) asserts that knowledge is not passively acquired, instead it is constructed from within the learners' mind as they engage in thinking.

Through IK, learners in this study were actively involved in discussions, debates and arguments that helped them establish scientific concepts on alcoholic fermentation.

5.6 Concluding remarks

This chapter interpreted and discussed the findings from this research. This study revealed that teachers hold a positive attitude towards the incorporation of IK. Incorporating IK made the teaching of alcoholic fermentation much easier. It improved the following aspects of classroom interaction: learner engagement, questioning and answering techniques, concept development from the known as well as classroom control. The study also revealed that the incorporation of IK aroused learners' interests, triggered critical thinking and made Science learning easier and more exciting than reading books. However, the study also revealed that lack of PCK and insensitivity to learners' cultural diversity negatively affected learning.

In the next chapter I summarises the findings of this research.

CHAPTER SIX

SUMMARY OF FINDINGS, RECOMMENDATIONS AND CONCLUSIONS

6.1 Introduction

In this chapter I briefly summarise the main findings of this study after which I make recommendations and draw conclusions. The chapter ends with a brief reflection of my academic journey during this research process.

In this study I endeavoured to answer the main question: How does the incorporation of IK enable or constrain the teaching and learning of alcoholic fermentation? To achieve this I started by investigating teachers' attitudes, perceptions and opinions of IK after which I examined how the incorporation of IK enables or constrain the teaching and learning process. To understand how the incorporation of IK enables or constrains the learning of alcoholic fermentation I also investigated learners' attitudes, perceptions, and opinions about the incorporation of IK.

6.2 Summary of findings

This study revealed that the teachers who participated in this study held positive views towards the incorporation of IK in Science education and are thus willing to incorporate it in their teaching. However, their efforts to incorporate IK are constrained by lack of PCK due to insufficient training, lack of written documents and lack of support from the Department of Education. It also emerged that although the teachers got either pre-service or in-service training, such training was not sufficient to equip them with the necessary knowledge and skills to effectively incorporate IK in their teaching. The teachers lacked both the cultural content knowledge CCK and the pedagogical content knowledge PCK to effectively incorporate IK.

This study also established that incorporating IK enabled the teaching and learning of alcoholic fermentation by increasing learner engagement. It improved the quality of learner-teacher engagement, learner-learner engagement and learner-content engagement. Basu and Barton (2007) postulate that students enjoy learning Science through their IK. The study also revealed that a learner-centred approach in which the teacher shifted from the traditional domineering position to a cultural broker, a group member and a co-learner was more effective in bringing about learning than the lecture method.

Incorporating IK stimulated intellectual activity and promoted deep thinking (Wood, 1992). It aroused learners' interest and motivated them to want to know more. Teaching strategies such

as group discussions, debates and arguments coupled with probing, redirecting questions to the class and scaffolding were effective in helping learners engage deeply with their IK and construct their own understanding of alcoholic fermentation. This underscored the claim made by Vygotsky (1978) that speech plays a crucial role in bringing about learning. In other words, learning is mediated through interaction with other members of the social group using cultural symbols such as language.

In this study, the use of their mother tongue *isiXhosa* helped the learners to discuss the chemistry of alcoholic fermentation using words they were familiar with. In this way incorporating IK made it easier for learners to understand alcoholic fermentation. It made it easier to conceptualise ideas such as to ferment [*ukubila*]. But *ukubila* in *isiXhosa* also refers to boiling and sweating. Nonetheless, there was a free-flow of ideas and experiences as learners shared their IK in their mother tongue.

However, the research also found out that if not effectively used, attempts to incorporate IK can frustrate and confuse learners. For instance, Teacher B's failure to creatively incorporate IK or unwillingness to relinquish power as the source of knowledge seems to have frustrated learners and caused them to misbehave by shouting as they tried to seize the opportunity to share their IK. Thompson (2013, p. 51) argues that constructivism promotes learning through "active engagement, inquiry, problem solving and collaboration with others". This implies that the behaviour of Teacher B's learners may be interpreted as resistance to passive learning.

This study also revealed that learners were enthusiastic to learn through the incorporation of IK. They said they found it enjoyable and felt that their teachers did not use IK frequently enough. They also felt that the incorporation of IK would yield better results if teachers tasked them to research in advance on IK based topics. These sentiments resonated with earlier findings which asserted that incorporating IK arouses learners' interests and makes Science enjoyable.

6.3 Recommendations

This study has revealed the incorporation of IK promotes the teaching and learning. It makes science more exciting to learn and easier to understand. In light of the above findings I make the following recommendations that; teachers should incorporate IK whenever possible. Teachers should also make use of the knowledgeable members of community to help them incorporate IK. I also recommend schools-based in-service training, thorough pre-service training on how to incorporate IK and more research on how to incorporate IK. I now discuss each of these below.

6.3.1 Role of IK in science lessons

This study has revealed that learners enjoyed and became actively engaged in the lessons when IK was incorporated. Additionally, they were able to make sense of the science concepts which in the past they perceived as difficult. I therefore recommend that teachers should endeavour to incorporate IK in their lessons where possible. Similarly, teachers could encourage their learners to research indigenous knowledge from their parents and in the community. In my view, indigenous knowledge is an easily available resource that teachers need to take advantage of to make science more accessible to their learners.

6.3.2 Development of teaching-learning materials

In her study, Mothwa (2012) recommended that more teaching and learning materials should be developed. In this study, I am making a similar plea and recommend that educators, publishers, researchers and other interested parties should develop teaching and learning materials that can be used to help teachers implement an IK based curriculum.

6.3.3 Continuous school based in-service training

I also recommend that the in-service training of teachers should be a continuous process. Schools should embark on school-based staff development programmes aimed at helping teachers acquire knowledge and skills on how to incorporate IK. The programmes may involve demonstration lessons, seminars, research and presentations as well as discussions on how to incorporate IK. Different schools have different needs, so they do not have to wait for the Department of Education to take the initiative to train teachers because such training may not meet their context specific needs.

6.3.4 Induction courses for the newly qualified teacher

From this research, it can be argued that teaching experience may be an important determinant of one's ability to come up with creative ways of incorporating IK. To deal with this problem, I recommend that schools should conduct induction courses to assist the newly qualified teachers on how to incorporate IK into effective teaching and learning. In addition, teacher training programmes should aim at equipping the trainee teachers with both the knowledge of the subject matter/content and socio-cultural pedagogical content knowledge to enable them to implement the IK based curriculum.

6.4 Areas for further research

This research has unravelled a number of issues which need further research. I therefore recommend further research on:

- The same topic, but using larger samples of learners and teachers;

- The effect of IK based instruction on learning aspects such as information retention/memory, understanding and application;
- How IK-based teaching can make use of the cultural diversity found in South African classrooms.
- Comparative studies between IK-based teaching and conventional teaching.

The above suggestions point to the fact that this study was limited in terms of its scope. It also had its own technical shortcomings. The section below discusses the limitations of this study.

6.5 Limitations of the study

This study had limitations in terms of its generalizability. As a case study the findings of this research cannot be generalised to any other institution or situation. The research was conducted at one high school in one Educational District of the Eastern Cape which may mean that the findings of the research are context bound. As already mentioned in Section 3.14, I wanted to include all the four teachers in our Life Science Department as participants in my research so as to increase the validity of my research but unfortunately two of the teachers turned me down and I was left with only two teachers to observe. Although this was a case study, the reduction of the number might have compromised the kind of data that I was able to come up with.

The other limitation is that the two teachers who accepted to take part in my research were completely different in terms of their teaching experiences. While this gave me an opportunity to compare good and bad practice in incorporating IK it limited the strength of my claims as they were mostly based on either Teacher A or Teacher B.

Another constraining factor in this study is the fact that I was studying learners and teachers who were code switching between English and *isi*Xhosa when I speak neither of the two languages as my home language. Although I can understand English well, my proficiency in *isiXhosa* is still limited.

Additionally, the use of recording devices such as a video camera may have altered the behaviour of teachers and learners. To counter this shortfall, I used triangulation. The data obtained from the lesson observations was complemented by stimulated recall interviews and focus group interviews.

6.6 Reflections

My academic journey through this research was a mixed bag of fortunes and misfortunes and challenges. However, through the unfailing support of my lecturers Dr. K. Ngcoza and Mr. K. Jawahar I managed to sail through. I am one of the students who kept bothering Dr. Ngcoza

to negotiate for our registration into the Master of Education programme. I just could not wait to enrol to further my studies because I did not want to waste any more time considering my age and that I am a married man with a family and children who need money to go to school.

When the admission letter finally came, I was so excited that my dream had come true.

However, to my surprise, my boss was not amused by the idea and he asked me to make a choice between continuing with my studies and my job. I persuaded him to allow me to keep both on condition that I would only attend to my studies in my spare time and would not be absent or disrupt the discharge of my duties or deprive or prejudice my learners in any way. However, this made me lose out on many writing workshops organised by the University such as the SAARMSTE Colloquiums at NMMU in Port Elizabeth and Fort Hare in East London. This disadvantaged me a lot as I was missing the opportunities to learn from others. It also psychologically made me feel low but Dr. Ngcoza and my colleagues kept encouraging me, for which I am highly grateful. It is Dr. Ken's words "If you want to walk fast walk alone but if you want to walk far walk with others", that kept me going. Whenever I was feeling low I would communicate with my colleagues [Alfred Mapfumo, Beatrice Musekiwa, Lineo Ramasike, Tsepho Motsididi, Farasten Mashozhera and Esther Ariola] and they would help me pick up the pieces and continue with the journey. However, not everything was gloomy because as a first year Masters student I was appointed as a part-time tutor to teach the B. Ed. Life Sciences students. This was the highlight of my career and my university life. I taught the group for two years and today I walk across Rhodes University with the joy of someone who has been more than just a student at this institution. Ironically, I started the course with a very low self-esteem to the extent that at one time I asked Dr. Ngcoza if I could make it in Science education. His response was just a smile and an assurance that I needed to have confidence in myself.

The academic journey through this research was difficult but at the same time very exciting. Having gone through a long and rigorous process to have my proposal approved, I found myself working under intense pressure to catch up with the time frame. I spent nights in the library trying to complete this study and I would always feel like I was chasing a moving target. At one time I thought I would not make it. Thanks goes to my wife, my colleagues in this cohort and my lecturers who kept encouraging me to push on.

What I found interesting was the data gathering and analysis process. The research process and the knowledge gained in this research were enlightening. When I chose the topic on IK I did not realise that I had joined what Odora-Hoppers (2000, p. 1) described as the "the voice of the wounded healers…..struggling against many odds to remember the past, engage the present and determine a future built on new foundations". As I engaged with literature I felt as if I was part of a self-rediscovery mission to retrieve the otherwise denigrated wisdom embedded in indigenous practices such as the making of *umqombothi*.

As an educator and a researcher I also learnt a lot from this experience that enabled me to reflect upon my own practices. I also learnt a lot about life in general from the teachers and learners I worked with as I conducted this research. The insights gained in this study enabled me to appreciate the role of indigenous knowledge in Science education. It made me curious to take a scientific look at my culture and contribute to the documentation as much information as I could come across. My view towards IK was transformed completely. For instance, the lesson observations and the literature reviewed in this study exposed me to best practice and poor practice in incorporating IK. This left me curious to know what causes some teachers to do well in incorporating IK, while some struggle to effectively do so.

Because of these insights gained in this study, I recommend that more research should be done on aspects that were unearthed by this study, some of which were not the main focus of the research. Having said this I now turn to aspects that were unearthed by this study that I think need further research.

6.7 Conclusion

This study sought to understand how the incorporation of IK enables or constrains the teaching and learning of alcoholic fermentation.

Drawing from the data obtained from the document analysis, the questionnaire, lesson observations, stimulated recall interviews and the focus group interviews, I concluded that the incorporation of IK enabled the teaching of alcoholic fermentation by simplifying the concepts taught. It improved aspects of classroom interaction and instructional strategies such as teacher-learner engagement, learner-learner engagement, discipline, learner motivation, learner participation, learner-teacher questioning techniques as well as the answering techniques used by the teachers.

I also concluded that the incorporation of IK enabled learning by promoting critical thinking, arousing learner interest, increasing learner motivation and simplifying the concepts learnt. In other words it promoted learning by appealing to learners' cognitive and affective domains. It stimulated their minds to think deeply and made them engage with content at a deeper level than would be possible in an ordinary lesson. Learners enjoyed learning science through IK. They felt that the incorporation of IK makes the subject more interesting and easier to understand. Contrary to their teachers learners felt that cultural; diversity would offer them an opportunity to learn other people's cultures.

Lastly, the study also revealed that although teachers viewed as beneficial to the teaching and learning of Science, some teachers lack the CCK and the PCK to incorporate it into effective instructional strategies, as evidenced by Teacher B and some respondents to the questionnaire.

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APPENDICES

APPENDIX A: PERMISSION LETTER TO THE PRINCIPAL

X High School [Pseudonym]

P. O. Box

Mthatha

09 May 2015

The Principal

X High School

Dear Sir

Ref: Permission to conduct an educational research at your school

I am kindly asking for permission to conduct an **Educational Research** at your school (in partial fulfilment of my Master of Education, Science Degree).

I would like to investigate ways of incorporating indigenous knowledge (IK) in teaching anaerobic respiration (fermentation). The CAPS curriculum requires us to incorporate indigenous knowledge in science teaching.

I guarantee that the research shall be conducted in compliance to academic ethics and shall not disrupt or compromise the smooth running of the school. The data obtained will be treated as confidential and shall not be used for any other purposes outside the confinement of this research.

Yours faithfully

Mutanho C.

…….. STAMP

APPENDIX B: LETTER OF CONSENT BY THE PRINCIPAL OF THE SCHOOL

I have allowed Mr. Mutanho C. to conduct **an educational research** at my school on the understanding that the research shall be done **specifically for educational purposes,** in compliance with academic ethics by not compromising the image of the school, the personal integrity and dignity of learners, teachers and any other participants involved.

Signature

…….

Date……. SCHOOL STAMP:

APPENDIX C: LETTER OF CONSENT FROM THE TEACHER

I……have agreed to assist Mr. Mutanho C. on his academic Project on the understanding that he will use the information I provide for academic purposes only. He also promises to continue working with me to support science teaching at our school.

Name ……

Signature……..

Date……..

APPENDIX D: LETTER OF CONSENT FROM THE PARENTS

I……have agreed to let my child……..to take part in Mr. Mutanho C's lesson on the understanding that he will use the information he will get from my child shall not be used against my child or in any way that disadvantages the child. He also promised that he will do everything to safeguard the rights of the learners and continue working with other teachers for the benefit of our learners.

Name ……

Signature……..

Date……..

APPENDIX E: LESSON PLAN FOR TEACHER A

X HIGH SCHOOL MTHATHA

LIFE SCIENCES LESSON PLAN **WEEK: 2**
Dates: 20-24/04/2015

EDUCATOR: Teacher A	**GRADE: 11**
TOPIC: LIFE AT ORGANIC LEVEL **-ORGANS AND SYSTEMS: THE LEAF AS AN EXAMPLE OF AN ORGAN**	**AIM: KNOWING LIFE SCIENCES & INVESTIGATING PHENOMENA IN LIFE SCIENCES**
-By the end of the lesson learners should be able to: a) describe the process of alcoholic fermentation using their indigenous knowledge.	

TEACHER'S ACTIVITIES	**LEARNERS'ACTIVITIES**	**ASSESSMENT STRATEGIES**	**RESOURCES**	**TIME DURATION**
Introducing the lesson by recapping 2. Assign learners group work 3. moves around helping learners and monitoring progress 4. Teacher sums up the main points and draw learners attention to the process of alcoholic fermentation	**Recapitulation** **Learners discuss in groups how umqombothi is made** **They find out the scientific justification of things done during the brewing umqombothi** **They respond to group questions** **Feedback session** **They listen and take notes as the teacher explains** **They write an excercise**	-Worksheets as class work -Work sheets for field work	Textbooks, notebooks, pens, the environment, soil samples (clay, sand & loam)	1HRS

Challenges: Barriers / Expanded Opportunities
Reflections: Absenteeism / Late coming / Anything that happened in class.

Term: 3 week 2 lesson plan:

Home work / class work / class test: Class work (work sheets)

EDUCATOR: ..... H.O.D: .....

PRINCIPAL: .....

DATE……..

APPENDIX F: TEACHER B'S LESSON PLAN

X HIGH SCHOOL MTHATHA

LIFE SCIENCES LESSON PLAN

WEEK: 2 Dates: 20-24/04/2015

EDUCATOR: MUTANHO C.	**GRADE: 10**
TOPIC: LIFE AT ORGANIC LEVEL **-ORGANS AND SYSTEMS: THE LEAF AS AN EXAMPLE OF AN ORGAN**	**AIM: KNOWING LIFE SCIENCES & INVESTIGATING PHENOMENA IN LIFE SCIENCES**
-By the end of the lesson learners should be able to: a) describe the process of alcoholic fermentation using their indigenous knowledge.	

TEACHER'S ACTIVITIES	**LEARNERS'ACTIVITIES**	**ASSESSMENT STRATEGIES**	**RESOURCES**	**TIME DURATION**
Introducing the alcoholic fermentation 2. Teach about alcoholic fermentation 3. Explaining Concepts to leaners	**Reading books** **Listening carefully** **They answer questions from their books** **They write an in their groups and answer questions**	-Worksheets as class work -Work sheets for field work	Textbooks, notebooks, pens, the environment, soil samples (clay, sand & loam)	1HRS

Challenges: Barriers / Expanded Opportunities
Reflections: Absenteeism / Late coming / Anything that happened in class.

Term: 3 week 2 lesson plan:

Home work / class work / class test: Class work (work sheets)

EDUCATOR: ..... H.O.D: .....

PRINCIPAL: .....

DATE……..