Exploring how teachers mediate learning of experimental techniques using fermentation and distillation of a traditional brew

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Demetria Paulus (13P7392)

Supervisor: Prof. KM Ngcoza

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DECLARATION OF ORIGINALITY

I **Demetria Paulus (13P7392)** declare that this thesis: Exploring how do teachers mediate learning of experimental techniques using fermentation and distillation of a traditional brew is a true reflection of my own work, and that this work or part thereof has not been submitted or been submitted for a degree in any other university apart from Rhodes University. Where I have used the words, quotes or ideas of other researchers, these have been acknowledged using complete references according to Rhodes Education Departmental guidelines.

Signature: *DPaulus* Date: 06 April 2017

DEDICATION

I dedicate this thesis to my elder sister, Savelia Mwadhinandje Paulus, for her love, wisdom and integrity that served as a source of inspiration to me. To my mother, Teonilla Niimbodi Paulus, for her unfailing love, the good upbringing she gave me and her unconditional support.

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ABSTRACT

Physical Science is one of the subjects in which learners perform poorly in most Namibian schools. For instance, in ||Kharas region where the study was conducted, from 2010 to 2016, the overall performance has ranged between 20-40%. Furthermore, according to the results analysis report from the Directorate of National, Examination and Assessments (DNEA), from 2012 to 2016, the ||Kharas region was ranked 11th, 12th, 13th, 14th and 10th in the regional rankings. From the Examiner's reports, the most poorly answered questions in the National Senior Certificate examinations are those that require learners to explain and show understanding. Additionally, the reports highlighted that learners lack practical skills or lack exposure to experiments and demonstrations to enhance their understanding (Namibia, 2014-2015).

It is against this background that this study sought to explore how teachers mediate learning of experimental techniques using fermentation and distillation of a traditional brew. In particular, the study addressed the following sub-questions:1) what are Grade 11 Physical Science teachers' perceptions and experiences on the inclusion of indigenous knowledge during Science lessons? 2) What factors influence Grade 11 Physical Science teachers' perceptions and experiences on the inclusion of indigenous knowledge? 3) How do Grade 11 Physical Science teachers teach experimental techniques conventionally- fermentation and distillation? 4) How does the inclusion of a practical demonstration on making *Ombike* enable or constrain Grade 11 Physical Science teachers when explaining concepts on experimental techniques - fermentation and distillation? Thus, the focus was on conceptual understanding through linking content to the context of the learners.

The study was underpinned by an interpretive paradigm whose focus is on understanding people's worldviews. Within the interpretive paradigm, a mixed methods (Quant-QUAL methods) case study approach was employed in two sequential phases with Physical Science teachers at one secondary school in Keetmanshoop. Data were collected using document analysis (to strengthen my context). In the first phase, a questionnaire with closed-ended and open-ended questions was used to gather quantitative and qualitative data from 17 Physical Science teachers. Additionally, I conducted interviews with two Physical Science teachers from one Secondary School in Keetmanshoop who were selected based on their expertise, teaching experience and their qualifications. Quantitative data were analysed using frequency tables and graphs. For phase two, lesson and the practical demonstration observations were videotaped and transcribed inductively. Thematic analysis was used to analyse the qualitative data. The study was informed by Vygotsky's (1978) socio-cultural theory with a focus on the mediation of learning, social interactions and learner engagement within the learners' Zone of Proximal Development (ZPD) in conjunction with Shulman's (1987) theory on pedagogical content knowledge (PCK).

The findings of the study indicated that the majority of the Physical Science teachers were aware of and supported the inclusion of IK; on the other hand the teachers indicated some challenges that come with IK integration. Some teachers acknowledged the importance of IK, such as the enhancement of understanding, proving of theories, and arousal of interest and context relevance. However, some teachers felt that there are misconceptions in IK that can be carried into the classroom, IK resources like textbooks are not available, and IK is not integrated in the syllabus and examinations and lack of teacher training *inter alia.*

The study recommends that the Ministry of Education, Arts and Culture especially the Division of Curriculum Planning and Development (NIED) needs to explicitly include IK in the Syllabus documents and suggest the inclusion of IK in the textbooks to the publishers to address these challenges. In order to enhance the teaching and learning with IK in Science, it is critical that teachers' training workshops are conducted and IK resources are designed so that IK integration can be successfully implemented. For that to happen, it is recognized that the teachers' PCK should be regularly upgraded through Continuous Professional Development (CPD) by the Subject Advisors (SA) so that the teachers are consistently guided on appropriate teaching methodologies and pedagogies about the inclusion of IK.

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LIST OF ABBREVIATIONS AND/OR ACRONYMS

CPD	Continuous Professional Development
DNEA	Directorate of National Examinations and Assessments
IK	Indigenous Knowledge
LCE	Learner Centered Education
MBEC	Ministry of Basic Education and Culture
MEC	Ministry of Education and Culture
MoEAC	Ministry of Education, Arts and Culture
MoE	Ministry of Education
NCBE	National Curriculum for Basic Education
NIED	National Institute for Educational Development
PCK	Pedagogical Content Knowledge-
QUAL	Qualitative
Quant	Quantitative
WK	Western Knowledge
ZPD	Zone of Proximal Development

CHAPTER 1: SITUATING THE STUDY

1.1 Introduction

The focus of this study was to explore how teachers mediate learning of experimental techniques using fermentation and distillation of a traditional brew. Researchers have shown that the inclusion of indigenous practices/local knowledge in science lessons enhances sense making as well as the development and understanding of scientific concepts (Kibirige & Van Rooyen, 2006; Mukwambo, Ngcoza & Chikunda, 2014). However, the inclusion of indigenous practices/local knowledge in science classrooms is under-researched in Namibia. This fact triggered my engagement with this research.

This chapter thus introduces the study. Here the context of the study including the Namibian curriculum, the research goal, research objectives, research questions, statement of the problem and significance of the study are discussed. The definitions of the key terms used in the thesis, as well as the thesis outline are outlined and the chapter ends with some concluding remarks.

1.2 Background of the study

Internationally the performance in science by most learners is poor (TIMSS, 2011; Howie, 2004; Reddy, Zuze, Visser, Minnaar, Juan, Prinsloo, Arends & Rogers, 2015). In her study conducted on the TIMSS results in 1995 and 1999, Howie (2004) found that the performance in Mathematics and Science were extremely poor in South Africa compared to that of other countries. This finding further revealed that South African learners were significantly below those of learners in all of other 40 participating countries including Ghana and Botswana from Africa. Howie (2004) further found that this was exacerbated in part by the lack of understanding of the Mathematics and Science questions and the inability of learners to communicate their answers, for instance, where they needed to explain the process or phenomenon.

The TIMSS report further revealed that teachers' attitudes and their beliefs about Mathematics/Science and the skillfulness of their teaching were identified as factors that might be causing this poor performance. Unfortunately, Namibia did not take part in the TIMSS research. Instead, it took part in the SATS (Ministry of Education [MoE], 2014; Shaakumeni, 2014), whose findings indicated poor performance in Mathematics, Science and English in

Grades 5 and 7. Similarly, the Examiners' Reports (MoE, 2014-2015), indicated that learners performed poorly in Physical Science in both Grades 10 and 12. The report further indicated that a minimal number of practical activities that were suggested was done. The report suggested that there is need to do more practical work in order to enhance understanding.

As indicated in the findings above, in the ||Kharas Region where this study was conducted, the pass rate in Physical Science was between 20-21% (MoE, 2014-2015) and this was also the case in other regions in Namibia. The Examiners' Reports further indicated that learners answered the questions on experimental techniques; in particular, fermentation and distillation which require them to explain these processes very poorly (see Table 1 as evidence extracted from the Examiner's Report for 2015). Yet, the concepts fermentation and distillation are very important concepts in chemistry education. As earlier indicated that, there is little research done on the integration of IK in Namibia, thus, the integration of IK is still at its embryonic stage, whose objectives are mostly sense making, conceptual development and understanding that will consequently improve the performance of learners (Klos, 2006; Wanja,2000).

Conceptual development and understanding were also emphasised in the studies conducted in Namibia by Uushona (2013) and Shifafure (2014). They found that learners' performance was poor in Physical Science due to the following reasons; lack of resources to carry out practical activities as suggested in the syllabus; teachers' lack of pedagogical content knowledge (PCK) on the inclusion of indigenous knowledge (IK) due to lack of training; the curriculum (syllabus) was not explicit in explaining how the IK can be integrated into science content and assessment activities; and finally the teachers' attitudes towards and experiences of the inclusion of IK in science lessons.

It is against this background that this study explored the possibility for the inclusion of indigenous knowledge (IK) in science lessons in order to enhance sense-making and conceptual understanding as proposed by the following scholars (Aikenhead & Jegede, 2009; Mapara, 2009; Ogunniyi & Ogawa, 2008; Shizha, 2007). Mapara (2009) posits that the inclusion of IK in science also teaches skills that encourage sensitivity to the survival of the environment. For example, in the context of this study the traditional fruits used to make *Ombike* are natural; clay pot and wood-condenser are made from locally available natural resources without any cost involved and are environmental friendly at the same time. This is also emphasized in the Namibian Curriculum (MoE, 2010), that teaching and learning should consider the context of the learners. For example, learners' activities should be designed using locally available materials that learners are familiar with.

The Namibian education system strongly advocates for a learner-centered education (LCE) approach, as laid out in *Toward education for all: A development brief for Namibian education* (MEC, 1993). This approach advocates a paradigm shift toward LCE in order to provide the kind of education that makes it possible for learners with varying backgrounds and different abilities to progress (ibid). For example, the National Curriculum for Basic Education (NCBE) (2010) states that learners learn best when they are actively involved in the learning process through a high degree of participation, contribution and production.

Thus, the LCE aims to enable learners to construct meaning in educational settings and to develop particular capacities needed to interact in their environment and with the world. The LCE therefore takes as its point of departure that the prior knowledge which is part of IK and the experiences of the learners provide opportunities for the construction of meaning in their context (MoE, 1993; Nyambe, 2008). However, Nyambe and Wilmot (2012) argue that while there is consistency in teacher educators' interpretations and the policy documents, the examples of how the teachers implement the learner centred pedagogy in their classrooms, indicates a disjuncture by both teachers and learners on the actual LCE approach.

Thus, the main goal of the National Curriculum for Basic Education (MoE) (NCBE), 2010) is to empower learners for the development of Namibia for the future as a knowledge-based society. This is characterized by the effective and wise use of existing knowledge and the creation of new knowledge (The National Curriculum for Basic Education, (MoE) (NCBE), 2010).

However, despite these goals and aims in the curriculum, Chisholm and Leyendecker (2008) point out that the LCE has not brought about any visible qualitative change in Namibian classrooms. Similarly, Nyambe and Wilmot (2012) confirm the tensions or contradictions that exist in curriculum implementation in Namibia. These tensions and contradictions among others are manifested by the fact that the LCE education was implemented soon after independence yet the performance in Physical Science is still generally weak. This suggests that there is a dire need for the capacity building of science teachers. Hence, I believe that a practical demonstration such as making *Ombike* will not only help learners to make sense of scientific concepts, but it may also help learners to comprehend scientific concepts such as fermentation and distillation. This may consequently assist learners to answer the questions confidently and correctly and improve learners' performance as opposed to the current status quo.

According to the results analysis reports from the Ministry of Education, Arts and Culture (MEAC), from 2012 to 2015 the ||Kharas Region was ranked position 11, 12 and 13 out of 14 regions. It emerged from the Examiners' reports that questions that require learners to explain and show understandings were among the most poorly answered questions in the National Senior Certificate examinations. Additionally, the reports highlighted that learners lack practical skills or a lack exposure to experiments and demonstrations to enhance their understanding (MoE, 2014-2015).

It is for this reason that this study explored whether the practical demonstration of making *Ombike* might give learners an opportunity to relate science with what is happening at home (Stears, Malcolm, & Kowlas, 2003; Oloruntegbe & Ikpe, 2011). This might also give value to cultural ways of knowing and allow room for debate and reasoning that consequently leads to meaningful learning. The inclusion of cultural/indigenous practices may address the lack of practical activities and might lead to an improvement in the low pass rate highlighted by the Examiners' reports. For example, many teachers have not been exposed to the inclusion of indigenous knowledge (improvising) during their teacher training and this has affected the teachers' attitudes toward IK (Shizha, 2007). Thus, the curriculum should be inclusive in both pedagogy and content.

The curriculum documents acknowledge learners' prior knowledge, experiences and their context but the challenges lie with the implementation of these tenets. Furthermore, the curriculum does not clearly explain how indigenous knowledge should be considered during teaching. This is exacerbated by the fact that the curriculum was inherited from the previous administration and was distant from the lives and experiences of most Namibians (*Toward education for all,* MEC, 1993). When the curriculum is not developed to include everyday contexts, it might result in confusion for learners (Kasanda, Lubben, Gaoseb, Kandjeo-Marenga, Kapenda, & Campbell, 2005). Thus, an indigenous curriculum has the promise of invigorating science educators who are interested in the pursuit of science from indigenous technologies, embedded in the 'taken for granted' and 'place–based' traditional knowledge systems (Phiri, 2008).

Similarly, local sciences present an opportunity for sustainability in development without relying exclusively on the outcomes of globalization systems of knowledge (ibid). For instance, the Namibian curriculum clearly states that learners' prior knowledge should be considered during teaching so that it is culturally inclusive, and yet this area is neglected in most teachers' training. This also seems to be under-researched in Namibia. Hence, this research explored how the inclusion of indigenous knowledge might help in closing this gap so that there could be cultural border crossing (Aikenhead, 1996; Aikenhead & Jegede, 1999) from home to school science. I now briefly discuss the requirements of the Grade 11-12 Physical science syllabus.

The Namibian Physical Science syllabus for Ordinary Level requires learners to study the topic experimental techniques. This topic consists of various topics, such as filtration, crystallization, paper chromatography, evaporation, simple distillation and fractional distillation whereby learners are expected to:

- Describe methods of purification or methods of separating mixtures by the use of a suitable solvent, filtration, crystallization, re-crystallization, and distillation (including the use of fractionating column);
- Identify substances and recognize that mixtures melt and boil over a range of temperatures;
- Evaluate the purity of substances from melting point and boiling point information, outline the importance of purity in substances in everyday life (e.g. salt, sugar, drugs), and suggest suitable purification techniques, given information about; and
- Carry out fractional distillation of a sample of wine/fermented sugar solution/fruit juice.

Ironically, in the first three competencies of the syllabus no practical work is suggested on distillation (MoE, NCBE, 2010, p. 30). Instead, a practical activity is only suggested in Organic Chemistry on making alcohol through fermentation as indicated in the last competency. My experience as a Subject Advisor is that linking these two topics presents a challenge to some teachers since they appear in different chapters. In many cases these topics are taught in isolation and theoretically (Czerniewicz, Murray & Probyn, 2000) and as a result learners struggle to comprehend what they have learnt as reflected in the Examiners' reports. There is also a misconception about fermentation being a biological concept and yet there is a lot of chemistry associated with it.

I also noticed that there is a gap in the curriculum documents (syllabuses). For instance, the concept distillation is taught in Grade 6 and 7 but it is not taught in Grades 8, 9, and 10 and is only taught again in Grade 11-12. This suggests that there is no consistent progression in the development of concepts in the curriculum and the learners treat these as new concepts in Grade 11. I now discuss earlier research findings on the inclusion of IK in Science teaching/learning.

In their studies conducted in Namibia on fermentation and distillation, Uushona (2013) and Shifafure (2014) found that learners do not perform well in these topics especially the questions that require cognitive demands. For example, learners were able to correctly answer the questions that required them to define, list, name and label diagrams (see Appendix D) which illustrates a part of the Grade 12 Physical Science Paper 3 Ordinary Level for 2015. According to the Examiners' Report for 2015, most learners were able to answer question 1 (a) (i) correctly. However, the learners were not able to answer or gave poor answers to question 1 (a) (ii) and question1 (b). These are questions required learners to explain, describe, and give reasons for the process of distillation (see Table 1). It could be argued that this is due to a number of challenges such as lack of practical activities and the lack of pedagogical knowledge of improvising by the teachers. This has resulted in limited content knowledge of the learners in showing any understanding of the concepts in experimental techniques as indicated in the Examiners' reports alluded to above.

Table 1 below shows the summary of a Grade 12 Questions (paper 3 NSSCO) for 2015 from the topics Fermentation and Distillation and the comments from the Examiners' reports on how the learners answered these questions.

Table 1: Comments from the Examiner's report 2015

Questions	Comments from the examiner's report	Marks awarded per question
1. (a) (i) State the names of apparatus **B, C** and **E** (see the diagrams of apparatus in	(a) (i) This part of the question was answered fairly well. However, the spelling of the scientific names of simple laboratory apparatus proves to be a challenge. Most of the candidates identified the apparatus correctly but could not spell their names correctly	3

appendix…, page...)		
(ii) Explain the how apparatus works.	(ii) Answered poorly. Most of the candidates could not explain how a condenser works, nor identify what cools down the steam/vapour/gas. While some talked about water/air being cooled instead of steam/vapour/gas	2
(b) Explain how these apparatus can be used to separate the mixture of alcohol and water in apparatus D.	(b) Answered poorly. Most candidates could not describe the fractional distillation process in a sequential approach. They rather listed the functions of the individual apparatus. The few that managed to fit the pieces together, referred to the mixture as a solution or boiling/burning instead of heating. In some cases, candidates generalized the use of thermometer as an apparatus used to measure temperature instead of to measure the temperature of steam/vapour/gas.	5

Thus, this research sought to add to the research done by Uushona (2013) and Shifafure (2014) on teaching fermentation and distillation through the inclusion of indigenous knowledge (IK). The studies on the inclusion of IK conducted by Uushona (2013) focused on the Grade 9 learners in the Omusati Region whereas Shifafure's (2014) focused on the Grade 11 Physical Science teachers in the Kavango region. This presents a different cultural setting to Uushona's and mine. In contrast, my study focused on the Grade 11 Physical Science teachers in one school in the ||Kharas region. It looked at how teachers teach both in conventional ways and through the inclusion of a practical demonstration on making *Ombike*, a traditional alcoholic drink. I was also interested to see how teachers mediated learning through the inclusion of IK in a multicultural environment which was not the case in Shifafure's and Uushona's studies. Additionally, my study took cognizance of the research done by Kasanda, et al. (2005) and Klein (2011) on the inclusion and role of everyday prior knowledge and indigenous knowledge respectively.

1.3 Statement of the problem

A research problem is a general educational issue, concern or controversy addressed in research that narrows the topic (Creswell, 2008, p. 70). This research project addressed the lack of conceptual understanding and sense-making during science lessons. From my own teaching experience and from the class visits I have conducted as a Subject Advisor, I observed that the teachers stick to the suggested materials in the syllabus to do experiments and yet some of these materials are mostly not available in the schools to conduct practical demonstrations. As a result, topics such as fermentation and distillation are taught in a theoretical way. That is, the teacher explains the concepts and the learners memorize them without any conceptual understanding. Consequently, learners struggle to comprehend these concepts and this has resulted in poor performance/low pass rate.

Also, evidence from the Examiners' reports indicated that learners struggle to explain and describe scientific processes or phenomenon (see Table 1). For these reasons, these reports suggested that more practical work and demonstrations should be done to expose learners to the reality of science. Despite these suggestions made in the Examiners' reports and in the syllabus, limited or no practical activities and demonstrations are done. Findings revealed that this is could be due to a lack resources required in the syllabus and a lack of pedagogical content knowledge (PCK) on the part of teachers on how improvise using local available resources (Asheela, 2017) and indigenous science Uushona (2013) and Shifafure (2014).

1.4 Significance of my study

My assumption is that the inclusion of indigenous knowledge when teaching the topic experimental techniques in Grade 11 Physical Science might help learners to make sense of the concepts of fermentation and distillation. Thus, this study may benefit the Physical Science teachers by showing them how to integrate IK during their science lessons. The results of this study may inform my work, and assist me as a Subject Advisor in how to support teachers in improving their practice and in particular with the incorporation of indigenous knowledge (IK) in their teaching.

This study may also hopefully assist the curriculum developers on how to integrate IK during science lessons either during syllabus development or during workshops. Lastly, the study may inform all science educators on how incorporate IK not only in this topic but in all other topics in the syllabus where integration may be necessary. Future research might be required in other topics where possibilities of integrating IK might be explored.

1.5 Research goal, objectives and questions

1.5.1 Research goal

The main goal of my study was to explore how Grade 11 Physical Science teachers mediate learning of concepts on experimental techniques (fermentation and distillation) conventionally and through the inclusion of a practical demonstration on making *Ombike*.

1.5.2 Research objectives

The objectives of this study were:

(i) To investigate the perceptions and experiences the Physical Science teachers have on the inclusion of indigenous knowledge in science lessons;

(ii) To establish the factors that influence the Physical Science teachers' perceptions and experiences of the inclusion of indigenous knowledge in science lessons;

(iii) To identify the appropriate teaching strategies that Physical Science teachers can use to help learners to make sense of concepts in Experimental Techniques;

(iv) To enhance teachers' understanding on how indigenous knowledge can support the understanding of scientific concepts during lessons; and

(v) To promote community members and community experts' involvement in science activities at school.

1.5.3 Main question

How do Grade 11 Physical Science teachers mediate learning of concepts on experimental techniques conventionally and through the inclusion of a practical demonstration on making *Ombike?*

Sub-questions

(1) What are Grade 11 Physical Science teachers' perceptions and experiences on the inclusion of indigenous knowledge during Science lessons?

(2) What factors influence Grade11 Physical Science teachers' perceptions and experiences of the inclusion of indigenous knowledge?

(3) How do Grade11 Physical Science teachers teach experimental techniques conventionally, i.e. fermentation and distillation?

(4) How does the inclusion of the practical demonstration on making *Ombike* enable or constrain Grade11 Physical Science teachers when explaining concepts on experimental techniques - fermentation and distillation?

1.6 Definition of key concepts

In this thesis, I have used many terms that could have different meanings in other contexts, or could be written differently. Therefore, I explain the meanings of these terms below.

Cultural content knowledge: Cultural content knowledge refers to a person's knowledge of the culture of a particular group of people.

Fermentation: According to Campbell (1990), alcoholic fermentation can be defined as a metabolic process whereby yeast converts $CH_{12}O_6$ to ethanol (CH_3CH_2OH) and carbon dioxide gas, in the absence of oxygen. Fermentation is a chemical process that involves the breaking down of organic materials such as glucose/sugar by micro-organism such as yeast to produce ethanol and carbon dioxide gas.

Fractional distillation: Atkinson (1985) defines distillation as the process of boiling to form vapour and the cooling of the vapour (condensation) which changes to liquid. Furthermore, fractional distillation is defined as a process separating two liquids by distillation, the distillate being collected as fractions which boil at different temperatures (ibid).

Indigenous knowledge (IK): specific forms of knowledge that is local and specific to place. Indigenous knowledge could be synonymous to cultural 'ways of knowing'.

Indigenous Knowledge Systems (IKS): the totality of the knowledge that a community holds.

***Ombike*:** A traditional alcoholic drink made from fermented traditional fruits. The fermented mixture is heated in a closed container and the vapour condensed to a liquid alcohol. It is estimated that this alcohol has a high percentage of alcohol of about 40% or more.

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.

School science: Physical Science as defined as a combination of Chemistry and Physics in curriculum documents.

Western (also Eurocentric) science (WS): knowledge accumulated over many centuries from both European and non-European cultures modified to better fit the ways of knowing of Western science.

1.7 Thesis Outline

This section briefly outlines the different components of this study which was conducted at a secondary school in the Kalahari Circuit in ||Kharas Region in Namibia. The thesis comprises six chapters and these are outlined below.

Chapter One: This chapter introduces the study. It outlines the contextual background to the study including the Namibian Curriculum; rationale for the study research goal and objectives; keys concepts of the study and the questions that the study sought to answer.

Chapter Two: In this chapter I review the literature that is relevant to this study. The chapter starts by discussing prior everyday knowledge, the prospects and challenges of incorporating indigenous knowledge in science, language as a meditational tool, practical demonstration; fermentation and distillation and the theoretical framework is explored.

Chapter Three: In this chapter, I present the research design and methodology of the study. The chapter discusses the research paradigm, the research design and outlines the research goal, 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: Here I present, analyse and discuss the data gathered using the different research instruments. The quantitative data is presented and analysed followed by the qualitative data. It starts with the data gathered from the questionnaires before proceeding to the semi-structured interviews. I discuss and interpret the data presented in light of the themes that emerged from the data that enabled me to answer my research sub-questions 1 and 2. The analysis and discussion of the data is done in comparison with the findings of similar research mentioned in the literature review chapter.

Chapter Five: In Chapter Five, I present, analyse and discuss the data gathered from the observations. It begins with the data gathered from the observations of lesson presentations, followed by the stimulated recall-interviews with the teachers and the practical demonstrations done. I discuss and interpret the data presented in light of the themes that emerged from the data that enabled me to answer my research sub-question 3 and 4. The analysis and discussion of the data is done in comparison with the findings of similar research discussed in the literature review chapter.

Chapter Six: Summarises the findings of the study, makes some recommendations based on the findings, includes a critical reflection of the journey throughout this study and finally draws a conclusion.

1.8 Concluding remarks

This chapter introduced the goal of my study which was to explore how Grade11 teachers mediate learning of the concepts in Experimental Techniques (fermentation and distillation) conventionally and through the use of a practical demonstration of making a traditional alcoholic drink called *Ombike*. The chapter outlined the background/context of this research. It also looked at the research questions to be answered, the problem statement, and rationale of the study, the key concepts used in the study and the thesis outline.

In the next chapter, I discuss the literature relevant to my study.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

The goal of this study was to explore how teachers mediate learning of experimental techniques using fermentation and distillation of a traditional brew. This chapter thus discusses the literature that is relevant to the research. The conceptual framework informing my study is everyday indigenous knowledge. Language is a tool for learning and practical work in fermentation and distillation. I also explore Vygotsky's socio-cultural theory and Shulman's pedagogical content knowledge as the theoretical frameworks informing my study.

2.2 Conceptual framework

The conceptual framework in research plays a vital role because it enables the researcher to discuss the key concepts underpinning the study (Imenda, 2014). Central to this study is a discussion on the inclusion of IK in science education, prior everyday knowledge, language as a mediating tool, and practical work and practical demonstrations. These key areas are discussed in the following sections.

2.2.1 Prior everyday knowledge

Prior everyday knowledge refers to the experience and knowledge the learners come with to school. It can be the knowledge learnt from the previous grades, experience learnt from home or their local environment (Roschelle, 1995). The connection between prior knowledge and school science promotes added engagement and participation for learners both with each other and with the content (Kuhlane, 2011; Stears, et al., 2003). Thus, prior everyday knowledge could be in the form of scientific knowledge or indigenous knowledge (IK). Combining this knowledge with what learners learn at school has the potential to bring about learning as 'conceptual change' (Kasanda, et al., 2005; Posner, Strike, Hewson, & Gertzog, 1982; Roschelle, 1995).

In addition, some scholars believe that considering learners' prior knowledge and experiences may support not only conceptual understanding but also linguistic development (Zhang, 2008; Hendricks, 2003). Thus, bringing the village into the classroom might develop positive attitudes towards the subject as learners can relate the content to their cultural environment (Klein, 2011; Rennie, 2011; Shifafure, 2014). However, this is not always possible since teachers tend to ignore IK or stick to what is stated in the syllabus and textbooks (Mapara, 2009; Webb, 2013). In most cases, the content in the syllabus and textbooks is based on foreign contexts and this might cause a cultural clash with the learners' culture. Furthermore, Roschelle (1995) accentuates that science learners need prior knowledge but prior knowledge can sometimes be misleading in that it introduces misconceptions. For this reason it is vital to mediate learning through scaffolding in order to clear out some of the misconceptions. I now discuss what the literature says about indigenous knowledge.

2.2.2 Indigenous Knowledge in Science

IK refers to a holistic, local, tacit, orally transmitted, based on the experience, learned by doing and repetition and it is constantly changing (Kibirige &Van Rooyen, 2006; Mutanho, 2016). In this research IK is understood to be the knowledge gained from the context of the teachers and the learners. Learning begins with what the learners know prior knowledge embedded in IK, before they proceed to learn new concept which is referred to as cultural border-crossing (Aikenhead & Jegede, 1999). This cultural knowledge facilitates learning through social interaction and thus learning becomes interesting and meaningful (Vygotsky, 1978).

However, IK as a body of knowledge does not come without problems. There are various challenges that come into play during integration when teaching. Central to this is the fact the most IK is not documented and IK is not in the textbooks or syllabus (Shizha, 2009). As indicated earlier, IK is orally transmitted and IK practices are done through trial and error and are not scientifically proven (Kibirige & van Rooyen, 2006). Thus, not all IK can be used at school because there might be some misunderstandings that need to be cleared up beforehand (Mukwambo, et al., 2014). However, Ogunniyi and Ogawa (2008) and Mukwambo, et al. (2014) concluded in their studies that both systems of thought are not mutually exclusive to each other but rather do complement each other.

As a result, many scholars call for the inclusion of indigenous knowledge (IK) due the number of benefits that accrue such as learners' interest is enhanced (Hodson, 1990), increased learner engagement, enhancement of conceptual understanding and development and recognizing the culture of the learners (Kibirige & Van Rooyen, 2006; Mapara, 2009; Mukwambo, et al., 2014; Ogunniyi, 2008; Shizha, 2007). These scholars believe that learners' indigenous knowledge and western science taught in school can and should correspond and complement each other, (Jegede & Aikenhead, 1999; Le Grange, 2012; Simasiku 2016). Shizha (2007) posits that the differences between modern science and indigenous science exist not so much in the content but in the ways of knowing and the interpretative framework that underpins such knowledge.

It is recognized, however, that the inclusion of IK presents difficulties. Most indigenous knowledge and indigenous practices are not well documented and are not scientifically proven (Kibirige & Van Rooyen, 2006). These practices have led to an attitude in the institutions and the system that hinders the successful incorporation of IK (Shizha, 2007). In his study, for instance, Shizha (2007) found that the teachers' conservative ideas exhibited a negative attitude towards indigenous science. Teachers think that the traditional knowledge is only important at home. Also, (Ramorongo & Ogunniyi 2010; Van Wyk, 2006) further argued that science teachers have been schooled largely in the scientific worldview; the teachers have not been prepared to implement a science-IKS curriculum; instructional materials, that is, textbooks and teachers' guides including IK are not available. This leads to problems with teachers incorporating IK into their science lessons.

Due to these views, perceptions and experiences, some teachers include IK in their teaching. But why other teachers do not? The common findings reveal that teachers' pedagogical content knowledge (PCK) considers how learners' prior knowledge and experiences play a vital role in learners' conceptual understanding before new ideas are introduced (Kasanda, et al., 2005; Ogunniyi, 2008; Roschelle, 2006). This requires the incorporation of learners' prior knowledge which may be embedded in IK as proposed by Mukwambo, Ngcoza and Zulu (2014). Although studies have found that some teachers strongly advocate for the inclusion of IK, Shizha (2007) and Ogunniyi, (2008), point out that the challenge lies with how to implement it. This might be due to a lack of teachers' training in the field of IK and the teachers' attitudes towards IK that leads to the successful integration in science.

The teachers' attitudes and knowledge about IK is central to the successful integration of IK in science teaching. In his study conducted in Zimbabwe, for instance, Shizha (2007) found that teachers were conservative 'gatekeepers' who exhibited negative attitudes towards indigenous science and hence supported the teaching of western science. According to him, this was attributed to the syllabus documents the teachers were using and the kind of training/schooling they had received. It is thus for these reasons that teachers devalue indigenous experiences, ways of knowing, and understanding, and in the process prevent students from experiencing culturally inclusive and relevant science.

Despite the challenges that come with the integration of IK in science classrooms, Kibirige and Van Rooyen (2006) contend that the inclusion of everyday experiences enables adult community members to participate in education and pass on their knowledge to learners. When community members participate in the educational discourse of their children, the curriculum becomes relevant to the lives and livelihood of learners. For instance, in the research conducted in ||Kharas Region by Klein (2011), it revealed that integrating traditional skills and knowledge of Nama people served as a bridge between the formal school system and the community. As a result, Klein found that there was a decrease in the drop-out rate and an improvement in the performance of learners.

This suggests that bringing a community expert to do a practical demonstration does not only involve parents in the education of their children but contributes a sense of value to indigenous science so that learners may respect their cultural heritage (Cocks, Alexander & Dold, 2012). This is why Phiri (2008) argued that indigenous science and western science content do not have many dissimilarities but the most important factor is the way the information is presented to learners. Also, Jegede (1999) posits that the culture of a learner's immediate environment plays a significant role in learning and that it determines how concepts are learned and stored in the long-term memory. Notably, this is only true when teachers understand the interaction between IK and WS worldviews.

The incorporation of IK presents underlying challenges with regard to its integration. Jegede (1999) claims that the science curriculum does not take account of both indigenous science and western science to promote the learning of concepts in an abstract way. If the IK is not part of the curriculum, it gives the impression that IK is less important, and this undervaluing of IK results in teachers mostly sticking to the known syllabus (Dziva, Mpofu & Kusure, 2011; Shizha, 2007; Webb, 2013).

Concurring with Kibirige and Van Rooyen (2006), Moyo (2011) agrees that with IK not being documented and with an oral and practical tradition it works on estimates since it has not been scientifically proven. This makes it difficult to integrate since no clear scientific procedure can flow during teaching and a lot of IK is usually lost when experts in the community die.

2.2.3 Language as a mediational tool

Language is not just a tool for communication, but it also expresses our cultural views of the world and our existence (Shizha, 2007). Thus, language is a vital component the teachers can use for incorporating indigenous science into school science curriculum. Although some teachers admit that using a local language or code-switching when teaching science helps the learners understand some scientific concepts better (ibid), the obstacle is the limited or absence of scientific terms in the indigenous language. In the study conducted in Kenya by Cleghorn (1992), he revealed that code-switching into the home language was used to foster understanding of key concepts.

However, terms such as, atoms; distillation; fermentation and many others do not exist in Oshiwambo and this might limit learners' and teachers' ability to clearly explain such concepts. For example, in Oshiwambo fermentation means boiling (*okupya)*. This is very confusing to the learners because the same term is used when something is heated until it starts boiling. This is not only a challenge in terms of self-expression and confusion among learners but the language of instruction may alienate students (Klein, 2011; Shizha, 2007). Hence, learners have to undertake dual translation to make sense of what they learn.

In an English dominated science instruction classrooms, learners may not apply what they learn to practical situations at home, thus documenting the subtractive nature of English as highlighted by Bunyi (1999). This could be one of the reasons why the teaching and learning of science in schools has not been successful. This is because science content is not linked to everyday life experiences and the language of instruction that is used lacks an African nature and African rationality (Shizha, 2007).What follows is a discussion of the concept experimental techniques.

2.2.4 Experimental techniques

An experimental technique is an introductory topic from the chemistry section in Grade11-12. It exposes learners to basic separating methods such as, filtration, evaporation, crystallization, heating, paper chromatograph, simple and fractional distillation. From its name (experimental techniques), this is supposed to be a practical topic but mostly these concepts are taught theoretically due to lack of conventional materials suggested for use in the syllabus. For the purposes of this study, the focus will be on fermentation (which is one of the organic chemistry competencies) and distillation. I now discuss each of these below.

Fermentation

According to Campbell (1990), alcoholic fermentation can be defined as a metabolic process whereby yeast converts $CH_{12}O_6$ to ethanol (CH_3CH_2OH) and carbon dioxide gas, in the absence of oxygen. Such a chemical reaction is referred to as anaerobic. Fermentation is a chemical process that involves the breaking down of organic materials such as glucose/sugar by micro-organism such as yeast to produce ethanol and carbon dioxide gas. During the separation process the organic materials (fruits) are soaked in the water. Due the presence of glucose/sugar the mixture begins to ferment after a few days. During fermentation, glucose from plants is turned into ethanol by enzymes (biological catalysts) such as those contained in yeast, the process is shown below:

$$\textbf{Glucose} \xrightarrow{\text{Enzymes}} \textbf{Ethanol} + \textbf{Carbon dioxide} + \textbf{Energy}$$

$$C_6H_{12}O_6 \xrightarrow{\text{Enzymes/yeast}} 2C_2H_5OH + 2CO_2 + ATM$$

The rate of fermentation is determined by the amount of sugar and the temperature involved. Thus, fermentation is practiced in everyday activities such as making *Ombike* and *Oshikundu* using indigenous fruits and vegetables, such as: Berries; Palm fruits. *Eeshegele, Eenyandi,* Water Melon; Dates, Raisins, Cane sugar and other natural sugars. My assumption is that referring to everyday activities when teaching scientific concepts such as fermentation might help learners to understand and see the relevance of the content. I now discuss the concept of distillation.

Distillation

Atkinson (1985) defines distillation as the process of boiling to form vapour and the cooling of the vapour (condensation) which changes to liquid. Furthermore, fractional distillation is defined as a process separating two liquids by distillation, the distillate being collected as fractions which boil at different temperatures (ibid). Dube, Gordon, Jeoffreys, Khalieli, Molapo and Odara (2012) point out that the component with the lowest boiling point is reached first as it evaporates first. In this case, the mixture of water and alcohol is collected first because it has the lower boiling point of 78°C compared to pure water which is 100°C at sea level. The two components (water and alcohol) are separated from one another by the vaporization process. The component with the lowest boiling point rises to the top of the container and goes to the delivery tube until it reaches the condenser where the vapour is condensed to the liquid form and collects (Dube, et al., 2012).

Distillation plays a vital role in oil and alcohol industries. In Namibia, distillation is used in the purification of sea water, in the separation of sugar and salt and is also a common practice in making *Ombike* a traditional alcoholic drink made especially in the villages. *Ombike* can be used as a bio-fuel, Thamilvanan and SenthamilSelvi (2013).This alcohol is an eco-friendly and can be used to recover our fuel shortage and during combustion ethanol relatively releases a low emission of volatile organic compounds, carbon dioxide (CO_2) and nitrogen oxides (NO). This emission of toxicity of ethanol is lower than those of fossil fuels such as petroleum, diesel and so forth (ibid). Thus, such indigenous practices/indigenous technologies can be used for environment sustainability.

Yet, many Physical Science teachers lack the pedagogical content knowledge of how to teach these topics. As a result, learners do not understand the scientific processes involved in distillation as revealed in the Examiners' reports (2014-2015) (also see Table 1ink Chapter 1).Thus, it is against this backdrop that this research explored how Physical Science teachers teach the concepts on experimental techniques - fermentation and distillation conventionally and through the inclusion of indigenous practice of making *Ombike*. Since learners are already familiar with the materials, as argued by Asheela, Ngcoza and Enghono (2015) and some have assisted their knowledgeable others to prepare *Ombike* it will be easy for teachers to help learners cross the border from IK to WS. In the next section I discuss the role of practical work/activities.

2.2.5 Practical work/activities

Practical activities/work refer to the theory which deals with concrete evidence/real life situations. Millar (2004) define practical work as those teaching and learning activities in science which involves student or learners at some point in handling or observing real objects or materials. Based on the definition above, practical work came to be seen as a means of allowing pupils 'to find out things for themselves' (Gott & Duggan, 1996). Furthermore, (Asheela, 2017; Maselwa & Ngcoza, 2003; Woodley, 2009) argue that practical work helps learners to acquire skills such as: manipulating equipment; making predictions, observing, recording, and analysing data, and drawing conclusions. They further added that the practical work approach in science teaching and learning is helpful for the learners in acquiring a better understanding of science (ibid). These scholars suggest that, practical work enhances conceptual understanding.

In contrast, Gott and Duggan (2004) cautioned that the assumption than an understanding of scientific evidence will emerge as a result of doing practical work, without being specifically taught or structured is questionable. They, thus regard practical work as having a key role in the teaching of evidence but only if the type of practical work is selected with care and with a clear purpose in mind (ibid).

2.3 Theoretical framework

A theoretical framework refers to the theory that a researcher chooses to guide their research (Imenda, 2014). It provides an explanation of an event or sheds light on a particular phenomenon or research problem (ibid). In this study, I used Vygotsky's (1978) socio-cultural theory in conjunction with Shulman's (1987) pedagogical content knowledge (PCK) to inform my study. In my view, these theories are appropriate for my study as they complement one another through viewing the learning that occurs through social interactions and acknowledging learners' experiences and culture. I now discuss each of these below.

2.3.1 Socio-cultural theory

Vygotsky's (1978) socio-cultural theory is premised on the fact that children learn from their interactions with society and their culture and with help they can improve their cognitive level of understanding. This theory puts the teacher in the role of a mentor or facilitator. Furthermore, the theory views social interactions, culture (language), and mediation of learning and level of development as key concepts that play a pivotal role in learning.

In this study I focused on how the social interactions and mediation of learning improves through the use of language as culture during the teaching and the learning of science, and through the use of cultural artefacts/concrete objects. In addition, the fact that the theory places social interactions and culture at the centre of learning during science lessons makes it well suited as a theoretical framework for this study because using the cultural artefacts of making *Ombike* is a strategy that can be used to elicit learners' experiences to teach the concepts fermentation and distillation.

Mediation of learning refers to the use of tools such as language, use of analogies, code-switching and scaffolding to make learning meaningful. Mutasa and Wills (1995) posit that scientific vocabularies are difficult to comprehend and are too long and sometimes mysterious thus mediational tools can be used to aid conceptual understanding. Some science terminologies do not exist in the local language and through code-switching can lead to a change of meaning

(Probyn, 2006; Shizha, 2007). Furthermore, lack of conceptual understanding is caused by the gaps between context and content and the language barrier. Thus, the use of the vernacular which is Oshiwambo during the practical demonstration of *Ombike* in particular might hopefully stimulate learners' interest to learn more meaningfully. Herein lies the importance of socio-cultural theory as espoused by Vygotsky (1978).

One of the fundamental concepts of socio-cultural theory, according to Lantolf (2000), is its claim that the human mind is mediated. This means that cognitive development is not a direct result of activity, but it is indirect; other people must interact with the learner, use mediatory tools to facilitate the learning process, and then cognitive development may occur (Vygotsky, 1978). Therefore, the practical demonstration on making *Ombike* can be used as a mediating tool to enhance meaning making. Thus, a knowledgeable participant/expert can develop curiosity and supportive conditions in which the learner (novice) can participate in and extend current skills and knowledge to a high level of competence.

This perspective further emphasizes the importance of society and culture in promoting cognitive development. In other words, students learn by fitting new information together with what they already know from their cultural environment. Stears, et al.'s (2003) findings revealed that culture is a contextual lens through which learners view and understand the world. This has a direct influence on learners' cognitive processes and understanding of science. It is precisely for these reasons that Mapara (2009); Shizha (2007); Ogunniyi and Ogawa (2008) and Aikenhead and Jegede (1999) call for science education to be culturally inclusive through the integration of IK during science lessons. For example, the integration of the indigenous practice of making *Ombike* when teaching fermentation and distillation concepts might enhance learners' participation and sense making. It is hoped that the teachers involved in this study would help learners to cross from IK to western science (Aikenhead & Jegede, 1999). Furthermore, the knowledgeable other who was responsible for the practical demonstration of making *Ombike* and the use of the mother tongue as a mediational tool, might make the process more understandable. This strategy could potentially enhance creativity, collaborative learning and link science to real life situations (Teemant, 2005).

The socio-cultural theory views the child as a product of social interaction. The child is assisted by more knowledgeable others to perform a task that is beyond that child's zone of proximal development (ZPD) until such time that the child is able to perform the task independently (Hall, 2007; Stott, 2016; Vygotsky, 1978; Wang, 2006). This process involves the social interaction of the teacher-learners, learner-learner, learners-knowledgeable others through demonstrations and through probing questions (dialogue or probing). Such mediated social interaction is central to learning (Khoza, 2016). However, socio-cultural theory can be complemented by the PCK theory.

2.3.2 Pedagogical Content Knowledge (PCK)

Shulman's (1987) Pedagogical Content Knowledge (PCK) is another perspective that informed my study. In his theory Shulman summed up effective teaching as three types of knowledge: content or subject knowledge; pedagogical knowledge and PCK. Although content or subject knowledge is explained as identifiable scientific knowledge to support teaching and learning in science (Friedrichsen & Dana, 2005), pedagogical knowledge is knowledge about general teaching strategies (Ormrod & Cole, 1996). PCK focuses on knowledge about teaching strategies in a given subject matter to learners (Ormrod & Cole, 1996) which encompasses teachers' content or subject knowledge, pedagogical knowledge and knowledge about learning (Loucks-Horsley & Matsumoto, 1999).

For this study I used Shulman's (1987) pedagogical content knowledge theory so that content, context and teaching pedagogy are explored to see what strategies enhance the understanding of concepts. In this study, it was hoped that the use of mother tongue by a knowledgeable person would help the learners to understand the process of fermentation and distillation during the practical demonstration of making *Ombike*. During this process, the teacher mediated learning by explaining and linking the science concepts emerging from the demonstration. By so doing, the learners were afforded an opportunity to relate fermentation and distillation to what they have experienced at their homes so that they could develop conceptual understanding. It is against this backdrop that PCK suits my study as it entails both the content (*what is to be learnt*) and the pedagogy (*how the content is taught*).

Furthermore, eliciting learners' prior knowledge and experience might assist during the practical demonstration of *Ombike* and can be used as pedagogy to teach the subject matter (fermentation and distillation). According to Khoza (2016), there are specific ways in which teachers engage in interactions with their learners.

2.4 Concluding remarks

In this chapter I discussed the literature relevant to my study. Firstly, I discussed the conceptual framework informing the study, namely, the role of prior everyday knowledge in science classrooms; indigenous knowledge (IK); language as a meditational tool and experimental techniques (fermentation and distillation) and the role of practical work/demonstrations. Secondly, I discussed the theoretical frameworks that informed my study, such as Vygotsky's (1978) socio-cultural theory and Shulman's (1987) Pedagogical Content Knowledge (PCK).

In the next chapter I outline the research design and research methodology.

CHAPTER 3: RESEARCH DESIGN AND METHODOLOGY

3.1 Introduction

Research design and methodology entail explaining the research procedures and conditions, the site, sample, and the data collecting tools that were used in the research to collect and analyze the data. In this chapter, I thus present the research design and methodology of the study. The chapter discusses the research paradigm, the research design and outlines the research goal and questions, the population, sampling procedure, contextual background of the research site, the data gathering techniques that were used. Additionally, the ethical considerations, validity and the limitations of the research are presented.

3.2 Research Design and Orientation

This study is underpinned by an interpretive paradigm (Bertram & Christiansen, 2015). Cohen, Manion, and Morrison (2011) and Maree (2008) posit that an interpretive paradigm is the lens through which you can examine the practice of research. Furthermore, a qualitative researcher carries out their research studies to reach the best possible understanding and focuses on the individual and tries to get inside knowledge of the person in order to understand him/her from within. This allows social interactions between the researcher and the participants. For example, in my case this allowed me to know the participants' perceptions and experiences in relation to the inclusion of indigenous knowledge, specifically in relation to the making of *Ombike* in the context of this study. Herein lies the role of socio-cultural theory which is the theoretical framework informing this study. Such an interaction may lead to the understanding of how people make sense of their world and how they make meaning of their particular actions (Maree, 2008). Thus, the interpretive paradigm gave me an opportunity to understand how the Physical Science teachers selected for the research help learners to make sense of the topic experimental techniques (fermentation and distillation) through the inclusion of a practical demonstration on making *Ombike*.

Within the interpretive paradigm, a mixed method case study (quantitative and qualitative) approach was employed. Merriam (2008, p.90) defines a case as an individual, group, institution, or community. It allows a researcher to examine a particular issue in a great deal of depth rather than looking at multiple instances superficially (Rule & John, 2011). Additionally, a case study provides a unique example of real people in real situations as proposed by Cohen, et al. (2011). Thus, a case study enables researchers to understand in-depth the context and the complexity within which the participants in the research site operate (Creswell, 2009). It also provides a platform for the researcher to interact with the participants which makes it appropriate for my study. Essentially, my study examined how teachers mediate learning of the concept experimental techniques-fermentation and distillation through the inclusion of the indigenous practice of making *Ombike*. My unit of analysis focused on the process of mediation of learning through the inclusion of the indigenous practice of making *Ombike* to enhance understanding.

3.3. Research goal, objectives and questions

3.3.1 Research goal

The main goal of this study was to explore how teachers mediate learning of experimental techniques using fermentation and distillation of a traditional brew.

3.3.2 Research objectives

The objectives of this study were:

(i) To investigate the perceptions and experiences the Physical Science teachers have on the inclusion of indigenous knowledge in science lessons;

(ii) To establish the factors that influence the Physical Science teachers' perceptions and experiences of the inclusion of indigenous knowledge in science lessons;

(iii) To identify the appropriate teaching strategies that Physical Science teachers can use to help learners to make sense of concepts in Experimental Techniques;

(iv) To enhance teachers' understanding on how indigenous knowledge can support the understanding of scientific concepts during lessons; and

(v) To promote community members and community experts' involvement in science activities at school.

3.3.3 Main question

How teachers mediate learning of experimental techniques using fermentation and distillation of a traditional brew.

Sub-questions

(1) What are Grade 11 Physical Science teachers' perceptions and experiences on the inclusion of indigenous knowledge during Science lessons?

(2) What factors influence Grade11 Physical Science teachers' perceptions and experiences of the inclusion of indigenous knowledge?

(3) How do Grade11 Physical Science teachers teach experimental techniques conventionally, i.e. fermentation and distillation?

(4) How does the inclusion of the practical demonstration on making *Ombike* enable or constrain Grade11 Physical Science teachers when explaining concepts on experimental techniques - fermentation and distillation?

3.4 Research site, participants and sampling

This research study focused on Grade 11 Physical Science teachers from one Secondary School in Keetmanshoop Town called Edu-Science (pseudonym) in the ||Kharas region. It is a government school offering Grade8-12. Furthermore, the piloting of the study was done with one female teacher from a different school in another circuit. The school, the research participants and I are all situated in Keetmanshoop town; this made access to the research site easy and allowed communication with my participants at any point during the research process. The participants were purposively selected based on their experience and the understanding of the subject matter (Bertram & Christiansen, 2015; Creswell, 2008). Additionally, eleven Physical Science teachers completed questionnaires, the data from which I have used to answer my two first research questions one research participant was a female expert from the community (Keetmanshoop Township) who carried out the practical demonstration on making *Ombike*. In Oshiwambo culture, females prepare *Ombike*, because in many cases they are more experienced than men. Furthermore, making *Ombike* in Oshiwambo culture is regarded as an activity reserved for women.

As a Subject Advisor, I regarded myself as an insider; I did not anticipate any problem during the data collection at Edu-Science SS. The Regional Director approved a request to conduct the study at the school. The principal also gave permission to conduct the study at his school. Approval letters were copied to Circuit office. Before the data gathering process began, I paid a courtesy call to my principal to inform him when my data gathering process would start and what I would be doing even though the letter requesting permission already indicated the scope of the research and what I would be doing at the school. I decided to have a one-on–one discussion to explain all the details about my research and also give the principal the opportunity to ask me questions about the study so that he had a clear picture of events. This went very well.

Formal information letters were written to my two research participants, to the community member and to the parents or guardians of the learners that were involved in the research. The letter explained the nature of the research and what their role would be. Oshiwambo language was used to explain the research aims to the community member to make sure that she understood everything about the research and the demonstration that she was supposed to do.

Having been a colleague of the participants, we had good rapport throughout my data collection period. It was easy for me to converse with the participants as I was able to speak to them in Oshiwambo, or in English depending on the subject under discussion. The data collection process took two weeks to conclude. I conducted some of my interviews during the afternoons after school. This is because Physical Science has six lessons every week for each class and the participants had lessons for most of the day. So, I used the participants' time tables and developed a master time table for data collection from the school. It was possible for me to arrange three lesson observations and collect data from the two participants and although we made some changes I managed to observe each teacher three times.

It was easy for me to keep in touch with the participants to let them know when to expect me because they had mobile phones. Cell phones greatly assisted in data collection. At some point, I was not able to do the stimulated recall interview immediately following class lesson observations but I came to an agreement with the participants about an appropriate time to do them. In many cases we had to pause and start from where we had left off as the participants attended to some of their other school duties. The breaks in-between were not that helpful because they disturbed the flow of ideas that we were busy with at the time of interruption. It was also quite time consuming to backtrack and to pick up where one left off.

3.5 Data gathering techniques

For this study the following research data gathering techniques were used to collect data, namely, questionnaires, semi-structured interviews, observations and stimulated recall interviews. I now discuss each of the data gathering techniques below (see Appendices I and J).

3.5.1 Questionnaires

In this study, open-ended questionnaires were administered to all the Physical Science teachers at the same time in the Keetmanshoop Teachers' Resource Centre during a subject meeting. This was intended to obtain an overview of the aspect under study. As a result, out of 22 questionnaires I received 17 (77%) questionnaires back.

The aim of the questionnaire was to help me to understand the teachers' perceptions and experiences regarding the inclusion of indigenous knowledge from a broader perspective especially when teaching the concepts on experimental techniques and the teaching strategies they use. I chose questionnaires as they can be easily administered to a large group (Bertram & Christiansen, 2015, p.78). However, the challenge lies with return of the questionnaires, which is very poor in most cases (Bertram & Christiansen, 2015). Although in my case only five questionnaires were not returned when I administered them, this is because the teachers were gathered at same venue and they were given time to complete them.

In addition, some teachers could not complete the questionnaires on that day and they promised to inform me when to collect them once they were done. It is recognized, however, that using questionnaires has its own challenges because respondents can give incorrect information (Bertram & Christiansen, 2015). In addition, I constantly called the participants enquiring whether they had completed the questionnaires so that I could collect them since some were not able to complete them on that day. I was not able to receive a 100% questionnaire return because some of the teachers indicated that they could not recall any IK related to the topic under study in their communities.

3.5.2 Semi-structured interviews

Semi-structured interviews are types of interviews whereby the researcher engages selected participants individually on a one-to-one basis (Johnson & Christensen, 2004). Interviews are used with the aim to explore and describe people's perceptions and understanding about a certain issue (Bertram & Christiansen, 2015). I chose semi-structured interviews because they allow for open-ended questions and the researcher can obtain first-hand information and clarification of some aspects through probing using follow-up questions (Cohen, et al., 2011) and clarification purposes (Bertram & Christiansen, 2015). I thus interviewed two teachers to get more insights from them regarding their perceptions and experiences and the strategies that influence their inclusion of IK on the topic experimental techniques-fermentation and distillation. Semi-structured interviews helped me to get sufficient information in order to answer the first and second sub-questions.

The interviews with the two participants were planned to be conducted the same day. However, this did not take place. I only managed to interview Teacher 2 (T2) as Teacher 1 (T1) was on sick leave. So, I had to reschedule the interview with T1. Since I was in possession of their cell phones, this made it easier for me to communicate with my research participants. The interviews with the two participants were planned to be conducted the same day. However, this did not take place. I only managed to interview T2 and T1 was on sick leave. So, I had to reschedule the interview with T1 again. Since I was in possession of their cell phones, this made it easier for me communicates with my research participants. On the rescheduled day I phoned to confirm the new interview time with T1.

To my surprise T1 informed me that he was not at school (absent). Interestingly, T2 told me that T1 was in fact at school. I realised that T1 was uncomfortable about being interviewed by me. While I was having a short briefing with T1 on how the lesson presentation observations would be done, T1 came in and informed me that he was ready for the interview.

Since I had my two smart phones ready with me for voice recording, I did not waste time for another reschedule. So, our interview began a few minutes after T1 showed up. The interview lasted for about 15 minutes which was more or less the same duration I had with T2. From that stage everything started going according to plan up to the last phase (phase2).

On reflection, it appeared that the teachers were not comfortable being interviewed even though they were given the interview questions early in advance. This was evidenced by the fact that the teachers kept on making several postponements before the interviews were conducted. Ultimately, however, I did manage to interview them. I was not able to find a better venue apart from one of the participant's classroom. The notice 'please do not disturb research interview in progress' was pasted on the door of classroom. However, this did not help as some teachers did not read the notice and just entered the classroom and started talking and greeting us while we were busy with the interviews. I had to stop the voice recording and inform them that we were busy with an interview.

3.5.3 Observations

Non-participant observation means the researcher is in the context and site of the research (Bertram & Christiansen, 2015). According to Cohen, et al. (2011), observations allow gathering of live data from live situations and help to establish insight into how the teacher teaches. Three lessons were observed for each teacher. All the lessons were video-recorded and transcribed. Transcribing videos was one of the challenges that I experienced during my research process. Since I took the videos myself, it was not possible to take field notes. For that reason, I was entirely dependent on the videos of the lesson observations data. What was challenging also was to filter the data and take only the useful data that would help me answer my research questions.

In the practical demonstration of making *Ombike*, for the first stage the learners observed the fermentation process (*Oku tutika no kupya kwiipambu yoodunnga*) of traditional fruits for 5-7 days and for stage two the mixing of fermented fruits were taken to the research site for a practical demonstration by the expert from the community. During this stage the learners recorded the time, day and observations made on the soaked pieces of Palm fruits (see the Table for the details in Chapter 5).

3.5.4 Lesson presentations and observations

It was interesting to observe that both participants have some cultural knowledge related to the topic fermentation and distillation although they are from different cultural backgrounds (Oshiwambo and Kavango cultures). Since the school is a multicultural school that consisted of Kavango; Oshiwambo; coloured; white; Nama/Damara; Zambezian learners including some learners' parents who are originally from Botswana and South Africa. The participants mostly knew about the practice of making beer and the teachers asked the learners whether they make traditional alcoholic beverage and to explain what they use and how they do it.

During phase 2, I observed the two teachers teaching the topics fermentation and distillation in order to find out whether and how they integrate IK in Physical science lessons. I observed and video recorded all the lessons to answer my research sub-question 3. Each teacher was observed three times in his class, Grade11B with 21 learners and Grade11D with 22 learners. The first lessons were introductory ones, the second lessons were to show the progression and the third lessons were for the conclusion. I then did stimulated recall interviews with the teachers and asked them to reflect on the lessons they presented (see Section 3.7.5).

During the same phase, the two research participants together with 43 learners observed the practical demonstration of making *Ombike* at the school (same site) where the community expert came to demonstrate the process of making *Ombike.* I video recorded the practical demonstration which helped the teachers learn how to include indigenous knowledge when teaching experimental techniques and this was intended to answer my research sub-question 4. During the practical demonstration the teachers mediated learning by linking IK to fermentation and distillation. Lastly, I asked the learners and teachers to write some reflections on their learning experiences about the practical demonstration.

3.5.5 Stimulated recall interview

A stimulated recall interview (SRI) is a follow-up interview that seeks clarification through watching the video tape together with the participants. The purpose of SRI is to allow the teachers to give their thoughts on their decision-making processes for their teaching behaviours as they view their lessons. The SRI followed soon after the lesson for the participants to give more insights in terms of their choice of activities and the teaching method used. Furthermore, the SRI is usually done soon after the event to increase the validity (Lyle, 2003; Nguyeu, McFadden, Tangent, & Beutel, n.d.). Having acknowledged the potential limitations of SRI, Nguyeu, et al. (n.d) propose that researchers should conduct an initial interview before the SRI and a follow-up in-depth interview after SRI with each participant.

3.6 Data analysis

The data collected were analysed inductively and I used Vygotsky's (1978) socio-cultural theory and Shulman's (1987) PCK as lenses. Regarding the use of socio-cultural theory as a lens to analyse data, Mortimer and Scott (2003) posit that the concept of a communicative approach is central so that teachers can develop learners' ideas. They highlight two aspects of a communicative approach, namely, *dialogic-authoritative* and *interactive-non-interactive* which I used to analyse data gathered from the observations in this study.

Furthermore, Mortimer and Scott (2003) explain that the dialogic communicative approach is characterized by science teachers acknowledging learners' views whereas the authoritative communicative approach places more emphasis on the school science point of view. In the case of the interactive communicative approach learner participation and engagement is encouraged and this is in line with the socio-cultural theory (Lemke, 2001; Vygotsky, 1978). In contrast, in the non-interactive communicative approach participation is limited.

Hence, the social interactions, teachers' content knowledge, teachers' pedagogical knowledge and teachers' experiences were categorised and analysed. These were divided into categories that were colour coded. These key themes featured in the interview questions, in the lesson presentations observation schedules and the practical demonstration.

3.7 Validity and trustworthiness

The data collected using different sources, namely, questionnaires, semi-structured interviews, videotaped observations and stimulated recall interviews were compared for triangulation purposes. Bertram and Christiansen (2015) define triangulation as a process of data collection from a number of sources.

In order to validate the data collected, the participants were given an opportunity to verify and confirm the transcripts through member checking (Bertram & Christiansen, 2015). Furthermore, the research was conducted for two weeks which is referred to as prolonged stay at a research site. Likewise, the stimulated recall interviews which were used to follow-up aspects observed in class contributed to the validation process.

3.8 Ethical considerations

The following ethical considerations were taken into account during the data gathering process. A letter seeking permission to conduct the research was approved by the Regional Director (see Appendix B). A copy of the approved letter from the Director was then sent to the Inspector's Office responsible for the school where the research was conducted prior the commencement of the data gathering process. The school principal authorized the research to be conducted at his school (see Appendix D). The two research participants (Physical Science teachers) agreed to take part in the research. They also agreed to be observed teaching and they agreed to the voice recording, video recording and photographs to be taken and as well to be interviewed both before and after the lesson presentations.

The teachers who were research participants and the community member all agreed voluntarily to take part in the research and they all signed the consent forms (see Appendix E). I assured them of confidentiality and the use of pseudonyms in the findings. The participant names and school given in the research findings of this study are thus pseudonyms to conceal the identity of the participants and the school. The community expert was informed of all the procedures in the vernacular language (Oshiwambo) and agreed before signing the letter of consent (see Appendix E). Since most of the learners were boarders, the school Principal had to ask the School Superintended to sign the consent form on behalf of the parents and guardians. Some class teachers also assisted in signing the learners consent forms. The learners were given letters of consent to be signed by parents/guardians for them to take part in the research. The researchers explained the study in detail and her expectations of the participants. In addition to that, I also allowed the participants to ask question for clarification.

3.9 Limitations of the study

This research is a case study and it only involved 17 Physical Science teachers and one community member in ||Kharas Region and mostly from Keetmanshoop town, and so the findings cannot be generalized to all the teachers in Namibia due to the small sample size used. However, some of the findings and insights gathered in this research on how to teach experimental techniques (fermentation and distillation) conventionally and through the inclusion of IK can be used by science educators throughout Namibia.

3.10 Concluding remarks

This chapter presented the research design and the methodology used to collect and analyse the data. The chapter discussed the research design and orientation, research site, research participants and sampling. The research data gathering tools such as questionnaires, interviews and observations were explored. This chapter also explained how the data were analyzed, and gave an account of how the data were validated. Trustworthiness, the ethical considerations and the limitations of the study were highlighted.

In the next chapter, I present, analyze and discuss the data collected from the questionnaires and semi-structured interviews.

CHAPTER 4: DATA PRESENTATION, ANALYSIS AND DISCUSSION (PHASE 1)

4.1 Introduction

The aim of the study was to explore how teachers mediate learning of experimental techniques using fermentation and distillation of a traditional brew. In this chapter, I thus present, analyse and discuss both the quantitative data and qualitative data gathered from the questionnaires (open-ended questions) and semi-structured interviews. The quantitative data are presented in tables and graphs. The qualitative data is analysed inductively and discussed in relation to the themes that emerged from the data. These themes provided the answers to the research sub-questions of the study. I first present the data from the questionnaires followed by the data from the interviews.

4.2. Results from Questionnaires: Quantitative Data

The quantitative data from the questionnaires were analysed based on the responses from the 17 Physical Science teachers who completed the questionnaires. The data is analysed using percentages and frequency tables. The quantitative data from the questionnaire answered my research sub-question 1:

> What are Grade11 Physical Science teachers' perceptions and experiences of the inclusion of indigenous knowledge during Science lessons?

I start by presenting and analyzing the profiles of the teachers. Thereafter, I present other data provided by the questionnaires.

4.2.1. Teachers' Profiles

Table 2 below presents the biographical information of the teachers who completed the questionnaires. This consists of the ages of the teachers, their gender and ethnicity. The teachers were assigned codes for identification according to the order in which the data was collated from the questionnaires. For example, the teacher's code T15Q6F, T stands for teacher, 15 stands for questionnaire number 15, Q6 stands for question 6 and F stands for female while M stands for male. In addition, the categories in Table 2 and 3 are directly linked to the frequencies of the teachers 'responses in those tables. For example, in terms of age, two teachers were in the age group of 20-25 years. The frequencies show the category that has more teachers, average or few teachers. The frequencies thus clearly show the categories that have more teachers, average or less. For example, in terms of ethnicity, the majority (11) of the teachers who took part in answering the questionnaire were Oshiwambo, speaking, followed by Silosi (2) speaking, while the Herero, Nama/Damara, Afrikaans and Rukwangali were each represented by one person.

Table 2: Phase 1 Demographic information of the participants 1 (teachers)

Biographica l Information	**Category**	**Teachers' codes**	**Frequency**
Age	20–25	T15Q6F, T16Q6F	2
	26–30	T3Q6F, T7Q6F, T12Q6F, T13Q6M, T14Q6F	5
	31–35	T2Q6F, T4Q6F, T5Q6M, T6Q6M, T8Q6F, T9Q6M, T10Q6M, T11Q6F	8
	36–40	T17Q6M	1
	41–45	T1Q6F	1
	46 – 50		0
	Above 50		0
Gender	Females	T1Q2F, T2Q2F, T3Q2F, T4Q2F, T7Q2F, T8Q2F, T11Q2F, T12Q2F, T14Q2F, T15Q2F, T16Q2F	11
	Males	T5Q2M, T6Q2M, T9Q2M, T10Q2M, T13Q2M, T17Q2M	6
Ethnicity	Oshiwambo	T1Q3F, T2Q3F, T3Q3F, T6Q3M, T9Q3M, T11Q3F, T12Q3F, T13Q3M, T14Q3F, T15Q3F, T16Q3F	11
	Herero	T8Q3M	1
	Silozi	T7Q3F, T17Q3M	2
	Nama/ Damara	T5Q3M	1
	Afrikaans	T4Q3F	1
	Rukwangari	T10Q3M	1

Table 3 below shows the biographical information of teachers such as: qualifications; grade taught and the number of years the teachers have taught Physical Science. The biographical information; categories; teachers' codes and frequencies are described above (see Section 4.2.1 above).

Table 3: Phase 1 Demographic Information of the Participants 2 (teachers)

Biographical Information	Category	Teachers' codes	Frequency
Qualifications	BETD/DiE	T4Q4F, T9Q4M, T10Q4M	3
	ACE/FDE/ MASTED	T1Q4F, T3Q4F, T5Q4M, T6Q4M, T8Q4M, T13Q4M	6
	HONS	T2Q4F, T7Q4F, T11Q4F, T14Q4F, T15Q4F, T16Q4F, T17Q4M	7
	MASTERS		0
	PHD		0
	Others (MSc)	T12Q4F	1
Grades Taught	8		4
	8-10	T5M, T6M. T8M, T9M, T13M	5
	10	T3F, T4F	2
	10-12	T1F, T2F, T7F	3
	11-12	T10M, T11F, T17M	3
	2	T12Q5F, T15FQ5, T16Q5F	3

No. of years the teachers taught Physical Science	3	T13Q5M	1
	4	T3Q5M,T14Q5F	2
	5	T6Q5M	1
	7	T2Q5F	1
	8	T7Q5F, T10Q5M, T11Q5F	3
	9	T8Q5M, T9Q5M	2
	10	T17Q5M	1
	12	T4Q5F, T5Q5M	2

From the information presented in Tables 2 and 3 above**,** the data showed that of the 17 teachers 11 were females (65%) and six were males (35%). Eleven of these teachers (65%) speak Oshiwambo whereas the rest (6%) speak other languages in the table 1. This suggests that although the sample is multi-cultural in nature, it is dominated by Oshiwambo speaking teachers. However, all the teachers indicated that they use English as the medium of instruction. This might be because, 11 out of 17 of teachers (65%), were Oshiwambo speaking as shown in Table 3 and they do not speak Afrikaans or Khoekhoewab which are commonly spoken in the South (Keetmanshoop) of Namibia where this study was conducted. Thus, the teachers face challenges with regard to ethnicity as far the inclusion of IK is concerned.

The table shows that of the 17 teachers, 16 teachers (94%) had obtained educational qualifications ranging from BETD/DIE to ACE/FDE/MASTEP. The data further show that 7(41%) Physical Science teachers have obtained Honours Degrees (HONS), six of whom are females (35%) and one teacher who is male (6%). In addition, only one teacher (6%) had obtained other qualifications, for example, a Master's in Science (MSc).

Furthermore, at the time of this study, five were teaching grade 8 to 10 (29%), and two were teaching grade 10 (12%). The total number of teaching years of experience in Physical Science ranged from 2 to 16 years. It also emerged that eight teachers (47%) were in the age range 31-35.

4.2.2. Other Quantitative Data from the Questionnaires

Data on their views on the inclusion of IK were presented in the form of tables; bar and pie charts.

Table 4: Teachers' understanding of the term IK

Category	Teachers' Code	Frequency
Awareness of IK in science	T1Q1F, T3Q1F, T5Q1M, T6Q1M, T7Q1F, T9Q1M, T10Q1M, T13Q1M, T15Q1F, T17Q1M	10
Gender patterns/ Female responses	T2Q1F, T4Q1F, T8Q1F, T11Q1F, T12Q2F, T14Q1F	6
No answer	T9Q1M	1
Off topic responses	N/A	0

Table 4shows that of the 17 Physical Science teachers, 10 teachers (59%) indicated that they were aware of some kind of IK in science, 6 female teachers (35%) explicitly explained the meaning of the term IK, and one teacher (6%) left that section blank (see Figure 1 below).

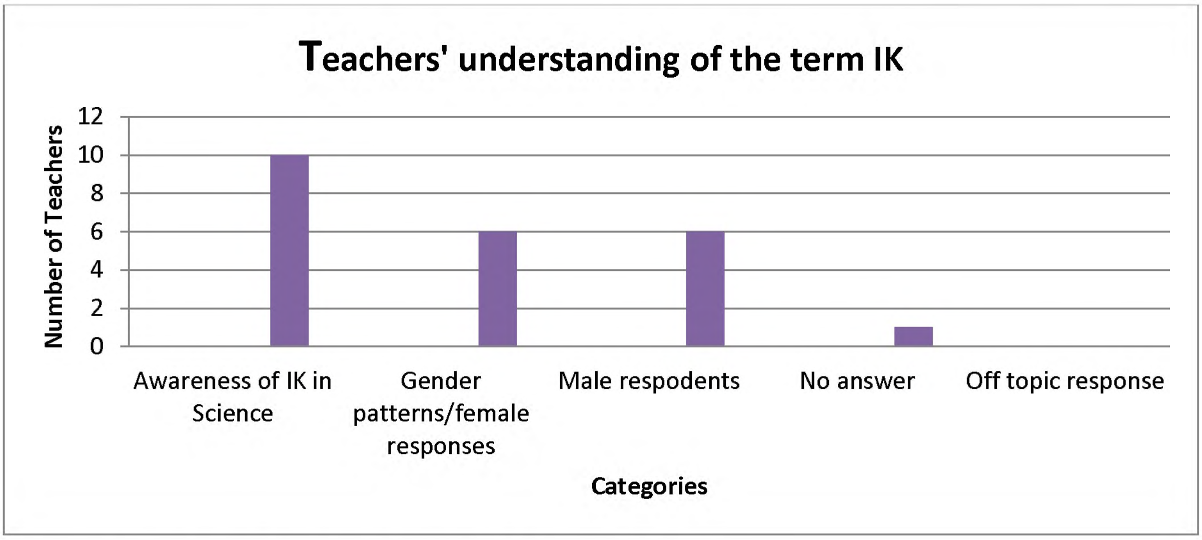

Figure 1: Teachers' understanding of the term IK

Figure 1, revealed that the majority of the Physical Science teachers are aware of what indigenous knowledge (IK) is. Of interest is that more female teachers gave detailed explanations of the term IK than their male counterparts. This could be attributed to the fact that making *Ombike* is associated with women. Furthermore, it emerged that more female teachers have higher qualifications than male (see the table above). Figure1 further shows that, only one teacher (6%) did not give a response. From Figure 1, it can be clearly seen that teachers are aware of what IK is. However, the challenge lies with implementation as found by Shizha (2007).

Table 5: Teachers' perceptions on the inclusion of IK in Physical Science

Category	Teachers' Code	Frequency
IK set a good link with academic knowledge	T1Q2F, T4Q2F, T5Q2M, T8Q2F, T14Q2F,	5
Enhances communication, creativity & experimentation	T2Q2F; T12Q2F; T13Q2M	3
Improves learners' understanding and applications	T3Q2F; T7Q2F; T12Q2F; T15Q2F;T17Q2M	5
IK assists learners with their assumed knowledge	T10Q2M	1
IK is helpful when teaching one cultural group	T11Q2F	1
IK makes lessons interesting	T13Q2M	1
IK improves performance	T16Q2F	1
Off topic response	T6Q2M	1
No response	T9Q2M	1

Table 5 above shows the teachers' perceptions on the inclusion of IK in Physical Science lessons as presented in Figure 2 below.

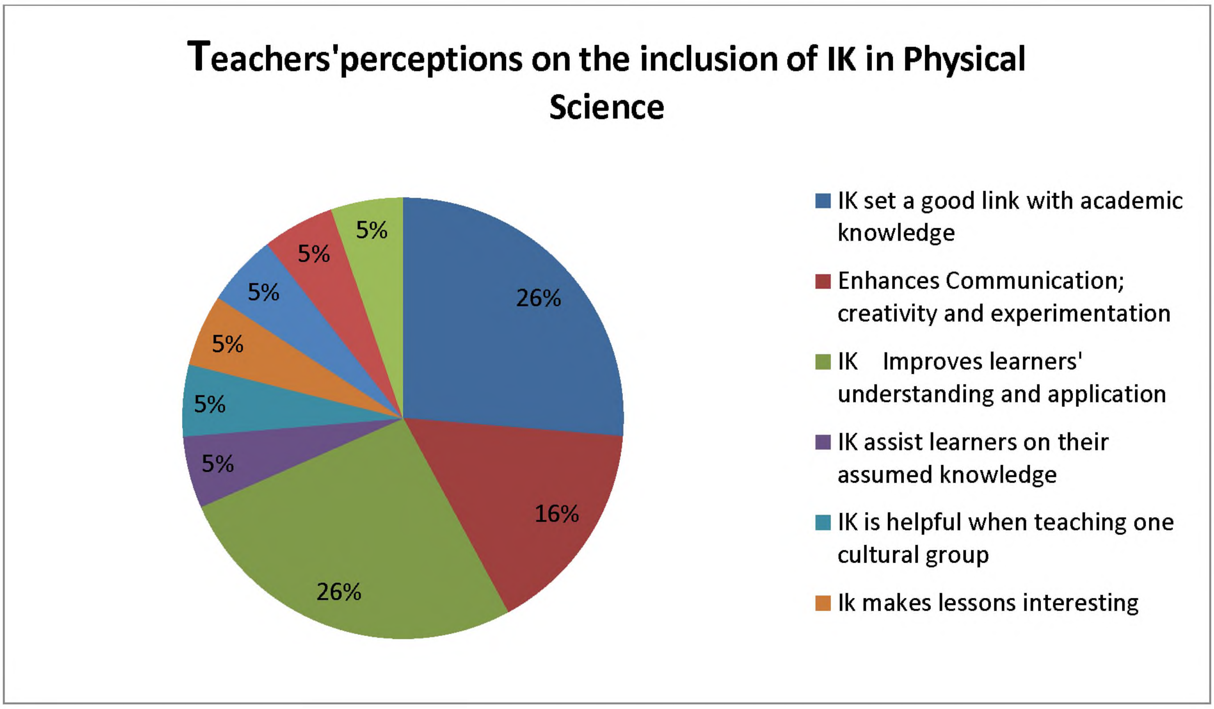

Figure 2: Teachers' perceptions on the inclusion of IK in Physical Science

The data in Figure 2 reveals that five teachers (26%) indicated that IK enables a good link to academic knowledge. This suggests awareness that learners' prior knowledge embedded in IK helps learners to learn new content as proposed by Rochelle (1995). The data further revealed that five teachers (26%) indicated that IK enhances learners' understanding and applications. Additionally, three teachers (16%) think IK enhances communication, creativity and experimentation. This is similar to the literature which says that western science and IK should not be treated as two different world views but should rather complement each other (Mukwambo; Ngcoza & Chikunda, 2014).

Table 6: Factors (prospects) that influence the teachers' perceptions on the inclusion of IK in Physical Science

Category	Teachers' Code	Frequency
Expertise possessed by community members	T1Q3F, T6Q3M	2
Enhance understanding	T10Q3M, T17Q3M	2

Availability of local materials	T12Q3F	1
Off topic answer	T2Q3F	1
No answer	T3Q3F, T9Q3M	2

Table 7 below presents the challenges as factors that influence the teachers' perceptions on the inclusion of IK in Physical Science.

Table 7: Factors (challenges) that influence the teachers' perceptions on the inclusion of IK in Physical Science

Category	**Teachers' Code**	**Frequency**
Misconceptions in IK?	T4Q3F, T8Q3F	2
Cultural clashes between IK and western science	T5Q3M	1
IK not scientifically proven	T7Q3F	1
Language barrier due to multicultural class	T11Q3F, T14Q3F	2
Time consuming and lack of resources	T13Q3M, T15Q3F, T16Q3F	3
Large class size	T16Q3F	2
Teachers' background on IK	T16Q3F	1

Table 6 and 7 were combined to form Figure 3 below that shows the factors (positive and negative) that influence the teachers' perceptions on the inclusion of IK in Physical Science.

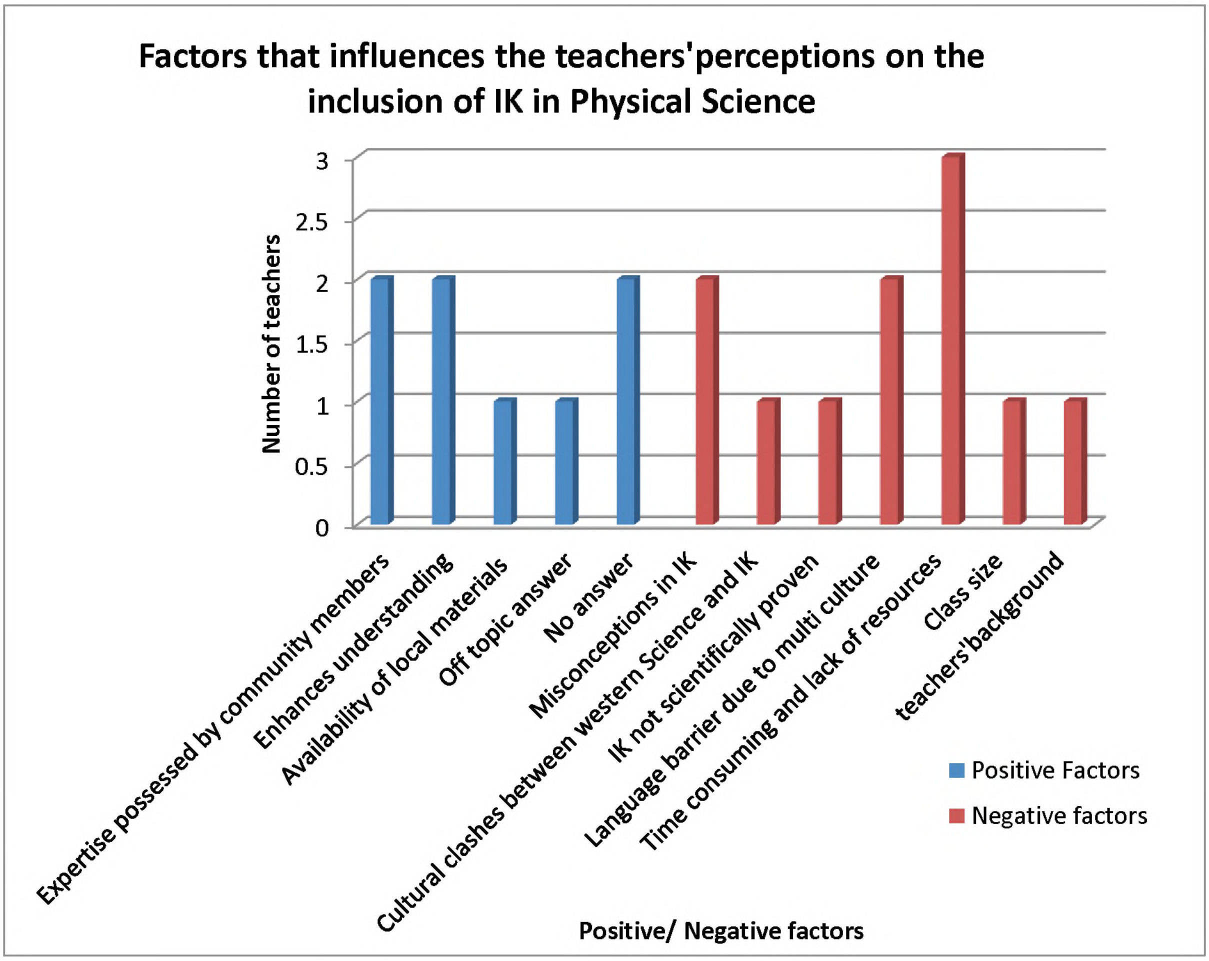

Figure 3: Shows the factors (positive and negative) that influence the teachers' perceptions on the inclusion of IK in Physical Science

In Figure 3 above, the data revealed that there were more challenges (7) than prospects (3).Of the 17 teachers, two teachers (12%) said that IK can be used during teaching because experts from the community possess expertise or skills and IK enhances concept understanding. This finding supports Rochelle's findings that prior knowledge (embedded in IK) enhances conceptual understanding, since learners already have some preconceived ideas that they can link to the new concept to be learned. Furthermore the data revealed that one teacher (6%) indicated IK during teaching enables the use of easily accessible local materials which help to address the shortage of conventional materials suggested in the syllabus (Asheela, 2017; Maselwa & Ngcoza, 2003).

On other hand, the teachers indicated some challenges that are associated with IK. These included the time factor and lack of resources; three teachers (18%); misconceptions in IK, two teachers (12%); language barrier due to multicultural conditions, two teachers (12%); and at least one teacher (6%) indicated the following: cultural clashes between IK and western science; IK not scientifically proven; class size and teachers' background. These correlate with Mukwambo, et al.'s (2014) findings that if cultural beliefs are not properly dealt with it may lead to misconceptions.

Table 8: Teachers' experiences of IK that relate to western/scientific ideas

Category	Teachers' Code	Frequency
Correct IK example given	T1Q4F, T2Q4F, T3Q4F, T5Q4M, T6Q4M, T10Q4M, T11Q4F, T12Q4F, T13Q4M, T14Q4F, T15Q4F, T16Q4F, T17Q4M	13
No example of IK given	T4Q4F	1
No experience of any IK	T7Q4F, T8Q4F	2
No answer	T9Q4M	1

Figure 4 below presents teachers' experiences of IK that relates to western / scientific ideas at home or in the community as indicated in Table 8 above.

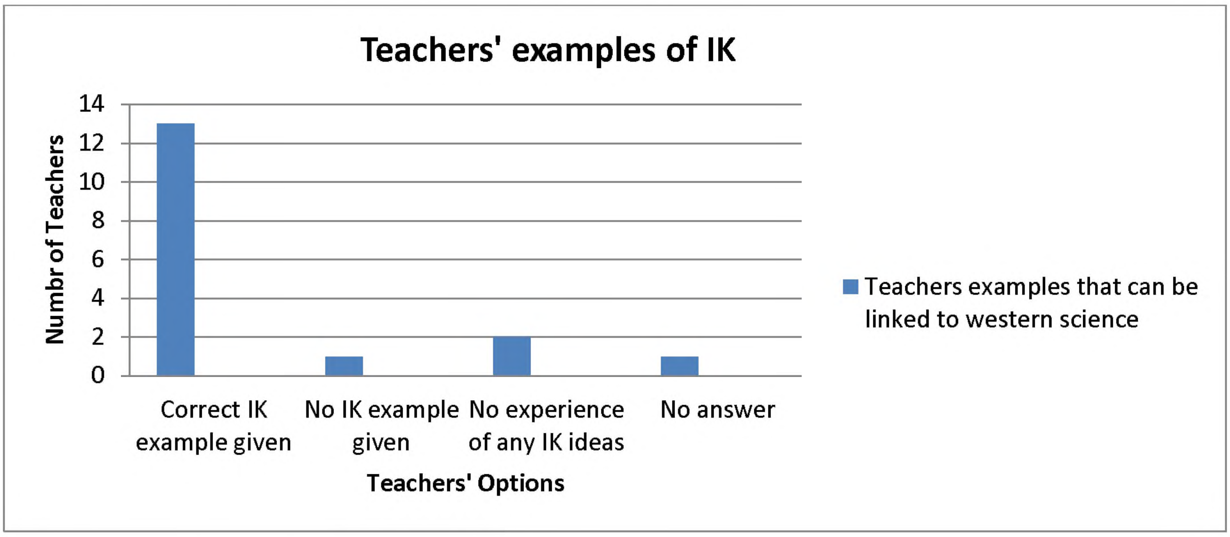

Figure 4: Teachers' examples of IK

Figure 4 show that teachers have some experience of IK. Of the 17 Physical Science, 13 teachers (76%) gave correct examples of IK ideas that are related to scientific concepts, such as making *Ombike*, *Oshikundu*, sour milk and one teacher (6%) did not give an IK example. Based on the findings above, it seems that teachers are aware of the importance of IK but they challenged by the implementation part (Shizha, 2007).

Table 9: Shows whether teachers were exposed to some kind of IK at home or in the community

Categories	**Teachers' Code**	**Frequency**
Teachers exposed to IK	T1Q5F, T2Q5F, T3Q5F, T5Q5M, T6Q5M, T10Q5M, T11Q5F, T12Q5F, T13Q5M, T14Q5F, T15Q5F	11
Teachers not aware of IK	T8Q5F	1
No answer	T4Q5F, T9Q5M	2
Off topic answers	T7Q5M, T16Q5F, T17Q5M	3

Figure 5 below presents the data regarding teachers' exposure to some kind of IK or not at home or in the community.

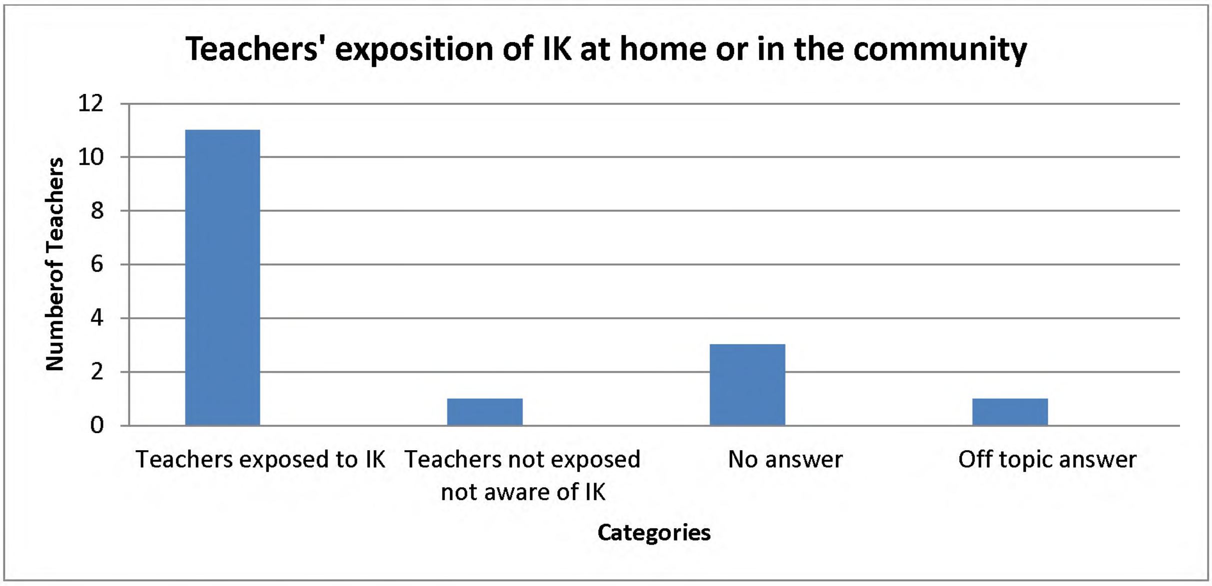

Figure 5: Exposure of teachers to IK

The data in Figure 5 above shows that11 teachers (65%) were exposed to some forms of IK and only one teacher (6%) indicated that she was neither exposed nor aware of IK. Based on the data presented in Figure 5, the majority of teachers (65%) were exposed to IK. when the teachers were asked to explain how they use IK in their lessons; many teachers were not able to describe how they do it. This might be due lack of training on the inclusion of IK in science as proposed by Shizha (2007) and Phiri (2008) in their studies.

Table 10: Were teachers taught IK at school and tertiary institutions?

Categories	Teachers' Code	Frequency
Taught IK	T6Q6M, T7Q6F, T10Q6M, T11Q6F, T13Q6M, T16Q6F, T17Q6F	7
Not taught IK	T1Q6F, T2Q6F, T4Q6F, T12Q6F, T14Q6F	5
No answer	T5Q6M, T9Q6M	2
Cannot remember	T8Q6F	1
Off topic response	T3Q6F, T15Q6F	2

Figure 6 below presents the data on whether teachers were taught IK at school and tertiary institutions.

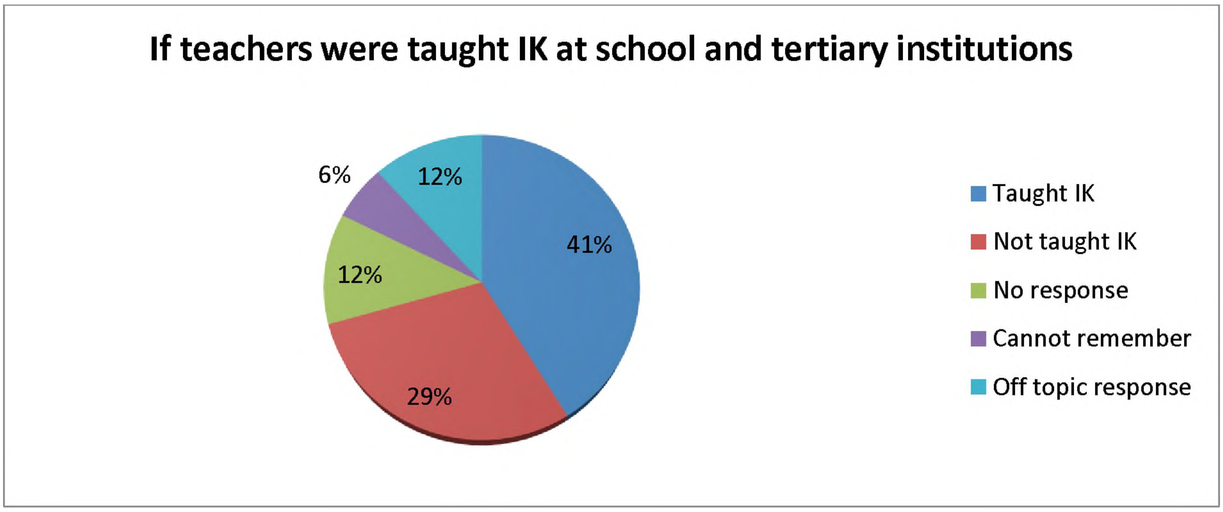

Figure 6: Shows the data on whether teachers were taught IK at school and tertiary institutions

Figure 6, revealed that six teachers (41%) were taught indigenous knowledge (IK), while five teachers (29%) were not taught IK. Of the 17 teachers, two teachers (12%) gave no answer or gave answers that did not answer the question and only one teacher (6%) indicated that she cannot remember whether she was taught IK or not. This data suggest that although some teachers indicated they were taught IK, this was mostly in the form of inferring (making reference to IK at home or in the community) but not as part of their teacher training.

Table 11: The teachers' usage of indigenous knowledge in their teaching

IK Usage	Teachers' Codes	Frequency
Have used IK	T1Q7F, T2Q7F, T3Q7F, TQ75M, T6Q7M, T10Q7M, T11Q7F, T13Q7M, T14Q7F, T16Q7F	10
Not used IK	T4Q7F, T7Q7F, T8Q7F, T12Q7F, T15Q7F, T17Q7M	6
Not sure	T9Q7M	1

The data from Table 11 is presented in Figure7 below.

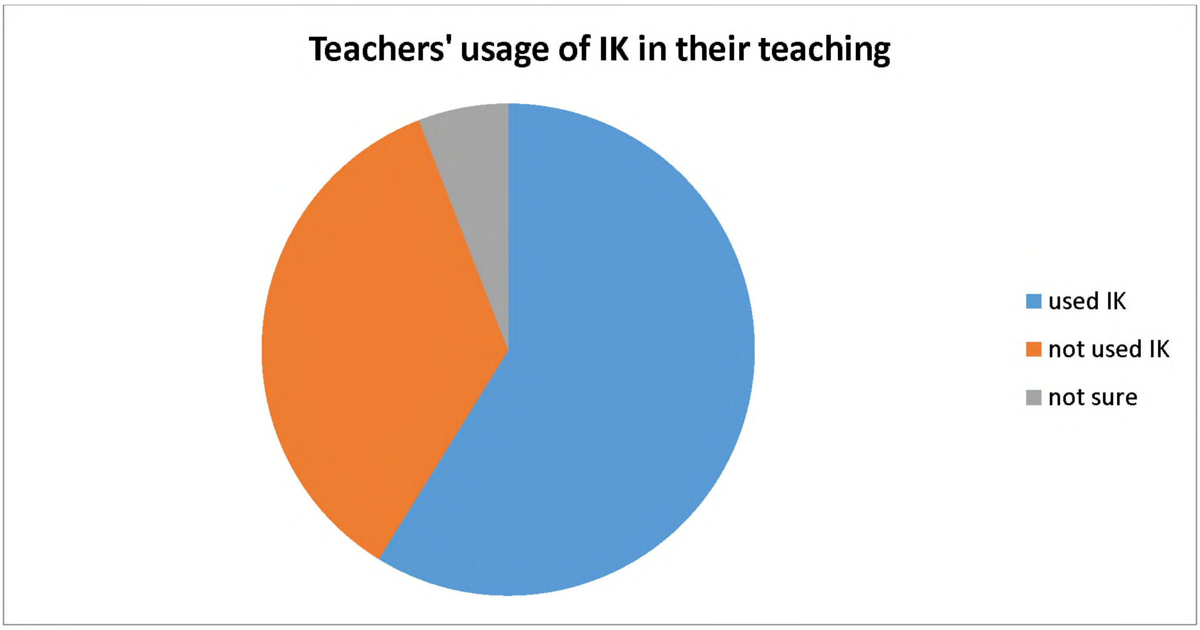

Figure 7: Teachers' usage of IK in their teaching

Table 11above shows that of the 17 Physical Science teachers, 10 teachers (59%) indicated that they do incorporate indigenous in their science lessons; whereas six teachers (35%) indicated that they do not incorporate it as shown in Figure7. This data suggests that the teachers are either making references to IK at home or are simply applying to learners' prior knowledge. From the questionnaire there is no clear evidence that the teachers have used IK, referring to their responses when they were asked to explain how they have used IK in their lessons. This is similar to the findings of (Phiri, 2008) that teachers claim to know IK and indicated that they use IK in their lesson but the data does not show sufficient evidence to support their claims.

Table 12: Teachers' views on why the teachers do not incorporate IK in the lessons

Categories	Teachers' Code	Frequency
No experience in doing practical work	T4Q7F	1
No topic that requires IK	T7Q7F, T8Q7F	2
Lack of resources	T12Q7F, T13Q7M	2
Preconceived ideas of the learners' content in the syllabus	T17Q7M	1
No answer	T1Q7F, T2Q7F, T3Q7F, T5Q7M, T6Q7M, T9Q7M, T10Q7M, T11Q7F, T14Q7F, T15Q7F, T16Q7F	9

Table 12 is presented in Figure 8 below.

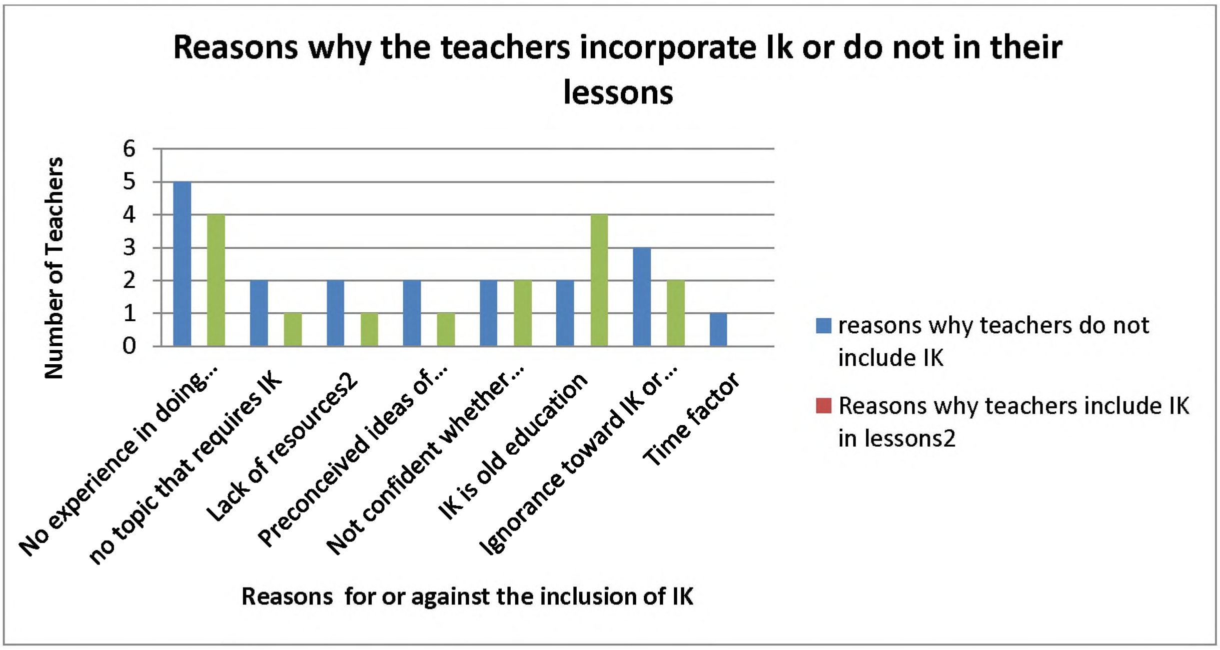

Figure 8: Reasons why teachers incorporate or do not incorporate IK in their lessons

Table 13: The advantages and disadvantages of incorporating IK in lessons

Advantages	Frequency	Disadvantages	Frequency
Used for cultural sustainability and for everyday life experience	1	If IK not well explored it might lead to misconceptions	3
Address challenges facing the society on environment	1	Some topics have no IK	1
Enhance concept understanding; arouse interest due to prior knowledge	6	IK not scientifically proven	1
Awareness of traditional methods/IK	1	Difficult to translate into English	1
Link context with content	2	Difficult to use in a multicultural environment	4
Make learning realistic	1	Time factor	2
Understand the importance of Physical Science in everyday life	1	Skepticism whether IK activities might not work	2
Preserve heritage	8		

Table 13 above shows the summary of the advantages and disadvantages of incorporating IK in lessons gathered from the teachers' questionnaires. From the table, the data indicated that six teachers (35%) said that IK enhances concept understanding and arouses interest amongst learners. Two teachers (12%) indicated that IK links the context to the content that the learners are learning. One teacher (6%) indicated that IK is used for cultural sustainability and for everyday life; addresses challenges facing the society on environment; creates awareness of traditional methods/IK; makes learning realistic and leads to an understanding of the importance of Physical Science in everyday life.

In contrast the teachers also highlighted some disadvantages associated with IK. Four teachers (24%) said that it is difficult to use IK in a multicultural environment; three teachers (18%) said that if IK is not well explored it might lead to misconceptions; two teachers (12%) said that the time factor was a hindrance and skepticism of whether IK activities would work when used and at least one teacher (6%) said that some topics have no IK; IK not scientifically proven and it is difficult to translate IK indigenous practices into English.

Table 14: Teachers' views on incorporating IK in the Syllabus and Lesson Plans

Statement	Strongly Agree	Agree	Not sure	Disagree	Strongly Disagree	No Response	Total
Syllabus	T1Q10F, T3Q10F, T7Q10F, T8Q10M, T10Q1M T11Q10F, T12Q10F, T14Q10F, T15Q10F, T16Q10F, T17Q10 M	T2Q10F, T6Q10M	T4Q10F	T510M, T13Q10M	0	T9Q10M	**17**
Total	**11**	**2**	**1**	**2**	**0**	**1**	**17**
Lesson Plans	T1Q10F, T7Q10F, T8Q10M, T11Q10F, T12Q10F, T15Q10F	T2Q10F, T3Q10F, T13Q10M T16Q10F, T17Q10M	T4Q10F, T6Q10M, T10Q10 M	T5Q10M	0	T14Q10F, T9Q10M	**17**
Total	**6**	**5**	**3**	**1**	**0**	**2**	**17**

Table 14 below shows the views of teachers on incorporating IK in the syllabus and in their lessons plans. There is a strong relationship between Tables 4 and 5. In Table 5, 10 teachers (59%) indicated that they are using IK while in Table 5, 11 teachers (65%) also strongly agreed that they do incorporate IK in their lessons. This could be attributed to the fact that the same teachers opted for strongly agreed and agreed in both Table 14 and 15 respectively (see the teacher's codes in Table 2 and 3).

Figure 7, revealed that the majority of the Physical Science teachers strongly agree that indigenous knowledge (IK) should be integrated in science lessons. Of the 17 teachers, 11 teachers (65%) strongly agreed for IK to be incorporated in science lessons, and at least 1 to 2 teachers agreed, or were not sure, disagreed or did not indicate their choices. In the same figure, six teachers (35%) strongly agreed that IK can be included in lesson planning, five teachers

(29%) agreed, three teachers (17%) were not sure, one teacher disagreed and two teachers did not indicate their choice. Figure 7 clearly shows that the majority of teachers would like IK to be part of the syllabus.

Table 15 below shows the views of teachers on whether IK should be included in the lesson delivery and in practical activities. Of the 17 teachers, 11 strongly agree and agree (65%) with IK integration in lesson delivery and during practical work/activities. There is a strong relationship between what the teachers said about the inclusion of IK in the syllabus and lessons plans with what the teachers said about the lesson delivery and practical activities. Tables 14 and 15 show some consistent trends in the teachers' responses. This might be due to the fact that the same teachers who opted for inclusion of IK in the syllabus and lesson plans are the same teachers who opted the inclusion of IK in lessons delivery and in practical work.

Table 15: Teachers' views on whether IK should be included in the lessons delivery and in practical activities

Statement	Strongly Agree	Agree	Not sure	Disagree	Strongly Disagree	No Response	Total
Lesson delivery	T1Q10F, T3Q10F, T7Q10F, T8Q10M, T10Q10M, T11Q10F, T12Q10F, T14Q10F, T15Q10F, T16Q10F, T1710M	T2Q10F, T6Q10M. T13Q10M	T4Q10F	T5Q10M	0	T9Q10M	**17**
Total	**11**	**3**	**1**	**1**	**0**	**1**	**17**
Practical work/activities	T1Q10F, T7Q10F, T8Q10M, T1Q101F, T12Q10F, T14Q10F, T15Q10F, T16Q10F	T2F, T3F, T6M, T10M	T4F, T17F	T5M, T13M	0	T9M	**17**
Total	**8**	**4**	**2**	**2**	**0**	**1**	**17**

Figure 9 shows that out of 17 teachers, 11 teachers (65%) strongly agreed for IK to be incorporated in lesson delivery and (6%) disagreed or did not respond. The figure above further reveals that 8 (47%) of teachers strongly agree to integrate IK in practical work/activities, and six of teachers (12%) were either not sure, disagreed or did not respond. These results show that the majority of teachers are in favour of the inclusion of IK in lesson delivery and in practical work/activities as shown in figure 9 below.

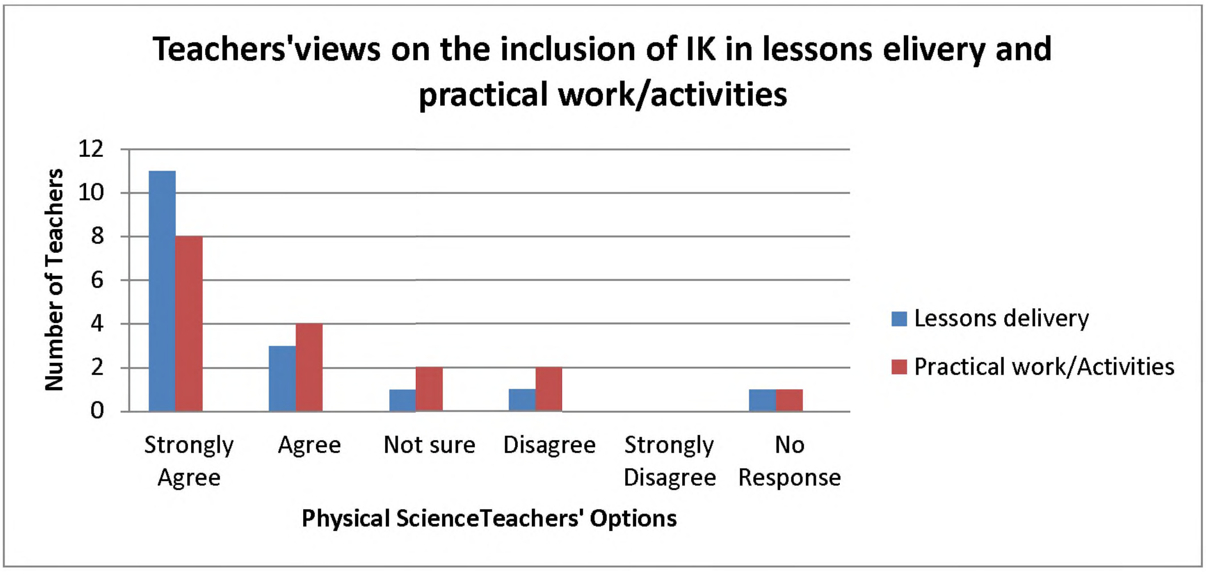

Figure 9: Views of teachers on IK: Lesson delivery and Practical work/Activities

Based on the findings that are reflected in Figure 1in relation to teachers' usage of IK, 10teachers (59%) indicated that they do incorporate/use IK when teaching science, while between one and two of the teachers are not using IK and one teacher (6%) was not sure if he is integrating IK or not. This finding corroborates with literature that teachers are strongly advocating for the inclusion of IK Phiri, (2008). However, Shizha (2007) posits that the challenge lies with the implementation part because IK was never part of the teachers' training in the past and it is not part of the curriculum/syllabus. For these reasons teachers are mostly teaching western science and western related approaches that they were exposed to Phiri (2008). Concurring, Dziva, Mpofu and Kusure (2011) support the fact that the teachers' conceptions and perceptions of IK is greatly influenced by the covert nature of the secondary school science syllabus on IK. Ten of the seventeen teachers (59%) indicated that they have used IK in their lessons. Evidence of an ability to provide examples of IK used by these teachers is explored further below.

From the findings (Tables 14 and15) on whether IK should be incorporated in the syllabus; lesson plans; lesson delivery and practical work/activities, the data revealed that 65%; 35%; 65% and 47%) respectively strongly agreed that IK should be integrated. While12%; 29%; 18% and 24% of the teachers agreed that IK should be included in the syllabus; lesson plans; lesson delivery and in practical work/ activities. While only 6% and 18% indicated they were not sure whether IK should be integrated and only 6 % -12% disagreed that IK should be integrated which is similar to 6% - 12% of teachers who did not indicate whether IK should be integrated in the syllabus; lesson plans; lesson delivery and in practical work/ activities respectively. These findings are similar to those of Ramorongo and Ogunniyi (2010) who highlighted that teachers have different views and experiences on the inclusion of IK in science.

Table 16: The teaching methods currently used by teachers to teach the topic experimental techniques- fermentation and distillation

Categories	Teachers' Code	Frequency
Explain the syllabus content and make references to related indigenous practices	T1Q11F	1
Do experiments in the lab using conventional materials as per syllabus	T2Q11F, T11Q11F, T13Q11M, T15Q11F, T16Q11F	5
Make use of diagrams and posters to teach the topic	T3Q11F, T10Q11M	2
Teach the topic theoretically	T4Q22F	1
Did not teach this topic	T7Q11F	1
Used group discussion	T17Q11M	1
No answer	T5Q11M, T6Q11M, T8Q11F, T9Q11M, T12Q11F, T14Q11F	6

The data in Table 16 is further presented in Figure 10 below on the teaching methods currently used by teachers to teach the topic experimental techniques-fermentation and distillation

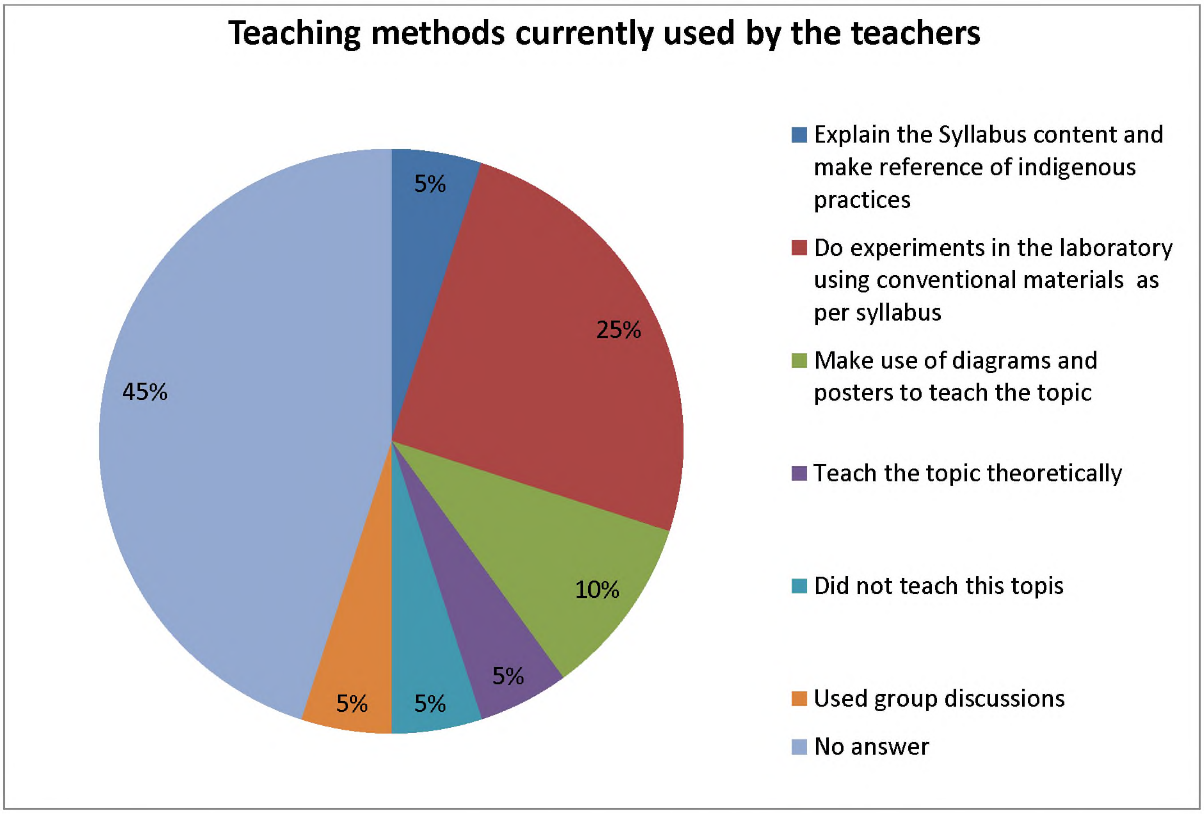

Figure 10: Shows the teaching methods currently used by teachers to teach the topic experimental techniques-fermentation and distillation

Figure 10 revealed that five teachers (25%) do experiments in the laboratory using conventional materials as per syllabus; two teachers (10%) make use of diagrams and posters to teach the topic; six teachers (45%) did not indicate the teaching methods they are currently using to teach the topic and one teacher (5%) said that they explained the syllabus content and make reference to related indigenous practices; teach the topic theoretically; did not teach this topic or used group discussion.

The data presented in Table 16 and Figure 10 show a similar trend with that of Ramorongo and Ogunniyi (2010) who observed that science teachers have been schooled largely in the scientific worldview and they have not been prepared to implement a science-IKS curriculum. Also, Shizha (2007) found that teachers' preparation and courses taken in teachers' colleges do not incorporate indigenous knowledge in the science curriculum and pedagogical practices. Thus, these findings suggest that, although the majority of teachers are positive about the inclusion of IK in teaching they are challenged by the lack of pedagogical content knowledge on the integration of IK which is absent in the curriculum.

4.3 Qualitative Data

The qualitative data from the questionnaires (open-ended questions) and semi-structured interviews are presented, analysed and discussed in this section. The qualitative data answered the following research sub-questions 1 and 2:

1. What are Grade11 Physical Science teachers' perceptions and experiences of the inclusion of indigenous knowledge during science lessons?
2. What factors influence Grade11 Physical Science teachers' perceptions and experiences of the inclusion of indigenous knowledge?

4.3.1 Qualitative Data from the Questionnaires

The qualitative data from the questionnaires were collated and colour coded to form categories. The common categories that emerged from the data were grouped to form themes. The categories that emerged from the questionnaires in order to answer the above two questions are: awareness of IK in communities; female responses /gender patterns in terms of knowledge transfer; experience of community members; IK is associated with misconceptions; cultural diversity and lack of resources and classroom size constraints regarding the inclusion of IK in science classrooms (see Table 17 below for the details).

Table 17: Generating themes from codes

Teachers' Codes	Description of marked text	Categories	Sub-question
T1Q1F,T2Q1F, T4Q1F, T14Q1F, T17Q1M	Local knowledge, expertise possessed; unique to specific culture or society; native/prior existing knowledge; cultural/ traditional norms and values; not scientifically proven, knowledge that is local based in a community; oral methods, not formally taught	Awareness of IK in communities	1
T2Q1F, T7Q1F, T8Q1F, T11Q1F, T14Q1F, T15Q1F, T16Q1F	Knowledge that we gain; IK is driven by local community; knowledge about our traditions; knowledge that we gain from society	Female response/ gender pattern in terms of knowledge transfer	1
T1Q3F, T6Q3M	Local people possess more knowledge; parents use techniques to solve problems	Experience of community members	2

T4Q3F, T7Q3F, T8Q3F, T11Q3F,T14Q3F	Mislead learners; not scientifically proven; traditional beliefs, instruments not giving accurate results; multicultural schools; language barrier	IK is associated with misconceptions	2
T11Q3F, T14Q3F	Misconceptions due to language barriers; teachers' background and that of the learners	Cultural diversity	2
T12Q3F, T13Q3M, T15Q3F, T16Q3F	Lack of resources; availability of local materials; overcrowded classrooms for experiments.	Lack of resources and classroom size constraints regarding the inclusion of IK in science classrooms.	2

4.3.2 Results from the semi-structured interviews

The transcripts of the two teachers who were interviewed were analysed in detail. The teachers' quotes that responded to sub-questions 1 and 2 were marked and colour coded (see Table 7 below). The marked text for T1 and T2 that were related were grouped to form **Categories**. For triangulation purposes, the **Categories** from questionnaires and interview transcripts were then combined to form themes in Table 8.

The two teachers were given codes for identification purposes. For example, T1-I stands for Teacher one- Interview while T2-I stands for teacher two- Interview as seen in Table 7 below.

Table 18: Generating Categories from interviews

Teachers' Codes	**Description of marked text-T1-I**	**Description of marked text-T2-I**	Western Knowledge (WK) **Categories**	**Sub-question**
T1-I,T1-2	Is more practical, learning by discovery, learn by doing IK can be used to relieve the shortage of scientific equipment in schools - contextualization of science - presence of prior knowledge - teachers make references to IK during lessons	-Understand better how to separate mixtures - learners tend to ask more questions - Learners enjoy/ interesting when content is related to that found at home. - learners understand better when IK is used	Potential regarding the inclusion of IK	1

	- IK make lessons interesting - IK unites learners from different cultural backgrounds - helps learners to know the relevance of the topics they are learning	- background knowledge makes learners understand easily/ prior knowledge		
T1-I, T2-I	- teachers' cultural background - IK not documented - cultural diversification/cultural inclusion - lack of resources - lack of knowledge on how to incorporate IK - attitudes of learners to IK - misconceptions that IK is old fashioned.	- mixed cultures makes it difficult to incorporate IK/ teachers do not know all the cultures - lack of IK resources - lack of expertise in IK - time factor (inclusion of IK syllabus -not all topics can incorporate IK	Challenges associated with IK	2

After grouping the common **Categories** from Tables 17 and 18 above, the following themes emerged.

- Awareness of IK;
- Potential regarding the inclusion of IK in science classrooms;
- Constraints regarding the inclusion of IK in science classrooms; and
- Cultural influences.

The themes above are presented in relation to sub-questions and the supporting theory/literature as indicated in the table below.

Table 19: Themes and supporting literature/theory

Themes	Research Sub-questions	Theory/Literature
Awareness of IK in communities	1	Webb (2013)
Potential regarding the inclusion of IK in science classrooms	1 & 2	Ogunniyi (2009)
Cultural influences	1 & 2	Aikenhead and Jegede (1999); Ogunniyi and Ogawa (2008); Shizha (2007); Klein (2011)
Constraints regarding the inclusion of IK in science classrooms	2	Aikenhead and Jegede (1999), Ogunniyi and Ogawa (2008)

I now discuss each of these themes below.

4.4 Themes that emerged from the data

The themes that emerged from the data either highlight the benefit of IK or the challenges of incorporating IK as discussed below.

4.4.1 THEME 1: Awareness and characteristics of IK in communities

Information from the questionnaires revealed that 16 of the 17 teachers (94%) showed some awareness of IK with only (T9Q1M) who left the questionnaire blank. This is similar to Webb's (2013) findings that there was shared awareness of IK across the respondents (teachers). Of the 17 teachers, 11 teachers (65%) were females and their responses were far more detailed in comparison with their male counterpart. For example, T1Q1F wrote that: "*IK is local natural knowledge and expertise possessed by the local community*", while T14Q1F defined IK as "*knowledge that is unique to a given society or culture and it is local based knowledge"* and teacher T15Q1F defined IK as "*local knowledge that is unique to a given culture or society*". The data suggests that the respondents are aware of what IK is. However, women seemed to be more knowledgeable about IK associated with *Ombike* preparation than men. This was shown by their detailed explanations (see Appendix I). This could be attributed to the cultural norms that the indigenous practice of making *Ombike* is a female activity. Also, this could be due to the fact that the majority of the teachers (65%) who participated were female *Oshiwambo* speaking. The data also showed that the majority of the female teachers (7) have attained Honours Degrees as compared to only one male teacher who attained the same qualification. Thus, the level of education might have an impact on the teachers' understanding of IK.

4.4.2 THEME 2: Potential regarding the inclusion of IK in science classrooms

From the questionnaires and semi-structured interviews the following categories emerged; teachers' responsiveness (positive) to IK; knowledge transfer; expertise possessed by communities; learning by doing; scientific knowledge embedded within IK and usefulness of IK/teachers usage of learners' prior knowledge. Most of the respondents indicated a variety of advantages that are associated with the inclusion of IK in science lessons. I begin with the teachers' openness towards the inclusion of IK.

From the data, 14 of the teachers (82%) gave positive responses on the inclusion of IK in science. For example, T3Q2F; T12Q2F; T15Q2F explained in detail the benefits of including IK in science. The data indicated that most of the teachers have a positive attitude towards the inclusion of IK. However, when teachers were asked to explain how to integrate IK, the data indicated that the teachers only made passing references to some indigenous practices instead of bringing the actual material to do practices or demonstrations. These findings suggest that, teachers are aware of the importance of IK but the challenge lies with its implementation. Regarding practical work, T1-I commented that:

> *"learners were able to be shown how fermentation and distillation process occur, IK is more of practical 'kids' are learning by discovery; proving scientific methods and then I have done it in a traditional way which was very interesting to the learners not only in the scientific laboratory but even at home in our home we can also do some of these scientific methods of separating like fractional distillation in a more traditional way"*

The teachers' interaction and participation in their communities' cultural activities facilitated acquisition of new knowledge through practical experiences (Radzik-March & Strutchens, 1994). To this end, T2 elaborated that, "*IK is more interesting to the learners*".

Teachers' usage of learners' prior knowledge

The data from the questionnaires and interviews indicated various prospects of integrating IK in science (see Tables 6 and 7). For example, T1-I said.

> *"Luckily, I am from one of the rural areas where that one happened in African way and when I went to show it was taught almost the same way it was done at home. When I went to school I was having the prior knowledge"* (T1).

As suggested by other scholars such as Roschelle (1995), Kibirige and van Rooyen (2006) and others, IK enhances conceptual understanding since learners are able to cross borders from what they know to the new content.

4.4.3 THEME 3: Cultural influences

What has emerged from the data is that teachers are challenged by the multicultural schools where they found themselves. They urged that, since they only know their own culture where they are from, it is difficult for learners to understand the cultural practices they were not exposed to and vice versa. Similarly, Webb's (2013) study found that the reasons stated by the majority of respondents were that IK needed to be integrated in the curriculum due to related issues of cultural heritage and dignity. From the interview T1-I described the factors that influenced the teachers' perceptions and experience

> "*It depends on where the teacher grew up and sometimes people just want to copy everything from the western cultures*".
>
> While T2-I said "*one must have strong cultural background; it also it depends on where the person is from and it is very difficult to understand your culture and the culture of all your learners in a multicultural school*".

This is similar to what, Atwater; Radzik-March; and Strutchens (1994) who posit that hardly and teachers incorporate multicultural science teaching strategies in their science classroom. Their study further argued that incorporating multicultural education in Science; teachers will be able to assist their diverse students to have a smooth border- crossing from IK to western knowledge (Aikenhead & Jegede, 1999).

In addition to that, the context in which teachers live and work influences their perception about teaching and learning, thus, the teachers' culture influences the way they view their teaching and learning of school science (ibid). For example, four teachers commented that:

"*It is very difficult to use IK in a multicultural school when the teacher only knows his/her culture*" (T1-I).

"*The fact that we teach multi diversity of different Namibia culture or tribe and another child from another tribe might understand which I am trying to trying to say/ demonstrate*" (T11Q3F).

"*Language barrier e.g. Omakwila is Oshiwambo word so Damaras won't know what you are talking about vocabulary that you can use from indigenous knowledge and cultural difference/background of the learners*" (T14Q3F).

"*Background of the teacher and the learner- sometimes the background where the teacher came from is not the same as the learners so it will be difficult for the learners to understand what example the teacher is giving as his/her indigenous knowledge*" (T16Q3F).

4.4.4 THEME 4: Constraints regarding IK in science classrooms

From the questionnaire and interviews, the teachers indicated that there are obstacles that limit them from using IK in their lessons. For example, misconceptions that are embedded in IK; cultural diversity in schools; lack of knowledge about IK integration; teachers' responsiveness to IK (negative); lack of teachers' training in IK; multicultural or language barrier; and lack of resources.

The data obtained further revealed some of the challenges the teachers experienced when incorporating IK. For example, T1-I expressed that:

"I did not have fruits to do fermentation (lack of resources); you need someone who has knowledge on how to make Ombike to explain the whole process; it depends on the number of topics to be covered in the syllabus and not all topics require IK integration".

Additionally, T2-I highlighted the following challenges; "*most of the materials are not available at all; sometimes you find yourself teaching up to 12 ethnic groups in one classroom*".

4.5 Concluding remarks

This chapter presented, analysed and discussed the data collected from questionnaires (closed ended and open-ended questions) and the semi-structured interviews. The key findings from the data suggest that teachers are aware of the importance of IK. They also know some IK practices from their homes or communities. However, the data revealed that teachers have no idea how to integrate IK in their lessons, as this information was not part of their training nor is it provided in the syllabus.

In the next chapter, the data from the lessons observations and practical demonstration observations are presented, analysed and discussed.

CHAPTER 5: DATA PRESENTATION, ANALYSIS AND DISCUSSION (PHASE 2)

5.1 Introduction

The aim of this study was to explore how Grade11 Physical Science teachers mediate learning of concepts on experimental techniques conventionally and through the inclusion of a practical demonstration on making *Ombike*. This chapter thus presents analyses and discusses the data gathered from observations. The qualitative data were inductively analysed and categories emerged from it. Thereafter, the common categories were combined into themes in relation to the literature/theory to answer the following research sub-questions 3 and 4:

- How do Grade11 Physical Science teachers teach experimental techniques such as fermentation and distillation
- Does the practical demonstration of making *Ombike* enable or constrain the teaching of fermentation and distillation?

I first present the data from the lesson presentations, followed by the data gathered from the practical demonstration of making *Ombike*.

5.2 Results from the lesson observations and practical demonstration

The data from the observations of lesson presentations are presented, analysed and discussed to answer my sub-question 3; while the observations from the practical demonstration are presented, analysed and discussed to answer my sub-question 4 as highlighted above.

5.2.1 Results from the lesson observations

The data from the lessons observations were analysed inductively to come up with categories. The codes T1 and T2 were used to identify the teachers while LL stands for statements made by the learners in class. The marked texts were selected using lesson observation schedules which were completed through transcribing the video tape recorded during the lesson presentations.

From the data gathered, it was also evident from the lessons that the teachers considered learners' prior knowledge by asking how *Ombike* is prepared and by asking for any local names. However, I observed at some point during the lessons that IK and science content were still treated as two separate items instead of being merged. The gap between IK and science content still existed during the lessons and no attempt was made to connect them. Teachers seem to struggle to cross the border of IK into science.

Figure 11: Shows one of teachers teaching

However, during the practical demonstrations, I observed that the teachers explained the scientific concepts that emerged from the practical demonstrations most efficiently. When the community member explained the process in her local language (Oshiwambo), the teachers linked the emerging concepts to the content in the syllabus. What was interesting was that even the non-Oshiwambo speaking learners were able to follow the process, ask questions and also explain what occurred at home. This might be because, apart from the language barriers, the learners were able to see and manipulate the materials themselves. Similarly, Hodson (1990) views the purpose of practical activities as a means to motivate learners by stimulating their interest, curiosity, excitement and enjoyment.

Table 20: Generating preliminary themes from codes

Research sub-question 3: How do Grade11 Physical Science teachers teach experimental techniques such as fermentation and distillation?		
Teachers' Codes	**Description of marked text from the observations**	**Categories**
T1, T2	How do you make alcohol at home? What do you use to produce alcohol?	Teachers make use of everyday knowledge
T1, T2	Mix ethanol with water and separate them using fractional distillation due to different boiling points	Use conventional materials
T1, T2	What do you call a condenser in your language?	Cultural inclusivity
T2	You see these bubbles it means fermentation has begun, come this side to see how alcohol is coming out, come this side Now let us observe the colour change for you to see	Learning by doing/seeing/practical work
T2	*Ombike* is traditional alcohol type made from fermented indigenous fruits, LL - What is *Ombike* Sir? LL- we don't make *Ombike* at home	Language barrier
T2	This solution we can make alcohol from glucose that we extracted from fruits, take this solution and put in a flask and heat it	Lack of content knowledge
T1	Teacher draws the diagram on the chalkboard and uses it to explain and made reference to the posters pasted on the wall.	Uses of posters and diagrams

5.2.2 Results from the practical demonstration

The practical investigation was done in two parts. The first part was to soak the palm fruits pieces in water in order extract glucose or sugar to show the fermentation process. Table 21 below shows the duration of soaking date and time and the observations made. The second part was used to demonstrate the fractional distillation process.

Table 21: Shows the duration and observations of fermentation of pieces of palm fruits

Date	Date & Time	Observations
	07:00 18.00	Soaking of palm fruits begins At 18:00 foam observed with effervescence/fizzy sound and almost all pieces of palm fruits floating. Warm water was used because the ambient temperature was very low to increase that rate of reaction
27.07.16	07:00 18.00	No foam. No effervescence and pieces still floating At 18:00 pieces floating, no effervescence Day 1 observations were caused by the warm water used
28.07.16	08:00	pieces still floating , no effervescence
.07.16	08.00	Little effervescence and little fizzy sound observed, pieces still floating
530.07.16	08:00	Bubbles observed/effervescence/fizzy a little more than the previous day. *Ombike* begins to smell, pieces still floating.
31.07.16	08:00	Fermentation/effervescence/fizzy sound increases, pieces floating, smell of *Ombike*
01.08.16	08:00	Fermentation/effervescence/fizzy sound increases, pieces floating, smell of *Ombike* few pieces start to sink
02.08.16	08:00	Fermentation/effervescence/fizzy sound increases, pieces floating, smell of *Ombike* more pieces sink
03.08.16	08:00 19:00	Fewer pieces remain floating, /more bubbles/more effervescence/more fizzy sound. At 19: 00 floating pieces become less and *Ombike* smell is stronger.
04.08.16	08:00 19:00	Only less than ten pieces still floating, very little effervescence. At 19:00 no pieces floating/all the pieces have sunk, no or very little effervescence is observed.
05.08.16	05.08.16 08:00	No pieces floating, fine bubbles, smell of *Ombike* This is a sign that glucose is completely extracted from the pieces of palm fruits and hence the mixture is ready to be distilled

 **Figure 12 The initial stage of soaking of Palm fruit pieces**	 **Figure 13: The soaking of Palm fruit pieces toward the end.**

In figure 13, fermentation it is in process as shown by the bubbles and foam on the picture and as the sugar is extracted for fermentation to take place the pieces sinks

Table 22 below shows how the themes were generated from the data collected. The following codes were used for identification: T2= teacher two; T1= teacher one; and CE= community expert. The common texts were grouped to form categories.

Table 22: Table 22: Generating preliminary themes from codes

Research sub-question 4: How does the inclusion of the practical demonstration on making *Ombike* enable or constrain Grade 11 Physical Science teachers when explaining concepts on experimental techniques - fermentation and distillation?		
Teachers' Codes	**Description of marked text from the observations**	**Categories**
T1/T2	This is a condenser with cold water, what is the function of a condenser, what is the name of condenser in Nama? "Esdrom" What is the name of alcohol in our local languages, ethanol is *Ombike/Kashipembe/karhart*	IK makes science interesting/ promotes social interaction/ learners' responsiveness
CE	*Ombikeohaininingwamoinimaihapungaashimemweenge, omanuwaOtoduluokulongifaEengalanadila, Eenghuyu,*	Involvement of community members
T1/T2	What is the name of a condenser in Nama, in Afrikaans? Any translation in Nama/Damara and Afrikaans	Cultural inclusivity

T1/T2	You see these bubbles it means fermentation has begun. Come this side to see how alcohol is coming out. Come this side Now lets us observe the colour change for you to see	Learning by doing practical work Learning by seeing practical work
T1/T2	I will repeat it in English my colleague in Oshiwambo, Van Neel will translate in Afrikaans, Trompy in Khoekhoewab … who will translate in Afrikaans?	Language barrier
T1/T2	From this solution we can make alcohol from glucose that we extracted from fruits. You take this "solution" and put in a pot like this	Lack of content knowledge

From the data presented in Tables 20, 21 and 22 the following themes emerged after grouping the common categories.

- Potentialities regarding the inclusion of IK in science classrooms;
- Constraints regarding the inclusion of IK in science classrooms; and
- Cultural influences.

The themes above are presented in relation to sub-questions and supporting theory/literature indicated in the table below.

Table 23: Themes and supporting literature/theory

Themes	**Research Sub-questions**	**Theory/Literature**
Potentialities regarding the inclusion of IK in science classrooms	3 & 4	Ogunniyi (2008)
Cultural influences	3 &4	Aikenhead and Jegede (1999), Ogunniyi and Ogawa (2008); Shizha (2007); Klein (2011)
Constraints regarding the inclusion of IK in science classrooms	3 &4	Aikenhead and Jegede (1999), Ogunniyi and Ogawa (2008)

5.3 Discussion of the qualitative data

This section discusses the findings on the Grade11 Physical Science teachers' perceptions and experiences on the teaching of the topic experimental techniques-fermentation and distillation conventionally and through the indigenous practice of making *Ombike*. These discussions mainly focused on the findings for sub-questions 3 and 4. The discussion is structured into the following themes;

- Potential regarding the inclusion of IK in science classrooms;
- Cultural influences; and
- Constraints regarding the inclusion of IK in science classrooms

I now discuss each of these below.

5.3.1 Potential regarding the inclusion of IK in science classrooms

The data clearly reveal that teachers are aware of the value of IK in their communities (see Tables 5; 6; 13; 18 & 22). The teachers highlighted some benefits of IK that enable learners to understand science concepts and develop an interest in learning science. This occurs because the learners are able to link school science with every day experience as proposed by Aikenhead (1996) and Le Grange (2007). The study revealed that the process of making *Ombike*is similar to the process of fermentation and distillation described in the syllabus. It is made from various types of fruits depending on their availability and hence this has localised learning and makes it more relevant. These findings corroborate Woodley's (2009) findings that practical work is a 'hands-on' learning experience that prompts thinking about the world in which we live.

The study revealed that most of the apparatus can be substituted with the local available materials to carry out the fermentation and distillation processes. The findings further indicated that the process of making *Ombike* helped learners to make sense of the topics fermentation and distillation in the classroom as they could describe these processes in class. This is equates with Czerniewicz, Murray and Probyn (2000) who found that the development of learning and teaching support materials (LTSMs) that are relevant to the learners' everyday lives will making learning interesting and meaningful.

From the interview, (Appendix: T1-I) said:

"It is important to use IK in our lessons, because it is very practical and interesting, 'kids' are learning by discovery". This quote suggests that teachers are positive about the inclusion of IK and they see how much value it can contribute. These findings complement Uushona's (2013) findings that making *Ombike* can enhance meaning making in science lessons.

5.3.2 Cultural influences

The findings that emerged from this study indicated that the cultural indigenous knowledge (IK) and skills acquired through the demonstrations by the community member could be used by teachers to improve the teaching of the topics of fermentation and distillation and lead to greater understanding by the learners. From the observations made during the lessons and the observations of the practical demonstration, there was a clear difference in terms of learners' participation, use of probing questions, learners' engagement and the interest of the learners. In some of the lessons presented, the teachers used the question and answer method and explained the concepts theoretically and only gave example in some instances. I observed that in these cases the learners were more reserved and the teachers did most of the talking. In comparison, during the practical demonstrations, there was social interaction and discussion and the learners asked more questions. These observations resonate well with the study by Kibirige and Van Rooyen (2006); Millar (2011) and Woodley (2009) who posit that practical work enhances learners' engagement, interest and conceptual understanding.

Throughout the investigation I realised that there was a lot of useful indigenous knowledge and practices that are hidden in the community which could be used more fruitfully in science learning (Shifafure, 2014; Rennie, 2011). During the practical demonstration of making *Ombike* by the community member it was revealed that there is specific scientific knowledge embedded in the making of *Ombike* even though it is not known by some educators. The Ministry of Education who compile the Namibian curriculum and syllabus are also not explicitly including the use of IK. This could be due to the fact that the teaching of science did not include indigenous knowledge in their training Van Wyk (2002). Thus, cultural science can be useful in areas where it is being practised and especially where there is a lack of learning and teaching materials.

5.3.3 Constraints regarding the inclusion of IK in science classrooms

As indicated in Tables7; 12; 13; 18; and 22, some challenges or constraints that inhibit the teachers from successful integration of IK were revealed. Although the data indicated a number of obstacles mentioned by the teachers; ranging from ethnicity, time factor, and misconceptions among others, the lack of teachers' training on IK could be the main contributing factor to its omission. These teachers indicated these challenges in the questionnaires, during the interviews and they were also observed during the lesson presentations. Interestingly, the same could not be said when the community member demonstrated the making *Ombike*. Although not all learners were Oshiwambo speaking, the learners were very interested and very observant. They kept asking the teachers to explain further and also asking other learners to explain more in their language so they could understand and express the ideas better.

This resonates well with the findings of Maselwa and Ngcoza (2003), who argued that, if learners are given a chance to bring in their ideas about science and engage in 'hands-on' and 'minds-on' activities, they are likely to learn more efficiently and at their own pace. This means that the practical activity enabled learners to learn in different ways, apart from listening which sometimes creates a language barrier, the learners could observe and manipulate the materials to make sense of what they are learning.

5.4 Concluding remarks

This chapter presented, analysed and discussed the data collected from lessons observations and practical observations. The key findings from this data suggest that teachers are aware of the importance of IK. They also know some indigenous practices from home or their communities. However, the data revealed that teachers are challenged by the lack of knowledge (PCK) on how to integrate IK in their lessons.

In the next chapter, the summary of the key findings, recommendations, areas of further research, limitations of the study and conclusion are discussed.

CHAPTER 6: SUMMARY OF FINDINGS, RECOMMENDATIONS AND CONCLUSION

6.1 Introduction

The main aim of this study was to explore on how teachers mediate learning of experimental techniques using fermentation and distillation of a traditional brew. In this chapter, I first discuss the summary of the key findings from my study, followed by the recommendations and areas of future research. I then highlight my personal reflections of my research journey and lastly conclude the study. I thus present the summary of the key findings in relation to my research sub-questions:

1. What are Grade 11 Physical Science teachers' perceptions and experiences with the inclusion of indigenous knowledge during science lessons?
2. What factors influence Grade 11 Physical Science teachers' perceptions and experiences of the inclusion of indigenous knowledge?
3. How do Grade 11 Physical Science teachers teach experimental techniques fermentation and distillation?
4. How does the inclusion of the practical demonstration on making *Ombike* enable or constrain Grade11 Physical Science teachers when explaining concepts on experimental techniques - fermentation and distillation?

The four research sub-questions helped me to answer my main research question:

> How do Grade 11 Physical Science teachers mediate learning of concepts on experimental techniques conventionally and through the inclusion of a practical demonstration on making *Ombike?*

6.2 Summary of the findings

Research sub-questions 1:

What are Grade11 Physical Science teachers' perceptions and experiences on the inclusion of indigenous knowledge during science lessons?

The data that emerged from the teachers' questionnaires and the teachers' interviews strongly highlighted the importance of IK in science classrooms. Similar to Webb's (2013) findings, the teachers, especially the female respondents, showed some awareness of IK by defining the term IK and giving detailed examples. The teachers highlighted the issues of cultural heritage and dignity which underlines the necessity of an IK school curriculum. In addition, the teachers felt that IK as a tool the can be used to enhance learning. For example, T1Q2F and T15Q2F explained that:

> *"IK sets a good link with academic knowledge to be learned at school"* (T1Q2F) and
>
> *"IK improves learners' understanding and applications"* (T15Q2F).

The above excerpts resonate well with the research studies by Le Grange (2012) and Simasiku (2016), who posit that integrating indigenous knowledge into science lessons helps learners to make connections between the indigenous and western worldviews. Thus, the science teaching that acknowledges learners' knowledge and culturally-based ways of thinking has the potential to make science more meaningful to learners.

This concurs with the teachers (T13Q2F; T16Q2F; T1-I and T2-I) who affirmed: *"IK makes the lessons interesting" and "IK improves performance".* This links well with what Roschelle (2009) and Khulane (2011) argued that, learners understand better when the materials presented to them is familiar. This suggests that when the teachers do incorporate IK in their lessons learners tend to probe more and there are increased social interactions between the teacher and learners and among the learners themselves. Thus, social interactions enhance meaningful learning as stated by Vygotsky (1978) in his seminal work.

Social interaction also occurs through the use prior everyday knowledge as a mediating tool. When the teachers consider learners' pre-knowledge, in this case when the learners are asked to explain the process of making *Ombike* this will enable them to link the process of making *Ombike* to the fermentation and distillation process. Thus, the learners will start to make sense of what they are learning as reiterated by Kibirige and Van Rooyen (2006).

Research sub-questions 2:

What factors influence Grade 11 Physical Science teachers' perceptions and experiences on the inclusion of indigenous knowledge?

For this research sub-question two aspects emerged from the data as factors that influence Grade 11 Physical Science teachers' perceptions and experiences of the inclusion of indigenous knowledge. These are the benefits and challenges the teachers experienced when integrating IK. The most highlighted prospect of IK is the expertise possessed by the community members. The teachers think that when the community members/experts are involved in their children's education, this motivates and enhances participation and improves their performance. Thus, this involvement gives value to IK as a body of knowledge. These findings are supported by Klein (2011) whose study was done in ||Kharas Region. He found that, the involvement of parents in school activities reduced learners' dropout rate and increased learners' involvement in and attendance at school activities and that eventually led to improved performance. Webb (2013) also argued that, involvement of community members may add value to a sense of cultural heritage and dignity. The findings in this study thus strongly correlate with Webb's (2013) findings that the majority of teachers indicated the benefit of IK as cultural heritage preservation. In a same line of thought, Cocks, Alexander and Dold (2012) also suggested that IK enables the maintenance of the cultural heritage and environmental factors. These suggest that the learners and teachers need to add value to their practices in the communities for the future sustainability of their culture.

The teachers also highlighted that the inclusion of IK enhances understanding. The process of making *Ombike* is a practical process that involves a hands-on and minds-on activity using easily accessible resources (Asheela, 2017; Maselwa & Ngcoza, 2003). The process also involves the manipulation of materials that are familiar to the learners. Thus, the learners tend to make sense of what they are learning and tend to remember the concepts learned (Millar, 2004). This makes learning more meaningful since practical activity/demonstration of making *Ombike* bring the reality into the class and this make science more relevant.

In contrast, the teachers also highlighted some factors as challenges that influence their perceptions and experiences of the inclusion of indigenous knowledge. To this end, the findings revealed that the inclusion of IK during teaching is time consuming and these indigenous resources are not easy to get in some areas. These findings concur with Shizha's (2007) findings which indicate that teachers struggle to incorporate IK because the curriculum does not make provision for how IK should be incorporated. Furthermore, Shizha, (2007) argued that the curriculum of teacher training is western based and does not include IK. Thus, the teachers mostly teach the way they were taught at the institutions of higher learning. The teachers' findings reveal that they teach to complete the syllabus and since the IK is not part of assessment, including it during school time may hamper the completion of the syllabus on time which is what the assessment is based on.

Another challenge that emerged from the findings are the misconceptions that are associated with IK. Teachers in this study seemed to be sceptical of whether the indigenous practices/experiments/activities will give correct results. As argued by Ogunniyi and Ogawa

(2008), IK is perceived as old science that is backward and outdated since it is not scientifically proven. Mukwambo, et al. (2014) complement Ogunniyi and Ogawa (2008) and the teachers' findings that, although IK is widely researched over the world and many findings have shown the importance of IK, they noted that not all IK is relevant for teaching purposes and if IK is not properly used it might lead to misconceptions on behalf of the learners. This means that, due to cultural norms and beliefs, teachers might confuse the learners if myths and science-based IK are not clearly defined.

For example, T2-I cautioned that: "*Ï think one must have strong cultural knowledge/ background and in our curriculum not all the topic you can relate IK*". The teachers in multicultural schools are challenged by the languages and culture of their learners which is different from that of their teachers. The teachers further highlighted that it is very difficult to incorporate IK in multicultural schools. The teachers claim that it is sometimes not possible to give an IK example for their culture since their learners are from different cultures they tend to struggle to gain any meaning from it. For example, T1-I explained that:

> "*Sometimes you find yourself teaching up to 12 ethnic groups in one class. So, to force them to listen to your explanation how the Herero people do, sometimes they might even tell you that I have nothing to do with a Herero culture. I am not a Herero and I will never a Herero, So, ethnicity and the availability of materials, i.e. making Ombike in the South requires one get materials from the north*"

The learners' attitudes toward IK play a very important role in the inclusion of IK. This correlates with Webb (2013) whose study found that learners have a negative attitude towards IK; they perceive science as what is written in the textbooks.

Research sub-questions 3:

How do Grade 11 Physical Science teachers teach experimental techniques fermentation and distillation conventionally?

In answering the sub-question 3, the teachers were interviewed about their current practices through the lesson presentation observations. The findings that emerged from the interviews indicated that the teachers use conventional materials to do practical activities in the science laboratory and explain by linking IK to the content taught through making references to IK activities at home such as making *Ombike*. In some cases teachers taught theory and gave examples only. For example, T 1-I confirmed that: "*Jaa ...I include it when I talk about how we produce our own juice or traditional like in my language Oshikundu. How do we produce it?*"

In this case, the teacher elicits the learners' prior knowledge through asking questions. The questions and answer method dominate the lessons presentations as the teachers tried to determine how much the learners know about the topic. This enhances the learners' engagement as a form social interaction which is one of the concepts advocated in the socio-cultural theory which underpin this study.

In the socio-cultural theory, the concept of language as a mediating tool plays a vital role in mediating learning. During the lesson observations, I noted that the teachers code switch between English and the mother tongue. The teachers also allow learners to use their mother tongue by asking learners to mention some of the terms in their mother tongue. For example, during the lesson presentation the teachers commented that:

> *"This is a condenser with cold water, what is the function of a condenser, what is the name of condenser in Nama? "Esdrom"* (T1-I).
>
> *"What is the name of alcohol in our local languages, ethanol is Ombike, /Kashipembe/ karhart*" (T2-I).

I observed that the teachers were comfortable to code switch, and this what Probyn (2009) termed 'smuggling vernacular into classrooms'. The teachers, however, did not code switch all of the time because they are teaching multicultural classrooms and only the learners that speak their mother tongue will understand. Thus, language barriers limit the smooth integration of IK according to the teachers.

Research sub-questions 4:

How does the inclusion of the practical demonstration on making *Ombike* enable or constrain Grade 11 Physical Science teachers when explaining concepts on experimental techniques - fermentation and distillation?

During the practical demonstration it was evident that the teachers used the cultural knowledge and linked it to the content in the syllabus. The community experts used cultural artefacts to explain the scientific process of fermentation and distillation. The learners used prior everyday knowledge and their experience to help them understand the new concepts (fermentation and distillation). The findings of this study also indicate that prior knowledge of learners is important in helping teachers build on learners' understanding to make sense of conceptual topics like distillation. These findings are similar to the study conducted by Shifafure (2014). The learners were asked to give their experiences and knowledge on this traditional brew which elicited the prior everyday knowledge which they have (Meyer, 2004). The findings indicate that learners know a lot about the community practice activities which are related to science. This was evidenced by the learners' level of engagement. The fact that learners were asked to express themselves in the language they were comfortable with made the lesson more interesting, lively and more interactive, and here lies the importance of Vygotsky's (1978) socio-cultural theory. These observations are similar to the findings of Woodley (2009) who found that practical work engages learners, develops understanding of the concepts, stimulates and supports thinking. Thus, based on the above findings, it is argued that effective practical work enables learners to build a bridge between what they can see and handle (hands-on) and scientific ideas that account for their observations (brains-on) (Maselwa & Ngcoza, 2003; Woodley, 2009). Apart from the benefits (enables) of IK in science teaching, there were also some challenges that were observed during the study.

From the data gathered from the questionnaires given to the teachers, during the interviews and during lesson observations, some of the challenges were highlighted. The most common problems were that teachers struggle with how to incorporate IK in a multicultural school; the misconceptions associated with IK and IK not being scientifically proven. Also some teachers felt that it is difficult to find these indigenous resources and where they are available; the teachers are challenged by the time factor. As IK is not part of assessment (examination) it tends to be neglected. Thus, it is recommended that IK be a full part of the curriculum.

6.3 Recommendations

The findings from this study revealed that there is strong awareness of IK among the teachers who took part in the study. The teachers highlighted some benefits of IK as well as the challenges. Thus, the following recommendations are made based on the teachers' responses from the questionnaires, interviews and based on the observations made in the lessons presented as well on the practical demonstration of making *Ombike*. I hope that these recommendations might lead to the successful implementation of IK in order to enhance learners' understanding:

- The curriculum developers together with Physical Science teachers should identify the possible topics where IK can be integrated and make suggestions about materials to be used and how they should be used. Suggestions of materials can be done with the consultation of community members/experts who are more knowledgeable in IK. The identified materials should be clearly indicated in the syllabus document.

- The curriculum at the institutions of higher learning should be IK oriented so that the teachers are trained in how to integrate IK in their lessons in order for them to teach effectively after their training.
- Curriculum developers should include IK in the suggested assessment activities so that the teachers can see the value of IK and make it part of their teaching and learning programs.
- Curriculum developers should work hand-in-hand with Advisory teachers to do on site training and monitor the implementation of an IK orientation curriculum and render support where it is required. The curriculum developers at NIED should work together with textbook publishers to ensure that the content to be published is in line with the syllabus and most importantly that it includes IK. In addition to that, teachers and institutions of learning that are responsible for the development of learning and teaching support materials (LTSMs) or teaching aids should develop materials that are locally based, cheap and easily assessable to teachers and learners. This will enable more practical activities to be conducted in science classrooms. This concurs with the study of Asheela, Ngcoza and Enghono (2015) which stressed that, cultural practices make use of easily accessible resources that would prove useful in areas where there is a lack of learning and teaching resources.
- More funds should be made available by the Ministry of Education and companies responsible for science promotion to do more research in the field of IK and enable the possibilities of documenting IK, as suggested by Kibirige and Van Rooyen (2006), in Namibia. This can be done with the involvement of community experts. It is recommended that such research and documenting IK should be done in all ethnic groups in Namibia, so that it can be used in multicultural schools like in ||Kharas Region. The teachers who participated in the study indicated ethnicity as the challenge that inhibits them from integrating IK in the lessons.

6.4 Areas for further research

From the findings and insights obtained from this study, I suggest the following areas for future research.

- Further research should be conducted in IK on the concept of fermentation and distillation in all subjects where these concepts are featured. This would lead to better understanding by the learners when they are exposed to a variety of activities regarding the uses and processes of these concepts in various disciplines.

- Further studies could be done on the same topic, but on a larger scale, for example, for the whole ||Kharas Region or all of Namibia in order to equip as many teachers as possible with the required knowledge to engage in interventions that can assist our learners to learn meaningfully.

6.5 Research limitations

This research is a case study and it only involved 17 Physical Science teachers and one community member in ||Kharas Region from Keetmanshoop town. So, the findings cannot be generalised to all the teachers in Namibia due to the small size sample used. However, some of the findings and insights gathered in this research can be used by Science Educators in the whole of Namibia. However, if I were to do this study again, I would try to include more teachers so that my research covered the whole region or even beyond. This research had a small sample of 17 teachers who answered the questionnaires, two research participants (teachers who were interviewed and presented lessons) and one community member. Despite the small sample size, some insights that emerged from this study can be used by educators to improve their teaching and learning.

6.6 Conclusion

The findings of the study concluded that Physical Science teachers are aware of and have experience of IK from their communities. The study also indicated that teachers perceive the inclusion of IK in the teaching of science in different ways. This was evident from the list of the benefits of IK and the challenges associated with IK the teachers indicated. Notwithstanding, the teachers in this study were very positive about the inclusion of IK and saw value in including it in their teaching However, their pedagogical content knowledge (PCK) needs to be improved through professional development for effective teaching to overcome the challenges they experience during their teaching.

REFERENCES

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

Aikenhead, G. S., & Jegede, J. (1999). Cross-cultural science education: A cognitive explanation of a cultural phenomenon. *Journal of Research in Science Teaching, 36*(3), 269-287.

Asheela, E. N. (2017). *Exploring how teaching the topic on formation of carbon dioxide gas using easily accessible resources to carry out practical activities influence Grade 8 Physical Science teachers'dispositions..* Unpublished master's thesis, Rhodes University, Grahamstown.

Asheela, E. N., Ngcoza, K. M., & Enghono, A. (2015). An indigenous practice of making a traditional beverage called Oshikundu as a strategy to enhance conceptual undertanding. In M.B. Ogunniyi & K. R. Langenhoven (Eds.), *The relevance of indigenous knowledge to African Socioeconomic Development in the 21st Centrury. African Association for the Study of Indigenous Knowledge Systems* (pp. 282-289). UNAM, Windhoek.

Atkinson, A. (1985). *Certificate in Chemistry* (4thed.). Harlow: Longman.

Atwater, M. (1994). Research on cultural diversity in classroom. In D. L. C. Gabel (Ed.), *Handbook of Research on Science Teaching and Learning* (pp. 558-576). New York: McMillan.

Bertram, C., & Christiansen, I. (2015). *Understanding research: An introduction to reading research*. Pretoria: Van Schaik Publishers.

Bunyi, G. (1999). Rethinking the place of African indigenous languages in African education. *International Journal of Education Development, 19*, 337-350.

Campbell, N. A. (1990). *Biology*. New York: The Cummings Publishing Company.

Chisholm, L., & Leyendecker, R. (2008). Curriculum reform in post-1990s sub-Saharan Africa. *International Journal of Educational Development, 28,* 195-205.

Chrispen, M. (2016). *Understanding how the incorporation of indigenous knowledge (IK) enables or constraints the teaching and learning of alcoholic fermentation in Life Science in Grade 11.*Unpublished master's thesis, Rhodes University, Grahamstown.

Cleghorn, A. (1992). Primary level science in Kenya: Constructing meaning through English and indigenous language. *International Journal of Qualitative Studies in Education, 5*,311-323.

Cocks, M., Alexander, J., & Dold, T. (2012). *Inkcubeko Nendalo*: A bio-cultural diversity schools education project in South Africa and its implications for inclusive indigenous knowledge systems (IKS) sustainability. *Journal of Education for Sustainability Development, 6*(2), 241-252.

Cohen, L., Manion, L., & Morrison, K. (2011). *Research methods in education* (7th ed.). London: Routledge.

Creswell, J. W. (2008). *Educational research: Planning, conducting, and evaluating quantitative and qualitative* research (3rd ed.). New Jersey: Pearson Education.

Czenierwicz, L., Murray, S., & Probyn, M. (2000). *The role of learning support materials in curriculum 2005*. Research paper for the National Institute of Curriculum Research and Development (NICRD), Department of Education.

Dube, T., Ndlovu, R., Khalieli, T., Molapo, L., Jeoffreys, B., Gordon, D., & Odara, C. (2012). *Macmillan Physical Science for Southern Africa*. Manzini: Macmillan Boleswa Publishers.

Dziva, D., Mpofu, V., & Kusure, L. P. (2011). Teachers' conception of indigenous knowledge in the science curriculum in the context of Mberengwa district, Zimbabwe. *African Journal of Education and Technology, 1*, 88-102.

Friedrichsen, P.M., & Dana, T. (2005). *Exploring elementary teachers' pedagogical content knowledge for supporting children's scientific inquiry: Orientations to teaching science*. New Orleans: National Association for Research in Science Teaching.

Gott, R., & Duggan, S. (1996). Practical work: Its role in the understanding of evidence in Science. *International Journal of Science Education, 7*(18), 791-806.

Hendricks, M. (2003). Classroom talk: “There are more questions than answers”. *Southern African and Applied Language Studies*, *21*(1&2), 29-40.

Hodson, D. (1990). A critical look at practical work in school science. *School Science Review, 70*(256), 33-40.

Howie, S. (2004). A national assessment in mathematics within an international comparative assessment. *Perspectives in Education*, *22*(2), 149-162.

Imenda, S. (2014). Is there a conceptual difference between a theoretical and conceptual framework? *Journal of Social Science, 38*(2), 185-195.

Jegede, O. J., & Aikenhead, G. S. (n.d.). *Transcending cultural borders: Implications for science teaching.* Retrieved September 6, 2013, from http:// eprints.ru.ac.za/1447/1/language and learning science.pdf http;//www.ouhk.edu.hk/~rcwww/misc/jegede html

Johnson, B., & Christensen, L. (2004). *Education research*: *Qualitative, qualitative and mixed approaches* (2nd ed.). Boston: Pearson.

Kasanda, C., Lubben, F., Gaoseb, N., Kandjeo-Marenga, U., Kapenda, H., & Campbell, B. (2005). The role of everyday contexts in learner-centred teaching: The practice in Namibian secondary schools. *International Journal of Science Education, 27*(15), 1805-1823.

Khoza, H. C. (2016). *Exploring teacher talk and its role in learner understanding of science content.* Unpublished master’s thesis, Faculty of Science, University of the Witwatersrand, Johannesburg.

Kibirige, I., & Van Rooyen, H. (2006). Enriching science teaching through the inclusion of indigenous knowledge. In J. de Beers & H. Van Rooyen (Eds.), *Teaching science in the OBE classroom*. Braamfontein: Macmillan.

Klein, J. (2011). Indigenous knowledge and education – the case of the Nama people in Namibia. *Education as Change, 15*(1), 81-94.

Klos, M. L. (2006). Using cultural identity to improve learning. *The Educational Forum, 70*, 363-370.

Kuhlane, S. (2011). *An investigation into the benefits of integrating learners' prior everyday knowledge and experiences during teaching and learning of acids and bases in Grade 7*: A case study. Unpublished master's thesis, Rhodes University, Grahamstown.

Lantolf, J. P. (2000). *Introducing sociocultural theory and second language learning.* Oxford: Oxford University Press.

Le Grange, L. (2012). Ubuntu as an architectonic capability. *Indilinga: African Journal of Indigenous Knowledge Systems, 11*(2), 139-145.

Lemke, J. L. (2001). Articulation communities: Socio-cultural perspectives on science education. *Journal of Research in Science Teaching*, *38*(3), 296-316.

Lyle, J. (2003). Stimulated recall: A method for research on teaching. *British Journal of Educational Psychology*, *51*, 211-217.

Mapara, J. (2009). Indigenous knowledge systems in Zimbabwe: Juxtaposing postcolonial theory. *The Journal of Pan African Studies, 3*(1), 139-155.

Maree, J. G. (2008). *First steps in research*. Pretoria: Van Schaik Publishers.

Merriam, S. B. (2008). *Qualitative research: A guide to design and implementation* (2nd ed.). San Francisco: Jossey-Bass.

Millar, R. (2004). *The role of practical work in the teaching and learning of science*. York: Department of Educational Studies, University of York.

Ministry of Education and Culture. (1993). *Toward education for all: A development brief for education, culture, and education* Windhoek, Namibia: Gamsberg Macmillan.

Ministry of Education. (2010). *Namibia Senior Secondary Certificate (NSSC) Physical Science Syllabus Ordinary Level*. Okahandja: NIED.

Ministry of Education. (2010). *The National Curriculum for Basic Education*. Okahandja: NIED.

Ministry of Education. (2011). *Report on the Examinations NSSCO/H*. Windhoek: DNEA.

Ministry of Education. (2013). *Report on the Examinations JSC.* Windhoek: DNEA.

Ministry of Education. (2014). *Report on the Examinations NSSCO/H.* Windhoek: DNEA.

Ministry of Education. (2014). *Report on the Examinations JSC.* Windhoek: DNEA.

Mortimer, E. F., & Scott, P. H. (2003). *Meaning making in secondary science classrooms.* Philadelphia: Open University Press.

Moyo, D. (2011). Science educators' ideas of the "science" in IKS and their willingness to include IKS in the school science curriculum. Unpublished Master of Science, University of the Witwatersrand, Johannesburg.

Mukwambo, M., Ngcoza, K., & Chikunda, C. (2014). Africanisation, Ubuntu and IKS: A learner-centered approach. In C. I. O. Okeke, M. M. van Wyk & N. T. Phasha (Eds.), *Schooling, society and inclusive education: An African perspective* (pp. 1-16).Cape Town: Oxford University Press.

Mutasa, N. G., & Wills, G. M. (1995). *Modern practice in education and Science.* Gaborone: Tasalls Publisher.

Nguyeu, N. T., Mcfadden, A., Tangen, D., & Beutel, D. (n.d.). *Video - stimulated recall interviews in qualitative research.* Queensland University of Technology, Brisbane, Australia.

Nyambe, K. J. (2008). *Teachers educators 'interpretation and practice of learner-centred pedagogy: A case study.* Unpublished doctoral thesis, Education Department, Rhodes University, Grahamstown, South Africa.

Nyambe, J., & Wilmot, D. (2012). New pedagogy, old pedagogic structures: A fork-tongued discourse in Namibian teacher education reform. *Journal of Education, 55,* 55-80.

Ogunniyi, M. B., & Ogawa, M. (2008). The prospects and challenges of training South African and Japanese educators to enact an indigenized science curriculum. *South Africa Journal of Higher Education, 22*(1), 175-190.

Ogunniyi, M. B. (2008). *An argumentation-based package on the nature of science and indigenous knowledge system, Book 1,* Development through the Science and Indigenous Knowledge Project (SIKSP), University of Western Cape.

Oloruntegbe, O. K., & Ikpe, A. (2011). Ecocultural factors in students' ability to relate science concepts learned at school and experienced at home: Implication for chemistry education. *Journal of Chemical Education, 88,* 266-271.

Ormrod, R. K., & Cole, D. B. (1996). *Changing approaches to teaching: A relational perspective.* Studies in Higher Educational Press.

Phiri, A. D. K. (2008). Exploring the integration of indigenous science in the Primary School Science Curriculum in Malawi. A dissertation. Available online, The Virginia Polytechnic Institution and state University.

Posner, G. J., Strike, K. A., Hewson, P. W., & Gertzog, W. A. (1982). Accommodation of a scientific conception: Toward a theory of conceptual change. *Science Education*, 66, 211-227.

Probyn, M. (2006). Language and learning science in South Africa. *Language and Education, 20*(5), 391-414.

Ramorongo, G., & Ogunniyi, M. (2010). Exploring teachers 'conceptions of the rainbow using an argumentation – based intervention. *African Journal of Research in MST Education, 14* (1), 22-35.

Reddy, V., Zuze, T. L., Visser, M., Minnaar, L., Juan, A., Prinsloo, C. H., Arends, F., & Rogers, S. (2015). *Mathematics and science achievement in the TIMSS 2011 study in South Africa. Mathematics and Science Education, beyond benchmarks: What twenty years of TIMSS data tell us about South African education.* Cape Town: HSRC Press.

Rennie, L. (2011). Blurring the boundary between the classroom and the community: Challenges for teachers' professional knowledge. In J. D. D. Corrigan, *The professional knowledge base of science teaching* (pp. 13-29). Dordrecht, The Netherlands: Springer.

Roschelle, J. (1995). Learning interactive environments prior knowledge and new experience. Retrieved March 2014, fromhttp://www.exploratorium.edu/ifi/resources/museueducation/priorknowledge.html

Rule, P., & John, V. (2011). *Your guide to a case study research*. Pretoria: Van Schaik Publisher.

Shaakumeni, S. N. (2014). Natural Science teachers' experiences and perceptions of the National Standardized Achievement Tests in Khomas region, Namibia. *Journal for Educational Reform in Namibia, 25,* 3-12.

Shifafure, A. M. (2014). *Understanding how Grade 11 Physical Science teachers mediate learning of the topic distillation in the Kavango Region*. Unpublished master's thesis, Education Department, Rhodes University, Grahamstown.

Shizha, E. (2007). Critical analysis of problems encountered in incorporating indigenous knowledge in science teaching by primary school teachers in Zimbabwe. *The Alberta Journal of Education Research, 53*(3), 302-319.

Shulman, L. (1987). Pedagogical content knowledge: A tentative model for teacher preparation. A paper presented at the Annual Meeting of the American Educational Research Association, Chicago, IL, April 3-7, 1991.

Simasiku, F. (2016). *Exploring Grade 9 Physical Science teachers' views and experiences on the inclusion of indigenous knowledge in their lessons: A Namibian case study.* Unpublished master's thesis, Education Department, Rhodes University, Grahamstown.

Stears, M., Malcolm, C., & Kowlas, L. (2003). Making use of everyday knowledge in the classroom: *African Journal of Research in SMT Education, 7*, 109-118.

Teemant, A. (2005). Evaluating socio-cultural pedagogy in a distance teacher education program: Assessing innovation in teacher education. *Teacher Education Quarterly, 32*(3), 49-62.

TIMSS. (2011). *International Science Report.* Findings from IEA's Repeat of the third International Mathematics and Science Study at the Eighth Grade. Chestnut Hill, MA: Boston College.

Van Wyk, J. A. (2006). Indigenous knowledge systems: Implications for natural sciences and technology teaching. *South African Journal of Education, 22*(4), 305-312.

Uushona, K. I. T. (2013). *An investigation into how Grade9 learners make sense of the fermentation and distillation processes through exploring the indigenous practice of making the traditional alcoholic beverage called Ombike: A case study.* Unpublished master's thesis, Education Department, Rhodes University, Grahamstown.

Vygotsky, L. S. (1978). *Mind in society: Interaction between learning and development.* Cambridge, MA: Harvard University Press.

Wang, L. (2006). Sociocultural learning theories and information literacy teaching activities in higher education. *Reference & User Services Quarterly, 47*(2), 149-158.

Wanja, K. (2000). *An inquiry into the integration of indigenous knowledge and skills in the Kenyan secondary science curriculum*. A dissertation available online, University of Toronto.

Webb, P. (2013). Xhosa indigenous knowledge: stakeholder awareness, value, and choice. *International Journal of Science and Mathematics Education, 11,* 89-110.

West, L., & Pines, A. (Eds.). (1985). *Cognitive structure and conceptual change*. New York: Academic Press.

Woodley, E. (2009). Practical work in school science: Why is it important? *School Science Review, 91*(335), 49-51.

Zhang, Y. (2008). Classroom discourse and student learning. *Asian Social Science*, *4*(9), 80-83.

APPENDICES

RHODES UNIVERSITY
Grahamstown.6140. South Africa
EDUCATION DEPARTMENT

15 June 2016

llKharas Regional council
|Awebahe. J. ||Hoeseb
Regional Director: Education, Arts and Culture
Private bag 2160
Keetmanshoop

Re: Request for a permission to conduct an educational research at [redacted] in llKharas Region

Dear Sir

My Name is Demetria Paulus (13p7392). I am a postgraduate M ED: Science Education student in the Department of Education at Rhodes University.

I am doing research on the inclusion of indigenous knowledge in science lessons: My research topic is **exploring how the grade 11 Physical Science teachers mediate the topic experimental techniques (fermentation and distillation) conventionally and through the practical demonstration of making *Ombike.***

My research involves Physical science teachers and the learners taught by these teachers. I will video- record all the lessons that I will observe. The reason for video-recording the lesson is that this study is a qualitative by nature and I am looking for a detailed analysis of how the inclusion of indigenous knowledge enhances learning in the above mentioned topics or not and how the teachers mediate learning on those topics.

It is against this backdrop that I am kindly requesting for a permission from your office to conduct the above mentioned research.

Thanking you in advance.

Yours faithfully

Demetria Paulus (13p7392)

(i) OBTAIN WRITTEN CONSENT OF THE PARENTS, GUARDIANS OR CAREGIVERS OF THE LEARNERS PRIOR TO VIDEO-RECORDING THEM (THE LEARNERS).
(ii) APPROVAL GRANTED FOR THE CONDUCTING OF THE STUDY.

2016/06/15
RA

DIRECTORATE OF EDUCATION, ARTS AND CULTURE
DIRECTOR
2016 -06- 15
P/BAG 2160
KEETMANSHOOP
//KHARAS REGIONAL COUNCIL

RHODES UNIVERSITY
Grahamstown.6140. South Africa
EDUCATION DEPARTMENT

15 July 2016

llKharas Regional council
Mrs C.D. Wantenaar
Inspector of Education, Arts and Culture: Kalahari Circuit
Keetmanshoop

Re: Request for a permission to conduct an educational research at [redacted] in llKharas Region

Dear Mrs Wanternaar

My Name is Demetria Paulus (13p7392). I am a postgraduate M ED: Science Education student in the Department of Education at Rhodes University.

I am doing research on the inclusion of indigenous knowledge in science lessons: My research topic is **exploring how the grade 11 Physical Science teachers mediate the topic experimental techniques (fermentation and distillation) conventionally and through the practical demonstration of making *Ombike.***

My research involves Physical science teachers and the learners taught by these teachers. I will video- record all the lessons that I will observe. The reason for video-recording the lesson is that this study is a qualitative by nature and I am looking for a detailed analysis of how the inclusion of indigenous knowledge enhances learning in the above mentioned topics or not and how the teachers mediate learning on those topics.

It is against this backdrop that I am kindly requesting for a permission from your office to conduct the above mentioned research. **Attached is the letter for a permission that was granted by the Regional Director of Education, Arts and Culture,** dated **15 June 2016.**

Thanking you in advance.

Yours faithfully

____
Demetria Paulus (13p7392)

RHODES UNIVERSITY

Grahamstown.6140. South Africa

EDUCATIO DEPARTMENT

16 June 2016

Mr P. Skeyer
The Principal
Ministry of Education, Arts and Culture
[redacted]
Keetmanshoop

Re: Request for a permission to conduct an educational research at [redacted] in llKharas Region

Dear Sir

My Name is **Demetria Paulus (13p7392).** I am a postgraduate M ED: Science Education student in the Department of Education at Rhodes University.

I am doing research on the inclusion of indigenous knowledge in science lessons. My research topic is **exploring how the grade 11 Physical Science teachers mediate the topic experimental techniques (fermentation and distillation) conventionally and through the practical demonstration of making *Ombike.***

My research involves Grade 11- 12 Physical science teachers and the learners taught by these teachers. I will be video- recording all the lessons that I will observe. The reason for video-recording the lesson is that, this study is qualitative and I am looking for a detailed analysis of how the inclusion of indigenous knowledge enhances learning or not and how the teachers mediate learning on the said topics.

It is against this backdrop that I am kindly requesting for a permission from your office to conduct the above mentioned research at your school. I can be contacted telephonically or via email: 0816739117/ pdemetria0@gmail.com

Thanking you in advance.

Yours faithfully

Demetria Paulus (13p7392)

T1

Rhode University

Education Department

15 June 2016

Dear Research Participant

Re: Participation in research on exploring how Physical Science teachers mediate the topic experimental techniques conventionally and through the inclusion of indigenous practice of making *Ombike.*

Thank you for agreeing to be a research participant in my study. As per our discussion, my research topic is as indicated above.

The study will be conducted in **three** phases. The first phase requires participants to complete a questionnaire. The **second phase** of the study involves the participants teaching the topic experimental techniques- fermentation and distillation and lessons observations by the researcher. After the lesson presentations and lesson observations, **the third phase** of the study requires the intervention where the community expert will carry out a practical demonstration of making *Ombike* and the two research participants (Physical Science teachers) will link the scientific concepts to the content taught in the Science class.

Your participation in this research study is completely voluntary and you can withdraw at any time. The data collected in this study will be published as a Rhodes University half thesis and will be treated with a high degree of confidentiality and anonymity.

Reply slip
I agree to participate in the research on condition that I can withdraw at any time.
Name...Simon S. Shikololo....Signature.....[signature].....
Contact number..0812134742......Date..01 – 08 – 2016

T2

Rhode University

Education Department

15 June 2016

Dear Research Participant

Re: Participation in research on exploring how Physical Science teachers mediate the topic experimental techniques conventionally and through the inclusion of indigenous practice of making *Ombike.*

Thank you for agreeing to be a research participant in my study. As per our discussion, my research topic is as indicated above.

The study will be conducted in **three** phases. The first phase requires participants to complete a questionnaire. The **second phase** of the study involves the participants teaching the topic experimental techniques- fermentation and distillation and lessons observations by the researcher. After the lesson presentations and lesson observations, **the third phase** of the study requires the intervention where the community expert will carry out a practical demonstration of making *Ombike* and the two research participants (Physical Science teachers) will link the scientific concepts to the content taught in the Science class.

Your participation in this research study is completely voluntary and you can withdraw at any time. The data collected in this study will be published as a Rhodes University half thesis and will be treated with a high degree of confidentiality and anonymity.

Reply slip
I agree to participate in the research on condition that I can withdraw at any time.
Name...WILLEM...HAMUNYELA....Signature............................
Contact number.0812414501..............Date.01/08/16...................

Semi-Structure interview Questions Transcript - T1

Research Title: Exploring on how do teachers mediate learning of experimental techniques using fermentation and distillation of a traditional brew.

Keys: Q: R- Question by the Researcher A: T1- Answer from Teacher one

Q: R what are Grade 11 Physical Science teachers' perceptions and experiences on the inclusion of indigenous knowledge during Science lessons?

A: T1*Ja…. of coursemost of the time you find them using traditional materials uuuhm… and as we are teaching in schools we have a shortage of scientific equipment. we can include some traditional materials in our lesson. let me say you are teaching about motion you can use bowl and arrows is a traditional you can use to explain. It is very necessary to include it.*

Q:R What factors influence 11Physical Science teachers' perceptions and experiences on the inclusion of indigenous knowledge?

A: T1*normally it depends on where the teacher grew up. Some teachers, uumh… they grew up in towns and they have never been in rural areas, so, they may not include these traditional things because they never seen them before.*

Sometimes people just want to copy everything from the western cultures. They think if you a eating with hands instead of eating with a spoon you are not civilised or modernised, but I think we should include it.

Q: R How do Grade 11 Physical Science teachers teach experimental techniques conventionally– fermentation and distillation? From the lessons presentations

Q: R How does the inclusion of the practical demonstration on making *Ombike* enable or constrain Grade 11 Physical Science teachers when explaining concepts on Experimental Techniques - fermentation and distillation?

A: T1 (Enables) *I was very happy to prove that science has never been only in Europe but before European came here and bring their subject like Physical Science, they already found us doing these physical experiments like a fractional distillation. Science has been existing already in Africa although we did not put them on paper. They have been already existing, so it was interesting for me for me to prove that that one, that this traditional distillation was already here traditionally before the westerns culture came. s*

A: T1(constrains)*Most of the materials not available at alland sometimes you yourself teaching up to 12 ethnic groups in one class. So, to force them to listen to you explain how the Herero people d, sometimes they might even tell you what I have to do with a Herero culture? I am not a Herero and I will never be a Herero. So, it is ethnicity and also availability of materials you might not find them there, but mostly is different cultures we are teaching.*

Q: R If you are relating a certain concept to your own culture do you allow your learners to relate to their own culture if there are any?

A: T1 *very much important, because we allow their interests*

Q: R In general, what advice can you give to the institutions of higher learning like UNAm as well as to the MoEAC and NIED who train teachers and develop educational documents we are using, in terms of IK integration?

A:T1 *You know that one will be difficult because we are living in a country where we have different ethnicgroups, but I will encourage these people that we must include our indigenous concepts so that our learners….. even if we lived 50 years from now our African culture cannot be swallowed by by the western culture world…. So that our African culture cannot be swallowed by the western culture.*

Q:R For how long now you have been teaching Physical Science?

A:T1*Nine (9) years*

Q: What did you find interesting or useful about teaching the topic experiment techniques: fermentation and distillation?

A: T1*Is more of a practical then kids are learning by discovering they are learning by doing.*

Q: How did you include the concept fermentation when teaching the topic Fractional Distillation?

A: T1*Uuuhm… What is the question again.. You have to put to mix these fruits for weeks or for eight days and they have to ferment and after that one you have to fractional distil alcohol from glucose that's what we do*

Q: R Basically what I wanted to find out. is.. because in the syllabus the fermentation part is not there although we know it come first before the fractional dist part we need to ferment

A: T1*Ja…The content need to ferment.*

Q: R What are some of your "aha"/ fascinating moments when teaching the topic experimental techniques especially the fermentation and distillation concepts?

A: *T1 Proving the scientific methods and then I have done it a traditional way which was very interesting to the learners not only in the scientific lab but even at home in our African homes we can also do some of these scientific methods of separating like fractional distillation in more traditional way.*

Q: R Could you please tell me about your experiences of how you were taught this topic- fermentation and distillation at school?

A: T1 Luckly *I…. I am from one of the rural areas where that one happened in African way and when I went to school how it was taught almost the same way it was done at home.*

Q: R So the teacher tried to ……

A: T1 *When I went there I was having the prior knowledge of how its done at home in school practice is done in a traditional way*

Q: R So…. the teacher tried to incorporate IK?

A: T1*Very much*

Q: R Could you please tell me how you are currently teaching these topic-fermentation and distillation during your Physical Science lessons?

A: T1*Fermentationuuuhm..I touch about it when we were doing acids. Then I explained to the learners We did it with the learners to uuhm..uuhm..ferment the Omaere, what Ovaherero people use then to to make or to produce Lactic acids that we found in a sour milk is kind of fermentation that one. And some traditional beer like Oshikundu is a result of fermentation that one. Fractional distillation I explain in the lesson.*

Q: R Do you include IK when teaching experimental techniques - fermentation and distillation?

A:*T1 It necessary to include it, simple because I am teaching people uuhm.. learners from different ethnic groups although some grown up in towns and never know those traditional method but for these who knew it it was an experience for them but we include both scientific and traditional one, although all of them are having same results*

Q: R Okay you said you are the incorporating IK

A: T1*Yes*

Q: R How do you incorporate them when u a teaching do you …do you make reference IK or do bring I practice or Indigenous technologies

A: T1 *Normally you can do the scientific one and most interesting is the traditional one where you try to bring all traditional materials you can make use of toto.. do traditional distillation of alcohol or fractional alcohol form glucose or use both but the traditional methods is more interesting especially for learners who grow up in Town.*

Q: R How do you incorporate IK in this topic when teaching? Do you make references when teaching or do you make practical activities or technologies when teaching this topic

A: T1 *You can do the scientific one but the more interesting is the traditional one….to do your fractional distillation of alcohol*

Q: R What are some of the examples of IK / practices did you try to incorporate when teaching this topic?

A: T1 *Fermentation most of the traditional beers are brewed through fermentation and fractional distillation like the Ombikemost of the… in Southern African most of ethnic groups they use that one..Like the Kavango people, in Zambia also, in Angola also and in Namibia they do that fractional distillation.*

Q: Could you tell me why you do not include I in your teaching?

A: T1

Q: What problems did you experienced/ encountered when you try to incorporate IK in your lessons?

A: T1

Q:R Do you think it is necessary to incorporate IK when teaching Science? Give reasons

A: T1 *Ja.. because we are teaching people from different ethnic groups, so people need to learn other peoples' culture, 'then..thats one way of making the lesson interesting and also uniting the people you are teaching. That people will not concentrate on their ethnic groups but rather on the scientific concepts that we want them to learn.*

Q: R What are your views in general on the inclusion of IK during Physical Science lessons?

A: T1*yes.. At school we are teaching Physical Science which is more which is modern and western but the learners that we are teaching are going back to our African homes where they have to do everything in their cultural way so… the moment are we include them we are trying to put them at same level at home and at school so that whatever they are doing at home is what they are doing at school or is part of what they are doing at school and in that way they learning from simple to complex.*

Q:R How IK could be used in the topic experimental techniques especially in the topic fermentation and distillation? Explain how and at which stage of the lesson do you incorporate IK during the Science lesson?

A: T1*From the beginning when you mix the indigenous fruits and say you mix them in a traditional clay pot and when you start after fermentation you can include all these traditional methods. If I understood your questions very well. You can include them at all the stages you can incorporate IK*

Q: Since some of your learners are not *Oshiwambo* speaking. How do you deal with the context and culture of your learners when incorporating IK?

A: T1*uuumh I was..I normally do not concentrate to Oshiwambo because this traditional fractional distillation is not only done by Oshiwambo people but by many tribes in Southern Africa is happening there, in Zambian I have seen it, in Angola is there and also in Namibia. I do not concentrate on my cultural back ground but I will say in our African traditional way. In that way although somebody is not Oshiwambo the moment you say African way, Africans are Africans they can listen to you.*

Q:R Is there any IK that you were exposed at home that you can incorporate when teaching fermentation and distillation concepts?

A:T1*Before I even went to school I use to see my grandmother and my mother doing it that one, before I did not even speak English and before I went to schoolI already knew the taste of that alcohol/ ethanol, before I went to school I already knew.*

Q:R During your teacher training were you exposed on how to incorporate IK in Physical Science?

A: T1*Jaa..we were taught in many many topics that it is very very important to incorporate… because you will…. some children they can't even speak English'. if you explain something in English uuumh.. they don't understand so, you have to refer to the traditional methods or you have to incorporate traditional/ indigenous. So that I will start planning from simple to complex*

Q: R what do you think could be the reason why some Physical Science teaches incorporate IK in their lessons and yet some do not?

A:T1*Mostof the time is very important to incorporate like what I have said before that's is very important to teach the kids uuhm..to include it so that the kids may know the relevance of the topic they are learning Ja.. and me…. Most of them they may not get very interested in traditional things they may say these are out fashioned and the world is developing up, they may say where will I do those things, like where will I do the fermentation of Omaere in Town, but we need to include these things.*

Semi-Structured Interview Transcript T2

Exploring on how do teachers mediate learning of experimental techniques using fermentation and distillation of a traditional brew.

Q: R	For how long now you have been teaching Physical Science?
A: T2	I have been teaching P.Sc. now this my sixth (6) years
Q: R	What did you find interesting or useful about teaching the topic experiment techniques: fermentation and distillation?
A: T2	What is interesting....it help people / learners to know how to produce certain substance and it help learners to understand how to separate substances that mixed together.
Q: R	How did you include the concept fermentation when teaching the topic Fractional Distillation?
A: T2	I include it during the of production ethanol
Q: R	What are some of your "aha"/ fascinating moments when teaching the topic experimental techniques especially the fermentation and distillation concepts?
A: T2	The moment I enjoyed is when you see the learners are asking questions, especially the separation of water from alcohol they want to know what exactly happened. That is the moment that I enjoyed. I ask them related to what they use at home, i.e. juices what they use at home or how they do it at home, what methods they use, if they two liquids how do they separate them... so that they can understand better.
Q: R	Do you include IK when teaching ET especially F and D
A: T2	Jaaa... I include IK
Q: R	How do incorporate the IK when teaching this topic?
A: T2	Jaa...I include it when I talk about how do we produce our own juice or traditional like in my language Oshikundu now jaa..how do we produce it and we have got our traditional jam made from Mutete and also some traditional liquor.

Q: R	What are some of the example of IK or practices did you try to incorporate during in this topic
A: T2	I talk about the Traditional Liquor, traditional juice and traditional jam that is what these are practice I have tried to incorporate
Q: R	Do you think is necessary to incorporate IK when teaching science and if so provide reasons
A: T2	Jaa.. It is very important as I said before because we are taking what we know from home and use it in to the new development ... a modern science we are learning. It is very important, it help people to understand it easily because they have already the background
Q: R	What your views in general on the inclusion of IK in P.Sc not only in this topic but in P.Sc. in general
A: T2	My views is very important as I said before because we are taking what we doing at home and make it into our lesson which help the learners to understand any topic in P.Sc easier because they have got already a background is just like similar like what we doing at home it make them easy to understand. That's my views.
Q: R	In your own views what are your perceptions or experiences when you teaching science as far as the inclusion of IK is concerns?
A: T2	Jaa...it makes the lessons interesting on other hand some of the experiences there are learners who do not have IK, they are cultures, learners are mixed now you find it difficult because some of them they don't have IK, it is difficult for them to understand. Like the coloured and Basters they don't have IK. They try to relate what they have seen home or culture although not really indigenous. They want know. Their culture is similar to the westerns. Their culture is similar to what is written in the books.
Q: R	What factors influence the Grade 11 P.Sc teachers' perceptions and experience on the inclusion IK?
	I think one can have strong cultural knowledge background that's one of them. One can have strong IK and also depend on where the person is from i.e. from rural or in town. If person was born in town it is difficult to incorporate IK. It is difficult to understand your own culture and the culture of all your learners in a multi cultural school. I ask them how they do it intheir culture and we incorporate it
Q: R	How are you currently teaching the topic E T- fermentation and D
A: T2	Uuuhm..distillation we use it when we were talking about the separation of crude oil that how I use it one and fermentation e talk about of production of ethanol from glucose.
Q: R	Did you try to do any practical activity regarding this topic?

A: T2	The practical activity that only we did was fractional distillation the separation of ethanol and water, fermentation we did not do any practical activity
Q: R	What were the challenges that hinders to do a practical activity on fermentation?
A: T2	Jaaa..The fermentation was that where I can get the fruits that I wanted to use… I did not have fruits to use
Q: R	Does the practical demonstration of making Ombike enables or constrain you when explain the concepts on ET especially on the concepts F and D
A: T2	It enable us to explain the concepts very well, because from the there.. just from the first steps of making Ombike we were able to show the learners the fruits and how they were made until fermentation took place and we show the learners the distillation process of Making Ombike
Q: R	What are the constrains/ challenges that you think come with this process of making Ombike
A:T2	It depend on where u find yourself do you have the necessary fruits to use do you the necessary apparatus like these condensers, do you wood- some of areas do have wood those are some of constrains.
Q: R	Do you think you can able to may be negotiating with community experts to invite or take your learners to observe and you explain the process there?
A: T2	I can say that is one of the constrains because you need someone who have knowledge on how to make Ombike you need an expert who know how to make Ombike. You need to find some people who can explain the whole process of making Ombike.
Q: R	
A:T2	In my view is good idea to include IK in our P.Sc. may be the only challenge it depending on how many topics we have in our syllabus or in our curriculum can include IK because is not all the topic you can relate to our IK. But its good ideas it coming from the background in our environment.
Q: R	What do you think the MoEAC can do to make this one a success, either the MoE, institutions of higher learning or the other stakeholder like NIED that develop syllabuses and so on. What advise you can give them to make sure that this dream of including IK in science is realised?
A T2	Jaa… I can give my advice is that, first thing is they have to identify the topics that are in the curriculum that easy first to relate to or can use indigenous language. Then after identifying then they have go and to invite teachers and have workshops and ask the IK in these topic and bring in the aspect like community members who are practising those Indigenous things before they decide on everything.

Teacher's Questionnaire

The focus of my study is to explore how *Grade 11 Physical Science teachers teach the topic experimental technigues– fermentation and distillation conventionally and through the inclusion of indigenous knowledge in their lessons in Keetmanshoop town of IIKharas Region.*

The information obtained in this questionnaire will be anonymous and will only be used for research purposes. *However, if you are willing for me to interview you, may you kindly contact me using the followingnumber* 0816739117 *or sms interview, I will call you back.*

Please answer all the questions as free as you wish.

PART A: **Profile ofteachers and schools**

1. School location (tick one)

Town Center	**Township**	**Village**
T2F, T3F, T6M, T9M, T10M, T14F	T4F, T7F, T12F, T13M	T1F, T5M, T8M, T15F, T16F, T17M

2.

Male	**Female**
T5M, T6M, T8M, T9M T10M, T13M, T17M	T1F, T2F, T3F, T4F, T7F, T11F, T12F, T14F, T15F, T16F

3. Ethnicity (tick the correct one)

Oshiwambo	**Herero**	**Zambezian**	**Afrikaans**	**Nama/Damara**	**Kavango**
T1F, T2F, T3F,T6M, T9M, T11F, T12F, T13M, T14F, T15F, T16F	T8F	T7F, T17M	T4F	T5M	T10M

4. Qualifications (tick the qualifications you have)

ECP	BETD/ DIE	ACE/FDE/ MASTEP	HONS	MED	PHD	Other
	T4F, T9M, T10M	T1F, T3F,T5M, T6M, T13M	T2F, T7F, T8F, T11F, T14F, T15F, T16F, T17M			T12F

5. Teaching Experience in Physical Science and total teaching experience?

Teaching experience in Physical Science	Total teaching experience
T1F-16, T2F-7, T3F-4, T4F-12, T5M-12, T6M-5,T7F-3, T8F-9, T9M-not indicated, T10M-8, T11F-8, T12F-not indicated, T13M-3, T14F-4,T15F-2, T16F-2, T17M-2	T1F-16, T2F-7, T3F-6, T4F-12, T5M-12, T6M-6,T7F-8, T8F-9, T9M-9, T10M-8, T11F-8, T12F-2, T13M-5, T14F-4, T15F-2, T16F-2, T17M-10

6. Age group (Tick one box)

20 - 25 yrs	26 – 30	31 – 35	36 - 40	41 – 45	46 – 50	Above 50
T15F, T16F	T3F, T7F, T12F, T13M, T14F	T2F, T4F, T5M, T6M, T8F, T9M, T10M, T11F	T17M	T1F		

PART B: Teachers' perceptions and experiences, strategies that influence the teachers, current teaching practice and the inclusion of Indigenous Knowledge / local knowledge

1. What do you understand by the term indigenous knowledge?

T1F- *local natural knowledge and expertise possessed by the local community.*
T2F – *IK is the local knowledge that is unique to a given culture or society. It is the basis for local level decision making in agriculture, health care, food preparation, education, natural resources management and a host of other activities in rural communities.*
T3F – *IK is the local knowledge that is unique to a cultural or society.*
T4F – *native knowledge or prior or existing knowledge that someone already has which is based on physical science.*
T5M- *The understanding of cultural norms and values*
T6M – *Knowledge obtained from your own environment / society. This knowledge can be about local trees, language, and people.*
T7F- *Knowledge that we gain from our local environment but not scientifically proven.*
T8F- *Is driven from local community and it oppose scientific knowledge / or it is not scientific proven.*
T9M - *Blank*
T10M – *knowledge based on the community where people live*
T11F – *Is the knowledge about our traditional norms, terms and vocabulary we use to describe or demonstrate something.*
T12F – *IK refers to knowledge that is from a specific area, meaning its not brought in from elsewhere. In other words it can be called local knowledge.*

T13M – *IK is the knowledge acquired naturally by using resources around you.*

T14F -Knowledge that is unique to a given society or culture and it is local based knowledge.

T15F - *Indigenous Knowledge to the local knowledge that is unique to a given culture or society.*

T16F - *Is the local knowledge that someone has from his / her background environment.*

T17M - *Knowledge obtained from our fore-fathers without being formally taught. Often this is obtained through oral methods*

2. What are your **perceptions** on the inclusion of indigenous knowledge during Physical Science lessons?

T1F- *IK is of higher necessity since there are linkages between academic knowledge and local knowledge.*
T2F– *IK is the information base for society, which facilitates communication and decision making, which facilitates communication and decision making. Indigenous information systems are dynamic and continually influenced by internal creativity and experimentation as well as by contact with external system.*
T3F – *IK help the learners to improve their understanding and applications, it also helps them to develop conceptual understanding and scientific epistemology, it generates casual theories to support claim it offer evidence to support theories.*
T4F – *It better to have prior knowledge of a topic and then one can link it to the new knowledge that needs to be learn.*
T5M – *Incorporating culture and link to the scientific perception and modern scientific principles will play a vital role in correcting IK and physical sc.*
T6M – *according to my understanding, phy.sc. is the subject that is more on non-living / substances and discover new things. Therefore I think it can be used in our lessons.*
T7F - *It's a good to allow learners to apply the knowledge they have learnt from their community so that they understand better what is happening and also to clarify some misconceptions.*

T8F*– This is where the theory of moving from knowledge to unknown come into play, learners are already exposed to IK from home and will be easier for them to link what they know to what they do not know.*

T9M *– Blank*

T10M *– It help pupils on their assumed knowledge*

T11F *– It will be very helpful to include use of indigenous knowledge especially when references to certain examples such fermentation, purification, distilled, filtration, but this can only be helpful when teaching one group of culture.*

T12F*– I believe it is a great opportunity for learners to learn about their local experiments and apply it in the real world. It will also help learners in a great deal as most of the experiments examples given in the book are foreign to the learners and materials are unavailable.*

T13M *– makes the lessons interesting. Learners will be eager to learn and they will learn better by seeing.*

T14F *- It makes learners to acquire ideas that things do change from time to time. If you refer them to indigenous knowledge they will know what you are talking about. e.g. Filtrating funnel let say you don't have it. Refer them to Omakwila.*

T15F *- From my point of view, the inclusion of indigenous knowledge in physical science lessons will help the learners to understand the subject content into details. The reason being learners are exposed to real life examples, on how they apply science in their community.*

T16F *- Including the local knowledge of a teacher when teaching may improve the performances of the learners due to the reason that the teacher understand the subject well and be able to explain it well from his/ her own knowledge.*

T17M *-The inclusion of indigenous knowledge will enhance understanding of the concepts and mastery of the skills.*

3. What factors do you think influence your **perceptions** on the inclusion of indigenous knowledge during Physical Science lessons?

T1F *- Some local community members posses more knowledge and understanding in similar themes or topics that are taught in Phy. Sc. Some of the knowledge / facts need to be developed to fit more in modern scientific contexts.*

T2F *– Observing that sorghum is used in flour when making traditional beer and it assumed that it is important for fermentation.*

T3F *– blank*

T4F *– It can endanger learner or might mislead learners since it is not scientifically proven.*

T5M *–Modern technology and indigenous beliefs, cultural norms and values, traditional beliefs and religious.*

T6M *– our old / grand parents have been using different techniques to solve their problems, that is similar to what is done in physical science.*

T7F *– safely of instruments to be used, some are not reliable or will not give accurate results.*

T8F *– It can endanger learner or might mislead learners since it is not scientifically proven.*

T9M *- Blank*

T10M *– pupils use it to apply it to the lesson's understanding*

T11F *– The fact that we teach multi diversity of different Namibia culture or tribe and another child from another tribe might understand which I am trying to trying to say/ demonstrate.*

T12F*– Availability of materials, availability of local experiments that pertain to physical science.*

T13M *– Time consuming and lack of resources.*

T14F *- Language barrier e.g. Omakwila is Oshiwambo word so Damaras won't know what you are talking about. Vocabulary that you can use from indigenous knowledge. Cultural difference/background of the learners.*

T15F - *Lack of natural resources / conventional material suggested to be used in the lesson/ syllabus*

T16F -1. *The number of learners per class-too many learners will cause the teacher not to use his/her indigenous knowledge when competencies in the syllabus and leave the real life experiences relating to a specific topic in physical science.*

3.background of the teacher and the learner- sometimes the background where the teacher came from is not the same as the learners so it will be difficult for the learners to understand what example the teacher is giving as his/her indigenous knowledge

T17M - The inclusion of indigenous knowledge will enhance understanding of the concepts and mastery of the skills.Information obtained orally and from our keen seems easier to understand and eliminates the effect of cramming. This information reduces the issue of having many notes and diagram cramming (rote or remote learning.

4. What are your **experiences** of indigenous knowledge that might relate to western or scientific ideas or process from the topic experimental techniques - fermentation and distillation?

(a) At your home?

T1F – *brewing local beverages and preparing of Oshikundu.*
T2F – *Learning from grandmother how she is using scientific knowledge by preparing fermented fruits to prepare ethanol through fractional distillation.*
T3F – *there are more activity involved that are locally done but in relation with fermentation for example, the fermentation of Oshikundu traditional drinks.*
T4F– *one carry out different experiments in the kitchen which is based on baking and cooking and this also includes measuring for fermentation and distillation, no experience.*
T5M – *The use of fire and scientific principles, the production of homemade brew and modern fermentation like Magau, !Uri-!khari, traditional and practice of distillation of "Kaal gat".*
T6M – *Fermentation at our house is done by preparation Ovambo liquor / Oshikundu distillation – this process has been used in the past when we did not have clean water. What is been done was,*
T7F – *haven't experienced*
T8F– *I am not aware of it.*
T9M - *Blank*
T10M – *Brewing of traditional beer (Kashipembe) – for both fermentation and distillation and making traditional drinks (Oshikundu) – for fermentation*
T11F – *brewing of traditional drinks /beers such as Tombos, Oshikundu, Omalondu, Ombike all these, drink are being fermented.*
T12F – *the brewing of "Wambo liquor".*

T13M – *Distillation of dirty water to make them consumable.*

T14F - *When brewing traditional Vambo liquor, fermentation comes in when you put dry fruits in water to activate the enzymes and glucose in fruit is turned into ethanol. Indigenous couldn't explain and give reason for things. Distillation is just to separate the mixtures. (eg the reason of putting water in the condenser).*

T15F - *In Oshiwambo culture we make the home brewed alcohol called Vambo liqueur, it can be produced using the process of distillation.*

T16F - *Distillation- people in the northern part of the country make the traditional liquor (OMBIKE)..the process include different types of Wambo fruits mixed with water and then* *put it in a small tank to be distilled and the final product come out clear liquid leaving all the residue of fruit remains behind in the tank and*

T17M - *Fermentation : the pasturing of milk in our rural homes , brewing of maheu where by left overs of food was crushed and mixed with water and mealie meal (chimera) springled in the contents. Enough water was added and the mixture allowed to stand.These processes does not involve distillation.*

(b) In your community?

T1F – *Preparation / fermentation of fruits to produce alcoholic beverages*
T2F *– Fermentation of sorghum flour which produce a traditional been a traditional beer this include Otombo, epwaka,*
T3F *- there is a preparation of traditional drink like Omalodu, Oshikundu that are made from grains.*
T4F *– none*
T5M *– collecting traditional !Nara plant and use the heat of the sun over time and ferment it.*
T6M *– Fermentation and distillation is done by people who are selling Tombos / Katokele / Oshikundu.*
T7F *– Fermentation of beer*
T8F *– not aware of it*
T9M *– blank*
T10M *– making of traditional Jam (Mutete Jam)- fermentation, making of traditional beer (Mutoho and Tombo)- fermentation, making of traditional beer (Kashipembe) – fermentation + distillation*
T11F *– purification of water from the rivers or boiling water to distill it before the brewing of Oshikundu or Ombike is done.*
T12F *- The brewing of Tombo, Okatokele, and Ginger beer*
T13M *– Community make Vambo liquor by fermenting traditional fruits, distill them during the process which will lead to the production of the alcohol.*
T14F *- People are making money out of it so they are taking it as a commercial thing.*
T15F *-In Oshiwambo culture we make the home brewed alcohol called Vambo liqueur, it can be produced using the process of distillation.*
T16F – *Blank*

T17F *- Browing of beer was cheaply done by our gandparents without difficulties of relying on notes and procedures outlined in text books*

5. Describe indigenous knowledge you have been exposed to at your home/community that has a process or facts about:

(a) Fermentation of indigenous fruits

T1F *– dried fruits are placed in a certain container where water is added and left to ferment for some days. The fruits are then traditionally distilled to produce alcohol.*

T2F *– I am exposed to the fermentation of Mahangu together with Sorghum which leads to Oshikundu, the traditional drink.*

T3F *– the knowledge that I have is the fermentation of Marula oil from Marula fruits.*

T4F *– none*

T5M *- ! Nara plants by Nama people, honey and water over a long period of time.*

T6M *– Fruit like berries, Eenyandi, Palm fruits, they are fermentation to produce liquors through keeping them closed for days.*

T7F *– Baking bread*

T8F *– not aware of it*

T9M *– blank*

T10M *– Making Mutete juice – Fruits of mutate tree is collect and pounded and left to dry and boiled till water evaporates.*

T11F *– E.g. watermelons, Marula fruits to brew Ombike which is on indigenous Alcoholic drinks*

T12F *– People use Eembe or Bird Plum/ wild Berries (BerchemiaDiscolour), to make wine and Wambo Liquor.*

T13M *– Palm tree fruits can be fermented to make alcohol once the natural sugar has been removed.*

T14F *- Put dry fruits (Eenghekete) in water to activate enzymes, when they are ready you pour the mixture in a pot and you close it then you put it on fire. What gets out is Traditional Vambo liquor.*

T15F *-Fermenting indigenous fruits can turn natural sweetness or sugar in the fruits into alcohol. For example, berries, palm fruits and many more.*

T16F *- Fermenting of different kinds of fruits before distillation in to make the traditional*

T17F - *There were no fruits to because fermented during our time but left over's of food especially pap was fermented to make mageu.*

(b) Brewing of homemade alcoholic drinks or beers?

T1F– *Marurajuices is extracted from Marura fruits. It is then left to ferment for some days. Fermented fruits are fractional distilled where alcohol is collected as a product.*

T2F *– Fermentation of palm fruits mixed with other fruits this goes through fractional distillation the steam condense which gives pure ethanol which used for drinking and its alcohol.*

T3F *– on the home – made drinks is the brewing of traditional drink like Omalodu, Oshikundu and Vambo liquor.*

T4F *– none*

T5M *- !Nara #aro (known berries to Nama/ Damara people and #au are also used as they contain glucose (sugar).*

T6M *– N/A*

T7F *– The alcohol had to be left for some day to allow it to fermentation and exposed to heat.*

T8F *– cannot recall*

T9M *– blank*

T10M *– making Mutoho(traditional beer) - Mahangu is soaked in water for a week until it germinate and then pounded and sieved to remove the powder (meal mill) than water is boiled and the mealie mills (Mahangu) is added and make solution and left to cool down and yeast added till it fermented than it is a beer. (it is a process).*

T11F *– We brew many different kinds of indigenous alcoholic drinks and beers from our local fruits, such as watermelons, Marula fruits, palm fruits and cereals.*

T12F *– Brewing of Tombo, whereby Sorghum is soaked in water with sugar to make an alcoholic drink. This use of Watermelon to make beer (homemade drink).*

T13M *– Using Sorghum to produce a traditional alcohol drink named ''Tombo'.*

T14F *- We put "ongudo" to act as a catalyst when we are brewing Oshikundu.*

T15F *- It is easier and a cheaper way to make homemade alcoholic drinks. It only requires the necessary skills for and resources for one to come up with the homemade beer.*

T16F *- Palm fruits (dates) and berries are used by different people in the northern part of the country to produce the Wambo liquor.*

T17F *- brewing of beer was done commercial by old mothers to earn a living and send some children to school. The beer is called kachasu.*

6. What were your <u>experiences</u> on the inclusion of indigenous knowledge in the topic experimental techniques- fermentation and distillation during Physical Science lessons?

(a) When you were taught as a learner?

T1F*- I was not real well informed of what happens during fermentation however all the necessary process were outline to me during the preparation of beverages.*

T2F *– I found it most comfortable and most effective in learning culture in class, I was already familiar with fermentation through traditional knowledge I learned from home therefore it was very easy for me.*

T3F *– On the home –made drinks is the brewing of traditional drink like Omalodu, Oshikundu and Vambo liquor.*

T4F *– When I was at school we did not had such a topic. I only learn about it when I started teaching. That was in 2005. I can only remember that one of my principals at high school which was a science teacher made pure alcohol. But he did it on his own.*

T5M *–N/A*

T6M *– This was just done theoretically*

T7F *– It made me understand the process very well and links the knowledge that I learnt at school with what was going on at home.*

T8F *– cannot recall*

T9M *– blank*

T10M*– very easy to grasp because it is knowledge from home to school*

T11F *– The experience as a learner was more on distillation. When we were taught about purification methods, various demonstrations such as those of purifying river water by distillation methods etc.*

T12F *- None. An example of making Wambo Liquor was only use, theoretically but no experiment was done to demonstrate how the process takes place.*

T13M *- as a learner I was just exposed to theory and teachers usually refer to the homemade drinks as an example due to lack of resources.*

T14F *- It was not well explained/well integrated*

T15F *- I realized that we have been using scientific skills in our daily lives unknowingly, because the production of Vambo liqueur can exactly be compared to fractional distillation.*

T16F - *In high school we were taught how the Wambo liquor is made by our science teacher as her indigenous knowledge. We did practical on distillation of separating different impurities using a Liebig condenser and a conical flask.*

T17F *– the lesson become live and vivid. More participation with little attention to new terminology.*

(b) At tertiary institution?

T1F *– Procedures were then well explained and I could reason as why fermentation took place and why alcohol boils off first before water.*

T2F *– N/A*

T3F *– This is the time-I start relating the learned knowledge and with the scientific point of view.*

T4F *– yes at College we started to learn about the topic.*

T5M *– N/A*

T6M – *AtCollege we learned about the topic theoretically.*

T7F – *I was not exposed*

T8F *– cannot recall*

T9M *– blank*

T10M *– It was easy because it is the knowledge applied was best on the experience from home and school.*

T11F - *At tertiary it was more on both distillation in the topic of separation method and fermentation was on organic chemistry topic of alcohol formation by fermentation.*

T12F *– none*

T13M *– Theory has been proved with experiments – resources were available.*

T14F -*It was not well explained*

T15F – *N/A.*

T16F - *I didn't do any practical on distillation or fermentation at the university*

T17M -*More attention was paid to the processes and terminology.*

7. Currently as Physical Science teacher, have you ever used indigenous knowledge in your teaching?

YES	NO
T1F, T2F,T3F, T5M, T6M, T10M, T11F, T13M, T14F, T16F	T4F, T7F, T8F, T12F, T15F, T17M

T9Q7M – not indicated

(a) If YES, what were the aspects or what were the examples of indigenous knowledge you have used when teaching the topic experimental techniques - fermentation and distillation?

T1F – *Learners are sent to explore ideas from their parents on how fermentation and prepare of alcohol traditional works. They are also sent to prepare their traditional condenser that they bring at school and be tested for effectiveness.*

T2F – *I refer learners to the traditional method that is used at home this includes Oshikundu and ethanol that is produced through fermentation of palm fruits mixed with other fruits.*

T3F – *Building houses using thatches. Burning the fire wood is an example of combustion. Using red Cabbage to make indicator.*

T4F – *N/A*

T5M – *Distilling – berries over a heat. Use of grape fruits to distill alcohol.*

T6M –*Normally I only give examples of local drinks especially or specific drinks like Otombo, Grapes liquors / "Maxou" "Nama" traditional (drink), but most of them are more on fermentation.*

T7F – *N/A*

T8F – *N/A*

T9M – *blank*

T10M - *production of traditional juice using traditional fruits, production of alcohol using traditional fruits, separation of liquids to get pure solvent from the solution (pure water from salt water).*

T11F -*The aspects on the topic experimental techniques was more about the appropriate instrument used such as flasks, thermometer or distillation. Brewing of Oshikundu, Ombike, Mageu etc.*

T12F - *blank*

T13M – *In this case, it was just the purification of water. Learners know that water need to be boiled to be pure. During the experiments, water vapour condensed and collected. No fermentation due to lack of resources.*

T14F - *Filtering using cloths, Brewing Oshikundu*

T15F – *N/A*

T16F - *I tried teaching the learners about how the Northern people do the traditional liquor but it was difficult for the learners because they even don't know what type of liquor I was talking about.. With the learners we used a Liebig condenser and conical flask, water, ink and a burner to separate the mixture of ink and water.*

T17F –*N/A*

(b) Explain how you used the indigenous knowledge in teaching the above mentioned concepts?

T1F – *Learners will be requested to do the preparation using the home made materials and also explain to the class all procedures involved during the preparation of alcohol traditionally.*

T2F – *We carried out an investigation in the lab were we carried out an experienced about fractional distillation of ethanol and it was successful.*

T3F – *N/A*

T4F– *My experience is practical still needs a lot of boost*

T5M – *N/A*

T6M *– N/A*
T7F *– I have not come across a topic which required me to use indigenous K.*
T8F *- lack of IK relevant to phy.sc.*
T9M *– blank*
T10M *– explanation of the separation of ethanol and the fruits (distillation), can be used to explain how to separate two liquids which have dissolved into one other*
T11F *–On distillation, collected river water, heat it until it's' boil, and filter it to demonstrate purification through distillation on fermentation, I heated a ripe water melon using a flask, pipes to demonstrate the fermentation of the alcoholic traditionally known as Ombike.*
T12F *– blank*
T13M *– water is heated, a delivery tube from the water to collect the water vapour, water vapour the condenser and collect it in another container.*
T14F *- When brewing traditional Vambo liquor, fermentation comes in when you put dry fruits in water to activate the enzymes and glucose in fruit is turned into ethanol. Indigenous couldn't explain and give reason for things. Distillation is just to separate the mixtures. (e.g. the reason of putting water in the condenser.*
T15F *– N /A*
T16F *- I tried linking the content of separating mixtures with the method of fractional distillation with the fermentation of fruits and distillation of the liquor as the last step of the process. From the local environment*

T17M *– N/A*

(c) If NO, what could be the reasons why you never used indigenous knowledge during your science lessons?

T1F *– N/A*
T2F *- N/A*
T3F *– N/A*
T4F *– My experience is practical still needs a lot of boost*
T5M *– N/A*
T6M *– N/A*
T7F *– I have not come across a topic which required me to use IK.*
T8F*– Lack of IK relevant to P. Sc*
T9M *– blank*
T10M *– N/A*
T11F *– N/A*
T12F *– I am currently not teaching Physical science even though I did it at high school and I did at tertiary institutions as my specialization.*
T13M *– For fermentation is due to lack of resources.*
T14F *– N/A*
T15F *-Due to lack of natural resources specifically indigenous fruits, it made it impossible to use indigenous knowledge in physical science*
T16F *– Blank*
T17M - *pupils will have a tendency of sticking to the examples and forget the new information taught. There will be great struggle to clear the minds of the old concepts mastered by the pupils.*

8. **What do you think what could be the reasons why <u>other</u> Physical Science teachers**
(a) Include indigenous knowledge during Physical Science lessons?

T1F *– show cultural respect, form a link with the community and sustain cultural knowledge.*
T2F *– Because it will remind learners of the features of their own culture.*
T3F *– To make the subject more locally based and they are able to apply scientific term into everyday life experience.*

T4F *– to expose learners to pratical and to make physical science interesting and joyfull, also to broaden learners' knowledge.*
T5M *– learners will compare with read like objects and scientific principles.*
T6M *– I think is just to bring reality in the classroom.*
T7F *– To include prior knowledge so that learners can relate to surrounding knowledge and what has been scientifically proven, for learners to understand the work very well.*
T8F *– To see whether indigenous product will give the same outcomes in an experiment in experiments as scientifically proven theory. Lack of scientific proven products / chemicals.*
T9M *– blank*
T10M *– To make learner understood easily*
T11F *– Because it us to better make learner understanding these scientific terms better when we demonstrate it through our indigenous knowledge, because some learners are exposed to these methods in everyday life hence they will better understand the link between these terms and their everyday use at homes.*
T12F *– They include it, because they have knowledge of it. Others find it a good example as to use the things that learners have seen or know off unlike many other experiments in the textbook.*
T13M *– Drill learners pre-knowledge and to allow learners to share ideas.*

T14F *- It will make learner understand and it will be easy for them to understand when the teacher is explaining*

T15F *- It might be that they want to relate science to real life situations, where can it be used. Secondly, it might be that they want to make it easier for the learners to remember the information and make it easier for them to learn the subject content.*

T16F- *Teachers include indigenous know so that the learners can see the relation between science and their daily life experiences. Sometime learners understand better when they can relate subject content with reality. To make topics interesting for the learners.*

T17M - *if there is a common practice which is an obvious case that everyone in the area had come across, this implies that the teacher we use the indigenous knowledge without doubt.*

It will also be very difficult for a teacher to ignore what is on the finger tips of the learners as their assumed knowledge.

(b) Do not include indigenous knowledge in their lessons?

T1F *– not confident whether it will work, no trust if they can get concrete information, lack of proper planning.*
T2F *–They perhaps think is the old education, or they viewed it as a backward to western scientific knowledge.*
T3F *– when they do not have knowledge on how to apply the local knowledge.*
T4F *– Do not have enough knowledge how to incorporate it in to their lessons.*
T5M *– No*
T6M *– lack of traditional knowledge of doing things / not common in the locations.*
T7F *– They might not want to confuse the learners with information which is not scientifically proven or something that they could refer to as a myth.*
T8F *- Fear of unknown outcome. Lack of skills to use IK by some teacher. No included in the syllabus.*
T9M *– blank*
T10M *– some lack indigenous knowledge*
T11F *– They might not be exposed to this indigenous knowledge or they might be ignorant, lack of time, due to teaching multi-diversity learners within a school might be difficult.*

***T12F** – IK is local knowledge in our country we have different tribes. Some do not have reference to Physical Science. Some teachers might not have knowledge of IK, others do not include it as it's not part of the syllabus. Others might just be ignorant towards IK.*
***T13M** – Due to the fact that people (learners) came from different background, they have different ways of manipulating IK than that of a teacher. It will be hard to experiment different ideas with a short period.*

***T14F -** They don't understand. They creativity and innovation is different*

***T15F** -It might be that they want to relate science to real life situations, where can it be used. Secondly, it might be that they want to make it easier for the learners to remember the information and make it easier for them to learn the subject content.*

***T16F** -Time is limited for subject lesson and teachers only focus in teaching what's required by the syllabus. Teacher doesn't have any indigenous knowledge about the topic. Teachers and learners coming from different ethnic groups so it will be difficult to include the indigenous knowledge from the teacher's background when teaching.*

***T17M** - if the example of the indigenous knowledge to be used is not common in an area then the teacher may not use the example since it will compromise the discussion. Pupils will have double problem of understanding the example and the link it to the lesson objective.*

9. (a) What do you think could be the <u>advantages</u> of including indigenous knowledge in Physical Science lessons?

***T1F** – Learners would been earlier and better when they are taught something they experience daily life, the cultural heritage would be sustained.*
***T2F** – To address challenges facing society, to make learners aware of the environment and equip learners with investigation skills.*
***T3F** – learners will understand better the lesson and find it interesting as it is being related to the content that they know.*
***T4F –** learners will enjoy the topic, they can start to develop their own business idea for the future.*
***T5M –** Awareness of traditional methods or lin*
***T6M** – Just for the learners to know that the process that there are discussing in the class are similar to the one that happening at home. This can be easy for them to recall or discover new initiatives that can benefit our national.*
***T7F** –Learners will be able to relate what's going on at home and what they are taught at school. To understand the work very well. Create awareness of IK.*
***T8F** – Make P. Sc more realistic and learners can link to what they know from home with what is happening in the class (P.Sc. class) and that will lead to clear understanding of the subject content.*
***T9M**– blank*
***T10M**– learners understand easily*
***T11F** – It will motivate learners to understand the importance of physic in daily life. It help us to diverse the Namibian indigenous knowledge.*
***T12F** – It help to preserve our heritage in a way as most of the indigenous knowledge are dying out as people are drawn more to western cultures.*
***T13M** – learners will understand the content better since they are using their own ideas or lining what they know with the western knowledge.*
***T14F** – N/A*

***T15F -** Itmakes learning easier, because learners are able to relate what is happening in their community with the subject content they are learning at school.*

T16F –*It link science with reality from local environment. Learners will understand the subject and be able to explain the subject content from their own experiences*

T17M -*Indigenous knowledge will be of great importance if the pupils all come from the same background where the knowledge is common to every family where they come from.*

(b) What do you think could be the disadvantages of including indigenous knowledge in Physical Sciences lessons?

T1F *- If not well explored, it might give wrong information. There a few communities' members who pose IK that one can invite to school and do some presentation.*

T2F *– Inability to deliver the performance outcomes.*
T3F *- at the other point some of the topic does not have content that can be support by local knowledge which makes it difficult for the learners to understand.*
T4F *– learners can start to experiments at home and what they get might cause problems if not used correctly and for the right purpose.*
T5M *- wrong perception of and altering of traditional beliefs.*
T6M *– we will always import things that can be done in our own country location.*
T7F *– can bring confusion among learners with cultural believes and what they learn at school.*
T8F *– inaccurate results*
T9M *– blank*
T10M *– Difficult to translate in English*
T11F *– It might accommodate all learners in their everyday household use*
T12F *– It will only be available to some people (learners) because to some cultures it could still not be indigenous as they have never heard of such and do not practice it.*
T13M *– Practicing some of certain IK will give learners a feeling of discriminatory act. In terms of brewing homemade beers, teaching learners how to produce alcohol will have a negative impact on their health, as they will produce their own breweries and consume them.*
T14F –N/A
T15F- *It can be time consuming, because one have to get all the materials ready*

T16F – *knowledge that a teacher knows might be a new thing to the learners and they will not be able to focus.*
T17M - *Indigenous knowledge will be a great disadvantage if a class had pupils from different cultures, where by some cultures uses the extract of the example as a common knowledge and the other cultures have not yet heard of the example. Pupils will end up trying to experiment and hence deviate from their set target objectives.*

10. Do you think indigenous knowledge should be included or not? (Tick in each statements for your choice)

Statements	**Strongly Agree**	**Agree**	**Not sure**	**Disagree**	**Strongly Disagree**
Syllabus	T1F, T3F, T7F, T8M, T10M, T11F, T12F, T14F	T2F, T6M	T4F	T5M, T13M	

	T15F, T16F, T17M				
Lessons plans	T1F, T7F, T8M, T11F, T12F, T14F- not indicated, T15F	T2F, T3F, T13M, T16F, T17M	T4F, T6M, T10M	T5M	
Lesson delivery	T1F, T3F, T7F, T8M, T10M, T11F, T12F, T14F, T15F, T16F, T17M	T2F, T6M, T13M	T4F	T5M	
Practical work/Activities	T1F, T7F, T8M, T11F, T12F, T14F, T15F, T16F	T2F, T3F, T6M, T10M	T4F, T17M	T5M, T13M	

T9Q10 – not indicated

11. How are you currently teaching the topic experimental techniques- Fermentation and Distillation? Explain the teaching methods you are using and the teaching aids you are using?

T1F *– During methods of separating mixtures, learners are asked to explain the preparation of Kashipembe. Those who know then explain to others. They are then tested to prepare common materials for the experiment where it is cameed. Out as either in group or is demonstration.*
T2F *– Learners centered approach, were learners have to practice this in the laboratory.*
T3F *– I only use the diagrams drawn in the poster because fermentation and distillation is a lengthy and it takes time. It cannot be done in 40 minutes that the lesson normally takes.*
T4F *– only theoretical for Grades 11-12*

T5M *– N/A*

T6M *– practical not get*
T7F *– I haven't taught or touched on the topic*
T8F *– None*
T9M *– blank*
T10M *– Write notes on the chalkboard, make use of group works and use diagrams*
T11F *– I used a Bunsen burner, beaker, thermometer to distill and purify river water. Fermentation is used by locally pipes, container, and heat to collect the fermented liquid.*
T12F *– Blank*
T13Q11M *– Distillation- Acids, flask, Bunsen burner, delivery tube, water. Method- heat/ boil water in a flask, collect water vapour with a delivery tube.*
T14F – N/A
T15F *–Due to lack of resources, I teach the way it is prescribed by the syllabus. Making use of the lab equipments to carry out the experiments and make use of posters and video that are demonstrating how fermentation and distillation work*

T16F – *Distillation- I use the conical flask and the Liebig condenser to explain the process of fractional distillation. Fermentation- I use the textbook as the teaching aid when I'm explaining this process in physical science*

T17M - *Currently we are using group discussion as well as carrying some experiments on distillation.*

12. What else would you like to share with me regarding the inclusion of local knowledge (indigenous knowledge) during Physical Science lessons?

T1F – *N/A*
T2F – *Scientific methods and conventional systems of resources management must learn to fit into traditional way of viewing for these values form the basis for the future survival.*
T3F – *I think it is more advisable to use local knowledge in the physical science lessons.*
T4F – *The topic can be included but maybe at a later stage like Grade11-12.*
T5M – *N/A*
T6M – *Fermentations and distillation can be one of them, but there are also some like. Mediation, use indigenous fruits / trees. Extraction of laboratory's acids and bases.*
T7F – *It is very important to include indigenous knowledge as this will be able to make learners / teachers clarify on misconceptions for better understanding the learners will learn to be relative*
T8F – *not now*
T9M - *blank*
T10M – *Some of the learners do not have knowledge or locally (indigenous Knowledge)*
T11F – *Aspects of rate of reactions, fermentation and separation methods are important because these are topics we use them in our daily house etc.*
T12F - *Blank*
T13M – *Local knowledge will be influenced by different cultures, what other cultures' methods of processing drinks can differ from the other one. Local knowledge is based on the diversity. The environment and its' resources.*

T14F – *More training should be given to teacher on how to include local knowledge in Physical Science lessons.*

T15F –*Inclusion of indigenous knowledge make learning more interesting and makes the lesson more live. But due to diverse culture, it can also be challenging, due to the fact that each culture or community have their own local knowledge and use different resources.*

T16F – *I suggest the lesson should be extended and put a components on a lesson where teachers and learners have to share this type of knowledge regarding the subject.*

T17M - *inclusion of indigenous knowledge should be used with tact. If it is not done tactfully, pupils may end up diverging from the intended goal of the day and or the teacher may dwell on this knowledge too much to an extend of not completing the syllabus or not explaining the technical terms*