An investigation into how grade 9 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

A thesis submitted in partial fulfilment of the requirements for the degree

Of

Master of Education

(Science Education)

Of

Rhodes University

By

Kleopas I.T. Uushona

January 2013

DECLARATION

I, the undersigned, hereby declare that the work contained in this thesis is my own original work and has not previously in its entirety or in part been submitted at any university for a degree.

Signature: .... Date...

ABSTRACT

One of the purposes of the Namibian curriculum is to ensure cultural inclusivity. That is, it recognises the inclusion of traditional cultural practices and experiences in science lessons where appropriate. Based on my experiences both as a learner and a science teacher, I have noted there is a rapid decline and loss of values in most of our cultural practices and heritages. This triggered my interests to do a study on an *Oshiwambo* traditional beverage known as *Ombike*. This study is therefore aimed at enhancing conceptual development, meaning making and understanding of concepts in fermentation and distillation.

This study was conducted with my grade 9 learners at a school where I was teaching in Omusati region of Namibia. A community member who served as an expert was also a participant. She was involved more in discussions, interviews and most importantly in showing and demonstrating to the learners how *Ombike* is made practically. Essentially, the goal of this study was to investigate how the indigenous practice associated with the making of *Ombike* can be used to support meaning making of fermentation and distillation processes.

This research is located within an interpretive paradigm where a qualitative case study was adopted. I consider this methodological framework appropriate in this study because it allowed me to use the following data gathering methods: brainstorming and discussion, observation, semi-structured and focus group interviews, and practical activities worksheet. Multiple methods were used for the purpose of triangulation and validation. An inductive analysis was used to discover data patterns and themes from the data. Moreover, ethical considerations were also taken seriously and all the participants gave informed consent.

The findings of the study revealed that brainstorming and discussions were an appropriate strategy in eliciting learners' prior everyday knowledge and experiences on, in particular, the making of *Ombike*. Furthermore, learner engagement and conceptual development were enhanced. This suggests that contextualisation of knowledge can enhance meaningful learning if it is properly planned. It was also found that practical activities in conjunction with mind maps helped learners to make meanings of scientific concepts. Based on my research findings, I therefore recommend the following three aspects:

- the consideration of learners` prior knowledge and experiences;
- contextualising knowledge through use of indigenous knowledge; and
- the learners' active involvement in practical activities with an emphasis on key scientific concepts to be developed. That is, there is a need to teach for conceptual understanding.

ACKNOWLEDGEMENTS

My acknowledgements will cover a wide range of people who have been of great help throughout my research endeavour. First of all, I would like to thank the almighty God for making me strong, determined and committed to complete my research study through many challenges. I also thank him for all the protection and holy support he gave me. Thanks God for giving me good people to work with!

I wish to extend my words of gratitude and appreciation to Dr. Kenneth, M. Ngcoza and Mr. Charles Chikunda, my supervisor and co-supervisor respectively for their tireless support, guidance, comments, directives and relevant supporting materials that contributed a lot to the completion of this study.

I am also grateful to my fellow Masters students for their tireless support during the course of my study. Guys, you were such special, inspiring and motivating colleagues!

I would also like to extend my heartfelt thanks to Mrs. Ndeapo Nicodemus, an expert in making *Ombike* for being so kind, welcoming and understanding. She demonstrated to the group of participants the cultural way of making *Ombike*. She also agreed to be interviewed and be involved in discussions regarding this study. I appreciate all her involvements because she is such a very busy woman and agreed to accommodate us in her busy schedules. It was through her that I was able to make *Ombike* known to the global academic world.

I would also like to express my sincere thanks to my Grade 9 learners for the year 2012 who were involved in this study and their parents who allowed them to participate in it. It was because of them I was able to do this study.

I would also like to acknowledge Mrs Taimi, Iidhini the school principal, for allowing me to do this study in her institution; Mrs Helmi Kanime, the school Head of Department (HoD), for being my critical friend in this study.

I will be guilty if I did not give a special word of gratitude to my parents; Mr. Linus Uushona and Mrs. Taimi Uushona, for my existence, for their moral support and high respect they gave to me. To my brothers and sisters; Shiwanda, Uushona, Taatsu and Namutenya your consistent, continual motivation and expectations you put on my shoulder is recognised.

Lastly, I thank all my friends, my relatives, my colleagues and everyone who have contributed to the completion of this study.

DEDICATION

This thesis is dedicated to my grandmother, Irja Nambula Amanyanga (*kuku GwaAmanyanga*). She grew me up through my infancy and youth. It was because of her that I attended school where I consistently performed well and was able to reach this academic level through her efforts.

TABLE OF CONTENTS

LIST OF FIGURES, TABLES, PICTURES AND GRAPHS

Figures

Tables

LIST OF ABBREVIATIONS AND ACRONYMS

- AIDS Acquired Immuno Deficiency Syndrome
- BEd-Hons. Bachelor of Education Degree with Honours
- BETD Basic Education Teacher Diploma
- ETSIP Education and Training Sector for Improvement Programme
- G1-12 Group 1-12.
- HIV Human Immuno-deficiency Virus
- HoD Head of Department
- IK Indigenous Knowledge
- LCE Learner Centred Education
- LoLT Language of Learning and Teaching
- LTSMs Learning and Teaching Support Materials
- MBESC Ministry of Basic Education, Sport and Culture
- MEC Ministry Education and Culture
- MEd Masters in Education Degree
- MHETEC Ministry of Higher Education, Training and Employment Creation
- MoE Ministry of Education
- NDP National Development Plan
- NIED National Institute for Educational Development
- NoS Nature of Science
- NSHE Natural Sciences and Health Education
- OBE Out-come Based Education
- PEEOE Predict, Explain, Explore, Observe and Explain
- T Teacher
- TB Tuberculosis
- ZPD Zone of Proximal Development

SYMBOLS USED IN THE TEXT

- C_2H_5OH Ethanol
- $C_6H_{12}O_6$ Glucose/sugar
- CH_3OH Methanol
- CO_2 Carbon Dioxide
- H_2O Water
- N$ Namibian Dollars
- O_2 Oxygen

CHAPTER 1

RESEARCH CONTEXT

1.1 Introduction

This chapter introduces my study which was an investigation into how Grade 9 learners make sense of the fermentation and distillation processes through exploring the indigenous practice of making a traditional alcoholic beverage called *Ombike.*

The first section of the chapter is the background to the study, followed with the research goals and questions, the theoretical frameworks that underpinned the study, data gathering techniques which were used to generate data, the potential value of the study, definition of concepts, and thesis outline. It ends with some concluding remarks.

1.2 Background to the study

In 2010, the Ministry of Education in Namibia introduced a new curriculum known as Curriculum 2010. One of the main goals of this curriculum is cultural inclusivity, that is, to recognize and include where appropriate traditional cultural practices and discoveries in the educational practises of the classroom (Namibia, Ministry of Education (MOE), 2009).

With these generational ideas, I have observed that there is a rapid decline and loss of value in most of our cultural practices and heritages hence the study of *Ombike*. *Ombike* is one of the cultural beverages made by the *Oshiwambo*-speaking people in the northern parts of Namibia and can be used to illustrate fermentation and distillation processes in the science classroom.

By engaging in this study I had hoped that the practical demonstration of this cultural practice would enhance learners' meaning making, conceptual development and understanding of the **fermentation** and **distillation** processes.

From my own experience both as a learner and a teacher, fermentation has been one of the key concepts in the Namibian science curriculum that learners find difficult to understand. Fermentation has been defined as "a process used to produce alcohol from sugar and yeast having carbon dioxide as a by-product" (Britz & Mutasa, 2008:58). But instead of using the examples of fermentation found in the textbook which are typically about the making of wine, it would enhance sense-making if the learners used the example of their traditional and local ways of producing an alcoholic beverage. Essentially, I see this as a strategy to contextualize scientific concepts, something which could make it easier for my learners to understand and experience science from their own real context (Stears, Malcolm & Kowlas, 2003; Oloruntegbe & Ikpe, 2011; Rennie, 2011). For example, in her research, Rennie (2011) emphasizes the importance of blurring the boundaries between science in the community and science in the classroom believing that this can enhance meaning-making in science. I concur with Rennie.

Thus, teachers need to have that knowledge and motivation of contextualizing the science concepts by seeking out appropriate everyday local examples. In addition, even when the textbook has no examples of a concept, teachers need to be able to improvise and seek out local relevant examples of these ideas.

Teachers have all kinds of potential resources to turn to, to help them contextualize their science teaching. In my view the community can be an important support and resource, as well as a source of knowledge. Also, there might be people with expertise in science and cultural traditions that may be used to support in teaching of science as co-curricular activities (Namibia, MOE, 2009:12). A word of caution is warranted here, though, that not all everyday experiences are genuinely educative.

1.3 Research goal and objectives

The main goal of this study was to investigate how the indigenous practice associated with the making of the alcoholic beverage known as *Ombike* can be used to support meaning-making, conceptual development and understanding of the **fermentation** and **distillation** processes with Grade 9 Physical Science learners.

To achieve this goal, the following objectives and questions guided the study. After each objective, the question that arises is given in italics:

- To get the learners views on their prior knowledge and experiences regarding the cultural ways of making *Ombike*; **Question:** *What are the learners' prior knowledge and experiences of the indigenous practices associated with the making of Ombike?*
- To use the experiences of making *Ombike* in enhancing scientific concept-development and understanding of the processes of fermentation and distillation; **Question***: How can the making of Ombike support meaning making of the processes of fermentation and distillation?*
- To integrate the learners' prior and newly acquired knowledge from their experiences of making *Ombike* into their practical activities; **Question:** *How might one integrate the learners' prior and newlyacquired knowledge from their experiences of making Ombike into practical activities?*

1.4 Data gathering techniques

The following data gathering techniques were used in this study:

- Brainstorming and discussion;
- Observation;
- Interviews; and
- Worksheets (practical activities).

A variety of data generation techniques were used with the view to enhance the validity of data through triangulation of methods.

1.5 Potential value of the study

The potential value of this study pertains to the use of the local-cultural practice (making of *Ombike*), in enhancing conceptual development of scientific concepts; namely, **fermentation** and **distillation**. This will help learners to see that scientific knowledge is part of their everyday lives. Also, through involving the community members in teaching science, I hoped to tap into their knowledge so that they could realize the educational value of their cultural practices.

By virtue of my position as a science teacher and educator, who has lived and taught in a place where science subjects were not equally valued and respected, I had to act as an agent of change in this matter. By investigating a cultural practice as demonstrated by local people I hoped to transform learners' perceptions into realising that science is all around them as part of their everyday lives.

Moreover, this study was not only intended to mobilise the use of *Ombike*, but also to raise the awareness in both science teachers and learners to continually think and make use of indigenous knowledge and cultural practices related to the many other science topics. This could make our learners to feel, see, and experience the essence or amount of science around them.

Finally, the unit of work and worksheets developed for this study could be used by many other teachers as an example to develop their learning and teaching support materials (LTSMs) (Czerniewicz, Murray & Probyn, 2000). It could also serve as a guiding tool and an eye-opener to other science teachers and to curriculum planners on the importance of including local knowledge in education.

1.6 Definition of concepts

Following are the brief definitions of some of the key concepts used in this thesis:

- **Ombike** is a local cultural homemade alcoholic beverage popularly made in the northern part of Namibia, which was used as a learning context in this research study.

- **Expert** is a woman from the community used as a research participant. She demonstrated the cultural practice of making *Ombike* to the learners.
- **Critical friend** is a science teacher used as a support teacher in this research.
- **Fermentation** is a chemical process that involves the breaking down of organic materials such as glucose/sugar by micro-organisms such as yeast to produce ethanol and carbon dioxide gas.
- **Distillation** is a method of separating mixtures through vaporization. It involves boiling the mixture and then condensing the vapour that forms.
- **Prior everyday knowledge** is the knowledge acquired from the community, home or the environment, which can be both indigenous and scientific knowledge.
- **Indigenous knowledge (IK)** is the local knowledge gained through social interaction in the community. It is specific to the particular community.
- **Conceptual development** refers to gradually increasing or expanding the content of particular concepts in order to create more understanding of them. For example, by teaching fermentation in each of the grades 6-10, better, and fuller understanding is created as the content keeps increasing.
- **Meaning-making** is when learners are able to make sense of the new concepts emerging in the topic being taught. It deals with the issue of whether learners are able to relate a particular situation to what they know or experience.
- **Practical activities versus practical work** refers to the activities that enable the learners to put into practice the theory and skills they are studying, often in a practical setting. Practical activities engage learners in field work, presentations and working in laboratories. It is influenced by a range of activities that requires careful planning and clear identification of the purpose of the activities. In contrast, practical work is any teaching and learning activity which at some point involves learners in observing or manipulating real objects. This in most cases happens only in the laboratory as opposed to practical activities.
- **Learner-centeredness** refers to the approach to teaching and learning which regards learners as central in the learning process. Teaching is planned in such a way that new knowledge is based on refining the prior knowledge of learners to create new understanding. A learner can construct meaningful and coherent representation of knowledge when supported and given instructional guidance as time goes on. A

learner is allowed to link information with existing knowledge in meaningful ways. Learners talk and act instead of merely ‘sitting and listening’.

- **Fair experiment/control** refers to the condition when you change only one factor/variable and keep all the other conditions the same in an experiment.

1.7 Thesis outline

This thesis reports on the entire processes involved throughout my research whose focus was on investigating how the indigenous community practices can be used to enhance learning of concepts of fermentation and distillation. It comprises of six chapters.

In **Chapter One**, I outline the background of the study, research goal and objectives, methods used for data gathering, the potential value of the study, definition of concepts and the thesis outline.

In **Chapter Two**, I present literature relevant to my research study. The literature chapter reviews the following; curriculum issues, nature of science, indigenous knowledge, prior knowledge, and the role of practical work in science lessons. Lastly, the chapter looks at the theoretical frameworks that underpin this study.

In **Chapter Three**, I present the methodology I used in my research. I first present the interpretive paradigm which informed it. I then discuss various data generation techniques that I used and the inductive/deductive method applied to analyse the data. The research site and participants; the ethical issues; validity and trustworthiness as well as limitation of the study are also discussed in this chapter.

In **Chapter Four**, I present a narrative account of the data generated from the research study during the data gathering process. The data in this chapter came from the gathering methods used in phase one of the study such as; brainstorming, presentation, practical demonstration, and group discussion. The presentation is mostly in the respondents’ own words with a minimum comment from me as researcher.

In **Chapter Five**, the data from phase two of the study are presented. The data comes from the semi structured interviews, practical activities worksheets and observation.

In **Chapter Six**, I discuss the findings presented in Chapters 4 and 5 using a set of analytical themes derived through coding. The interpretation of the findings is also presented in this chapter. I end by attempting to make meaningful knowledge claims related to the research question.

Chapter Seven is a conclusion of the study. It presents a summary of the findings. Recommendations based on the research and areas for future investigation are also given as well as the limitation of their application. I end by briefly discussing my personal reflections with regards to my academic growth.

1.8 Concluding remarks

In this chapter I outlined the research background/context and other research elements such as; goals and objectives, data gathering techniques, and the potential value of the study.

The next chapter discusses the literature that informed and shaped my research. I look at literatures on; curriculum, nature of science, indigenous knowledge, and practical work.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

In this chapter, I discuss the relevant literature that informed my study. Basically, this study attempted to bring out the benefits of integrating learners' prior everyday knowledge and experiences in conjunction with the use of indigenous cultural practices and practical activities with a view to enhance conceptual development and understanding of the fermentation and distillation processes.

The focus of this chapter is directed towards specific basic aspects of the curriculum; in particular, the science curriculum and I have attempted to put into perspective the following:

- Curriculum issues paying more emphasis on learner-centred education;
- The scientific background of concept under study: fermentation and distillation;
- Role of prior everyday knowledge and community experiences;
- The role of practical activities; and
- The theoretical framework that underpins my study.

I now discuss each of these in detail.

2.2 Curriculum issues

In order to improve curriculum relevance, the use of everyday context in science curriculum teaching has been promoted in Africa over the past decades. This was one of the main ideas behind the research study conducted by Kasanda, Lubben, Gaoseb, Kandjeo-Marenga, Kapenda and Campbell (2005:1807) in Namibia and who stated that the drive for political and social self-confidence has encouraged the building of a science curriculum based on learners' everyday experiences (Stears, Malcolm & Kowlas, 2003). This is also expressed strongly through curricula highlighting local cultural achievements including those in indigenous technologies, for example, in Ghana (Yakubu, 1994), Mozambique (Baloi, 1994) and Swaziland (Lubben, Campbell, Maphalala, & Putsoa, 1998).

Since the independence of Namibia in 1990, as in other developing countries the education system has been informed by the principle of learner-centred education (LCE). In Namibia, this principle is in an African context which embraces diversity, but which is emerging from a colonial past where ethnic differences were deliberately perverted and negatively exploited (Namibia, National Institute for Education Development (NIED), 2003:17). To this end, a balance therefore needs to be found between the prescribed knowledge and the knowledge brought into the classroom by the learners from their own experiences and the community (Rennie, 2011). This balance was realised through the implementation of LCE.

The then Namibian Ministry of Education and Culture described the LCE approach as follows, in its broad curriculum for Basic Education Teacher Diploma (BETD) (1992:3):

> Learner centred education presupposes that teachers have a holistic view of the learner valuing the learners' life experiences as a starting point for their studies. Teachers should be able to select content and methods on the basis of the learners' needs. Teachers should use local and natural resources as an alternative or supplement to ready-made materials and must develop their own and learners` creativity.

Pomuti (1999:14) further describes LCE as follows:

> LCE is a social process where the emphasis is on collaboration and the exchanging of ideas, experiences, values and attitudes. It is a negotiated process where our understanding expands through interactions and active engagement with others.

Based on the previous descriptions, this implies that the teacher must provide the settings that are appropriate for particular and desired learning experiences. In this sense, teachers are seen as facilitators, demonstrators and role models giving learners a leg-up to the next level of learning. Supporting this, Nyambe (2008) views a learner as someone whose rich experiences form the basis upon which a lesson is organised and facilitated, when he quoted;

> Every young child has a store of rich experience. Building on learners' experiences is a sound way to stimulate interest and to lead into new and more significant and practical learning. A learner-centred curriculum seeks to do just that: to begin with learners' interests and experiences and to use them to lead learners toward what is less familiar and not yet familiar (Namibia. MEC, 1993:61).

Furthermore, learner-centeredness entails teaching that "emphasizes what the student should know, understand, do and be able to become", as opposed to what the teacher educator should achieve (Meier, 2005:78). While acknowledging the teacher's central position in the teaching and learning process, LCE accords the teacher educator a non-authoritarian but active position as a guide, initiator, advisor, observer and a facilitator of students` learning activities (Coetzer, 2001:36; Richardson, 1997:5).

LCE also values the individual needs and the interests of the students and thus accords the students a strong voice in the design and implementation of the teaching and learning process (Stears & Malcolm, 2005; Thompson, 2012). The interests and life-world of the students form the basis of the curriculum, and students are actively involved in determining the content of education (Meier, 2005:77).

Learner-centred teaching is "based on democratic pedagogy, a methodology which promotes learning through understanding and practice directed towards empowerment to shape one's own life" (MBESC & MHETEC, 1998:2). According to the policy document: *Towards education for all* (Namibia, MEC, 1993), teaching and learning is supposed to be organized in such a way that:

- The starting point is the learners' existing knowledge, skills, interests and understanding, derived from previous experiences in and out of school;
- The natural curiosity and eagerness of all young people to learn to investigate and to make sense of the widening world must be nourished and encouraged by challenging and meaningful tasks;
- The learners' perspective needs to be appreciated and considered in the work of the school;
- Learners should be empowered to think and take responsibility not only for their own, but also for one another's learning and total development; and
- Learners should be involved as partners in, rather than receivers of, educational growth (p. 60).

It is now the time for teachers to regard our learners as human beings who are able to demonstrate a critical understanding of how society has changed and developed, and appreciate the learner as a responsible citizen who is able to participate in nation building. Thus, teachers are expected to work together as a team and to promote a cooperative culture of learning amongst learners, encouraging problem-solving and project approach (Bernstein, 1996:56).

From a learner centred perspective, teachers are also urged to structure their lessons in ways that facilitate and encourage active learner-participation and involvement in the pedagogic process. In addition to active participation, "teaching is supposed to use a variety of methods, including class visits, excursions, demonstration teaching, micro-teaching, team-teaching, group work, individual study and tasks, seminars, tutorials and lectures" (Namibia, MEC,1993:59).

This curriculum extends the ideas of 'constructivism' into the 'social constructivism' perspective where this project is also located (see Section 2.7.3). The purpose of this curriculum reform was to make the education system suit the needs of the nation and be at par with other nations in overcoming emerging global challenges such as; technology, HIV/AIDS and climatic changes. The curriculum is directed toward helping achieving the national development goals set out in the National Development Programmes two and three, NDP 2 and NDP 3; the Education and Training Sector Improvement Programme, ETSIP 2007; and the long term perspectives of Namibia Vision 2030 (Namibia, Ministry of Education (MOE), 2009).

The new curriculum is also aimed at the realization of Namibian Vision 2030, which foresees Namibia as a "prosperous and industrialized nation, developed by its human resources, enjoying peace, harmony, and political stability" (Namibia, MOE, 2009).

Through this lens, Namibia is seen as developing from a 'literate society' to a 'knowledge based society,' -one where knowledge is constantly acquired and renewed, and used for innovation to improve the quality of life for all (Namibian, MOE, 2009:2). With this understanding, learners are provided with an environment that will allow them to discover and continually construct knowledge in order to enhance their understanding of life.

Furthermore, in a learner-centred approach, there is a greater acknowledgement of human resources for teaching and learning than otherwise. The knowledge and experience of the community, the learners themselves and the teachers are recognised and used as learning resources. In another sense, relative to the richness of the learning they provide, these resources should be regarded as cheap.

A sense of the worthiness of their culture is encouraged by taking learners to the expert's place of work to observe a community-cultural practice which they could not initially imagine as associated with classroom knowledge. This sense of worthiness extends to them, thus creating interest and confidence in the subject. Kasanda, et al. (2005:1807) also concedes that everyday contexts allow learners to take control over their own learning. Furthermore, Lubben, Campbell and Dlamini (1996) advised that using the context based approach would increase the learners' participation in class and help to determine what is to be learned.

Delpit (1995:141) too argues that, "in a mainstream educational thinking, many teachers feel that they are losing control if learners do not fit in with their traditional teaching content and methodologies". I agree with Delpit as part of my own understanding, it means that there is still a big challenge in terms of transformation, because most teachers are still found to be clinging on the old system, hence finding it difficult to fit in and effectively implement the learner-centred approaches. Perhaps, there is a need to strike the balance between teacher-centred and learner centred pedagogies as opposed to seeing them as in two worlds apart.

For instance, despite the introduction of LCE, there have been challenges facing its full and effective implementation. One of the reasons why learner-centred education has been perceived as a foreign element in Namibia might be that it was not coached in an appropriate African metaphor for the upbringing of children (Namibia, NIED, 2003). Thus, teachers need to be properly trained so that they can be able to scaffold and support their learners.

Vygotsky (1986) developed a concept of the ZPD which suggests that designers (teachers) provide a scaffolding role to enable learners to participate in a more complex discourse than they could handle on their own (Brown & Ferrara, 1985). This is one of the reasons why I opted to bring in a cultural practice as a mediational learning tool to enhance meaning making, conceptual development and understanding of concepts of the fermentation and distillation processes.

The curriculum further emphasizes the role of its link with the community. As such, the community can be an important support and resource, as well as a source of knowledge. Also, there might be people with expertise in science and cultural traditions that might be used to support the teaching process and other co-curricular activities.

2.3 The role of prior knowledge and community experiences in learning science

Learners' everyday knowledge and experience can be used in the curriculum in a number of ways including ; as a starting point for learning science (Roschelle, 1995), as a reference point for thinking about the nature of science, or as a context for applying scientific ideas and skills (Stears, Malcolm & Kowlas, 2003). Curricula can be structured in a learning cycle that first takes learners' everyday knowledge into account and uses it in building more formalised structures, and then links the formal knowledge back to particular contexts in learners' lives. In each phase, there is room for learners to be critical in thinking about knowledge. The process is consistent with constructivist learning and recognition of prior experience, and with crossing between different ways of knowing.

When learning experiences are more concretely related to familiar situations and is interactive, resistance often disappears and learners construct new concepts quickly. Prior knowledge fosters a theoretical shift to viewing learning as conceptual change (Ryder, 2001).

In my own view, it is impossible to learn without prior knowledge. Eliminating or ignoring prior knowledge of making *Ombike*, for instance, will not make it easier for rural learners to understand the scientific concepts of fermentation and distillation learned in the classroom. Rather, the exploration of the local and related practices would form a starting block to learn new scientific concepts as has been reiterated by Roschelle (1995).

However, there are factors making it difficult for learners to make sense of science in their everyday lives. According to Stears, et al. (2003), the science that happens outside of school differs from the science learned at school. They further argue that the science concepts used in schools are abstract, idealised and based more on the textbook world. Ryder (2001:37) too maintains that “the science knowledge featuring in everyday context is characterised by uncertainty and disputes among scientists”.

Another challenge that goes along with the effect of prior knowledge is that learners arrive at school each day informed by their experience in the community, but in most cases they are expected to set aside knowledge from these experiences while at school. As a result, there is a "creation of the boundary between the school science knowledge and the functional science in the community" (Rennie, 2011:19). Rennie (2011) urged the blurring this boundary by teaching a science curriculum that includes significant science-related issues beyond the classroom.

Rennie (2011) further alluded to the need of the pedagogical knowledge for teachers to incorporate authentic, community issues into the classroom or to move learners outside of the classroom to work with issues in the community. Hence, teachers themselves need to be scientifically literate so that they could be comfortable in dealing with the everyday situations that arise in the community.

It is very important for the teacher to allow learners to experience functional science in the real world and see community experts as scientists in their work place. This would give learners opportunities to see the relevancy of disciplinary science concepts and learn how to transfer knowledge from in-class to science experience out of class and vice versa.

2.4 Indigenous knowledge

The term indigenous knowledge (IK) has been defined as "the knowledge or way of knowing, reflecting the dynamic way in which people living within a given geographical locality have come to understand themselves in relationship to their environment and how they organize that folk knowledge of flora and fauna, cultural beliefs, and history to enhance their lives" (Semali & Kincheloe, 1999:3). This can be perceived as a legacy of knowledge and skills unique to a particular indigenous culture. It involves wisdoms that have been developed and passed on over generations (Kibirige & Van Rooyen, 2006). It is a local knowledge that developed from interaction between the people and their environment as a result of community practical engagement in everyday life.

According to Ogunniyi (2007:965), IK is a way of knowing and interpreting experiences peculiar to a particular cultural group. When we use a certain cultural practice in the classroom, we are not only aiming for the understanding of the concepts in mind but also in a way we are creating a strong awareness and recognition of the culture. One can conclude that each culture has got its heritage passed on over generation and in the long run, these can be useful tools in learning. It should be borne in mind however, that the downside of this intergenerational knowledge is that in the process some knowledge might be lost.

With the introduction of learner-centred approach in the Namibian curriculum (see Section 2.2), there is a provision of cultural inclusivity. Such teaching and learning is necessarily context-based. This is supported by Breidlid (2003:87) who says that, the inclusion of indigenous elements in the curriculum is clearly an attempt to contextualize it.

Unlike in the past, teachers are encouraged to elicit and integrate the background knowledge their learners come with and bring to their classrooms. This is so because nowadays classrooms are comprised of many learners from different cultures with specific individual learning abilities and difficulties. Oloruntegbe and Ikpe (2011:267) maintain that although "science is a global phenomenon" with some peculiarities in the children`s local environments, it could influence and aid their science learning in and out of school".

Thus, IK will promote innovativeness and creativity among educators by using local materials given the scarcity of the modern ones as teaching aids. For instance, if there are a lot of pests in a school garden then instead of purchasing expensive pesticides, one could ask learners to bring various traditional and local materials used by their parents to eradicate or drive off these pests from their fields. For example, the *Aawambo* in Namibia use a special weed called '*etse lya kuku*' in their huts to repel mosquitoes instead of buying pesticides such as 'Doom' which might itself have some negative impact on the environment.

As the new Namibian Curriculum 2010 emphasizes the issue of cultural inclusivity in education, it is now a challenge to find ways to adequately include IK in our teaching and learning practices and harmonize it with the nature of science (NOS). To this end, educators are encouraged to identify and design classroom tasks by bringing in elements of IK that connect with classroom science. This is important because it is a way of contextualizing learning and that makes it easier for learners to learn from what they already know.

However, there is a need of a strong relationship between the school and the community. The community could be closely involved in the life of the school through the use of expertise in teaching of cultural practices, and as a context for learning (for example as a project site). Furthermore, as has been said in NIED (2003:32), the knowledge and experience of the community, of the learners and the teacher can be recognized and used as learning resources in the classroom.

In relation to the arguments raised above, Rennie (2011:13) talks of "blurring the boundary between the classroom and the community", where she emphasised the need for community experts and teachers to work together on a regular basis so that learners could experience 'real-world' science. The approach I took of using an expert from the community to demonstrate a cultural activity to learners of preparing a traditional alcoholic beverage *Ombike* resonates with Rennie's sentiments.

With this approach, I endeavoured to link what is learnt at home through experience and what is taught at school. Precisely, learning is viewed as a human construction when children try to make sense of their world through active exploration of their environment and social interchange with people around them. Roth (1998:11) points out that learning is not only the result of individual sense–making efforts, but it also involves the interaction between all living and what he calls arte-factual components of a community of participants.

Kibirige and Van Rooyen (2006) warn that although we may acknowledge and respect our learners' IK, this does not mean that we should not expose factual errors. This means that we should always scrutinize the IK that learners might have, and correct any misconceptions that they might bring to the class. I agree that misconceptions and risks should be cleared, as often the knowledge that learners bring to the class is a mixture of facts and fiction.

2.5 Nature of Science

Breidlid (2003:88) uses the term "modernity" in relation to nature of science (NOS), as a term linked to European societies which started with the journey of discoveries such as the scientific inventions of the 17th century. Similarly, NOS has been described in literature as an individual understanding, conception, perception, views, beliefs and values about the product of science, process of science, and the scientific enterprises guiding scientists to execute their work well (Vhurumuku & Mokeleche, 2009:97).

Along with such a background of NOS, I could also consider the definition of Lederman (1992:331) who defines it "as the epistemology of science, science as a way of knowing, or the value and beliefs inherent to the development of scientific knowledge". In relation to my project, one could not merely investigate the traditional home brewing of *Ombike* without having a specific prime focus which would guide the investigation process and hence learning of scientific concepts.

In science, three main aspects can be singled out, namely, content, processes and attitudes. Content in science deals with the body of knowledge that has established concepts. The method by which the knowledge is obtained is called the process of science. Most of the methods by which science knowledge is acquired are observation (use of senses systematically), estimation (sensible guesses), classification, communication, predictions and experimenting (testing to prove a law or principle) (Namibia, MOE, 2009).

Attitude as a way of thinking includes the development of cognitive skills, practical skills (setting up fair test), communication (use of language), social skills (team work, keeping rule, and constructive criticisms), curiosity, objectivity and ethics (Namibia, MOE, 2009). Ultimately, the three issues raised above play a key role in realising the essence of science in any aspect such as my research study.

A thorough understanding of NOS by learners, teachers, scientists, and members of society in general is both desirable and necessary. This will ensure a good relationship between both these parties to assist each other in order to enhance the proper education of the children. Citizens who understand NOS and are scientifically literate, can contribute positively in socio–scientific debates and make reasoned decisions on issues requiring some understanding of scientific knowledge and the process of its development and validation (Namibia, MOE, 2009).

Hence, these citizens are expected to create a platform which would see them narrowing the gap between scientific knowledge and the community's general knowledge. Ogawa (1995) argues that teaching Western modern science is enhanced when students become aware of the personal and indigenous science in a classroom.

Furthermore, Aikenhead and Jegede (1999:272) talk about 'border crossing'. They explain the term as a process where a child tries to integrate the new learned (scientific) knowledge at school to the knowledge and experiences he/she got from home. Educators and learners face the challenge of cognitive border crossing between science and the indigenous knowledge system prevalent in their respective communities (Aikenhead & Jegede, 1999).

It is therefore advisable to encourage communities to live an "amalgamated lifestyle" (Ogunniyi & Ogawa, 2008:184). For example, most Africans in rural areas can be said to live an amalgamated way of life which combines knowledge derived from modern science and technology with that of their indigenous practices. This could be reflected in their farming, fishing, hunting, marriage, traditional festivals, and initiation ceremonies and so on.

Looking at both ideas raised above about 'border-crossing' and 'amalgamated life style', I foresee them fitting well in my context as a teacher and a researcher. Using a community cultural practice or ideas to pave the way towards understanding of scientific concepts clearly shows the importance of contextualising teaching.

2.5.1 Scientific background: Fermentation and distillation processes

Fermentation and distillation processes are key scientific concepts in this research. They feature in the process of making alcohol where the fermentation process begins before the process of distillation. Hence, follows a detailed scientific content or background of these concepts in their order of use.

Fermentation process

Fermentation is one of the oldest known food preservation techniques. Along with drying and salting, fermentation has been a key method of extending the lifespan of foods, allowing them to be available and eaten safely, in times of scarcity or seasonal non availability.

Fermentation involves the action of desirable micro-organisms or their enzymes on food ingredients to make biochemical changes, which causes significant modification to the food. Alternatively, yeast may convert the glucose to ethanol and carbon dioxide in leavened breads, or the sugars in grain or fruit beverages to beers and wines. The use of yeasts has allowed the production of a range of fermented beverages, enabling safe consumption of liquid when fresh water supplies are not available. In Africa, a thick, sour alcoholic beverage is made from sorghum or millet, or sometimes maize or banana (Geoffrey, 2003).

In another description, fermentation is described as a chemical process that breaks down organic materials by **microbes** (e.g. bacteria and yeast). It is an energy yielding metabolic process by which **sugar** or **glucose** molecules are broken down to **carbon dioxide**, (CO_2) and **alcohol/ethanol** (C_2H_5OH) in the absence of air**, anaerobic respiration** (Philips, 1998).

Thanks to anaerobic action, it seems that fermentation does not require oxygen. According to Geoffrey (2003), the presence of oxygen will cause some species of yeast to completely oxidise to carbon dioxide and water instead of producing ethanol. Based on my own understanding and experiences, this could possibly be one of the reasons as to why local winemakers do not like to frequently open the fermenting mixture.

The overall process of fermentation is to convert glucose/sugar ($C_6H_{12}O_6$) to alcohol (C_2H_5OH) and carbon dioxide gas (CO_2). The reactions within the yeast cell which make this happen are very complex but the overall process is as follows:

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

Despite the effect of oxygen on the process of fermentation, there is also an interesting aspect of the presence of yeast in the alcohol. Yeast can only tolerate a limited amount or level of alcohol (about 5%). Beyond that, the yeast is denatured and can no longer continue with fermentation.

Temperature is also one of the factors which should be taken into consideration. There is a specific temperature limit for fermentation to continue in a normal way. In his study on fermentation, Geoffrey (2003) discovered an appropriate temperature limit for fermentation which is between 15°C and 27°C.

At an industrial level, fermentation is the process used to make wines and beers of different flavours, depending on the types of fruits used. However, some wine makers choose to add sugar or yeast for a variety of reasons. One of the reasons for this is apparently to speed up the process in order to increase the productivity over a short period of time. However, it has been found that the product of these reactions will no longer produce pure ethanol but rather **a poisonous alcohol** called **methanol** which sometimes causes blindness.

Based on the description from: UXL, Encyclopaedia of science, (2002), methanol has been explained as follows;

> Methanol, or methyl alcohol (CH_3OH), is a colourless, flammable liquid that is miscible with water in all proportions. It melts at -97.8°C and boils at 67°C. Methanol is a fatal poison. Small internal doses, continued inhalation of the vapour, or prolonged exposure of the skin to the liquid may cause blindness. As a result, commercial use of methanol has sometimes been prohibited.

Distillation process

Distillation is a technique by which two or more substances with different boiling points can be separated from each other. For example, fresh water can be obtained from seawater (water that contains salts) by distillation. When seawater is heated, water turns into a vapour that can be condensed and captured. The salts in the seawater remain behind.

In contrast to the preceding example, distillation is most commonly used to separate two or more liquids from each other.

Imagine a mixture of three liquids; A, B, and C with the boiling points of; 30°C, 40°C and 50°C respectively. The three-liquid mixture described above is added to a distillation flask. The mixture in the flask is heated by a Bunsen burner or some other apparatus. Its temperature rises until it reaches the boiling point of any one liquid in the flask. In this example, liquid A begins to boil when the temperature in the flask reaches 30°C. It turns into a vapour at that temperature, rises in the distilling flask, and passes out of the flask arm into the condenser.

The condenser consists of a long tube surrounded by a larger tube. The outer tube contains water, which enters near the bottom of the condenser and leaves near the top. The water passing through the outer jacket of the condenser cools the vapour passing through the inner tube. The vapour loses heat and condenses and then it flows out of the condenser down into a receiving container which could be a flask or a beaker placed in position to capture the liquid/distillate (UXL, Encyclopaedia of science, 2002).

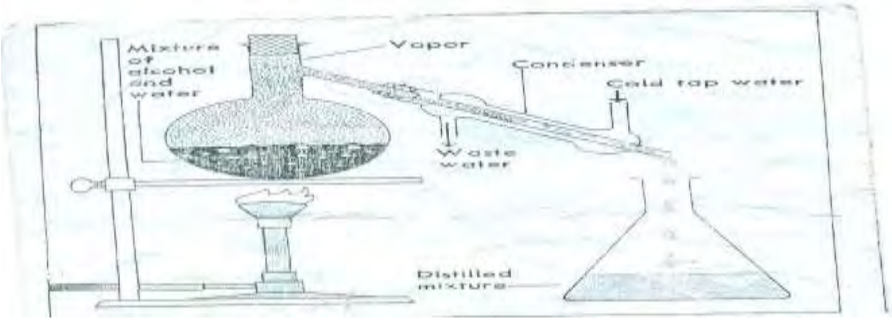


Figure 2.5.1: A distilling flask

The stronger alcoholic beverages such as spirits (where *Ombike* is believed to be included), are made from fermented alcohol through the distillation process. In contrast to fermentation, distillation is a physical process. According to Torrance (2005:224), it begins when the fermented mixture is heated, turning the alcohol into vapours. The vapours are collected and then cooled back into a liquid that is more alcoholic than the fermented liquid.

Earl and Wilford (1998:22) speak of *fractional distillation* which relies upon liquids having different boiling points. When the mixture is heated, the vapours of ethanol and water boil off at different temperatures and can be condensed and collected separately. Ethanol boils at 78°C, whereas water boils at 100°C. This means that, when the mixture is heated, the first vapour is mainly ethanol because it boils first before water. This is presumably what is happening when *Ombike* is being prepared.

2.6 The role of practical work in teaching and learning science

In order to have a precise understanding of the value of practical work activities, I will try to find out what other researchers had said in this regard. Millar, Le Maréchal and Tiberghien (1998:36) take a broad view of practical work as "those teaching and learning activities in science which involve students at some point handling or observing real objects or materials they are studying". In essence, practical work can develop understanding of abstract concepts from dealing with concrete situations.

In my personal view, the use of practical work should not solely be used in science teaching, but rather alongside other teaching approaches. Practical work can also be used as a vehicle for arousal of interest and curiosity (Hodson, 1990:35) and as a way to attract learners' attention (Pea, 1993:268), provided that its aims are precisely and clearly stated to the learners in a favourable learning environment. I agree with these two authors based on my own experience as a teacher. A time when one is presenting a certain topic to a group of learners who seem to lose interest, if one brings in any demonstration or let them do an activity one sees how everyone comes closer.

From a constructivist perspective, learning is seen as a natural process in which individuals engage throughout their lives, through an active engagement with their environment (Reiner & Gilbert, 2004). Hence, the process of learning can be seen to emerge from learner motivation and curiosity.

Ramsden (1994) argues that for curiosity to be aroused and stimulated, it is necessary to position activities and experiments in the context of everyday life experiences of learners. He goes even further to argue that the very questions that underpin practical work inquiries should emerge from learners' prior experience. However, Oloruntegbe and Ikpe (2011:266) caution that if learners do not see science as a real-life experience, they are likely to experience difficulty in learning science and become disenchanted with studying it.

Learners should feel that they have freedom to direct and adapt the activities according to the questions which emerge from their own experiences. This encourages them at various stages of the inquiry to "predict, explain, explore, observe and explain (PEEOE)" their action as it is proposed by Maselwa and Ngcoza (2003:650). Following the 'PEEOE' approach, would help them to develop various scientific concepts of a specific topic so as to enhance the conceptual understanding of science in general. The other advantage is of a linguistic nature and herein lies the notion of 'words-on' practical activities as espoused by Maselwa and Ngcoza (2003).

The teacher is thus expected to provide guidelines and a framework for the inquiry as well as actively assessing the process, involvement and participation of all learners. He/she is expected to co-learn along with learners as well as providing opportunity for learners to reflect on their mistakes. This is strengthened by Zion and Slezak (2005) who claim that the role of a teacher during practical activities is to display flexibility and creativity as well as devoting time to each learner and building confidence in learners.

In this discussion I am pointing to the role of the teacher during practical work in allowing learners to manipulate instruments and apparatus available so as to discover things on their own. Giving this freedom would strongly encourage and motivate shy learners in particular. Towards an end of any activity, the teacher can facilitate the process whereby learners design their own representation of the underlying concepts of the experiment. This could be done pictorially through such aids as 'mind maps' and 'concept maps' (Maselwa & Ngcoza, 2003). These could be used as tools for learners to show the links between the various concepts developed during their activities.

Hodson and Hodson (1998) argue that scientific understanding is more than personal beliefs held for personally convincing reasons and that learning science, for one self requires an understanding of, and ability to use appropriately, a set of culturally defined methods for conducting inquiries. If science education is a matter of enculturation (Hodson & Hodson, 1998:17) into the beliefs, practices, values and styles of discourses on the community of scientists, then learners need an opportunity to work alongside and gain assistance, encouragement and support from someone who has already been successfully encultured. This can either be their teacher or an experienced parent from the community. On the other hand, learners bring a lot of experience to the classroom. Hence, they need direction and proper facilitation in order to carry out practical tasks as per the rules of science.

Modelling is a term used for the clear and skilful demonstration of an expert practice. It should also involve the provision of opportunities for critical questioning, interspersed with opportunities for guided participation by the 'novice'. These should be informed by critical feedback from the 'expert', who is ready to answer all the viewers' or audiences` queries. These skills comprise the stock in trade of the apprenticeship approach to the teaching and learning of complex tasks (such as home making of *Ombike*) in real life practical situations (Lave & Wenger, 1991).

Moreover, for any subject to be learned in a social constructivist set up, the use of language should be considered. During practical activities learners need to interact with each other through expressing their views and understandings with their group through a particular language.

Given that the subject matter of science is the material world, it seems natural and rather obvious that learning science should involve seeing, handling and manipulating real objects and materials, and that teaching science will involve the act of 'showing' as well as of 'telling'.

There is a wide belief that, discovering things through experimentation is the very essence of science and that learners should be taught the fundamentals at school level. This argument has been justified by the opinion that learners enjoy practical work and that they learn through seeing things happen (Parkinson, 2002:114).

Despite the apparent consensus that practical work in science has a legitimate role in the teaching and learning of science many criticisms concur with Hodson`s (1990:33) observation that, "…practical work, as conducted in many schools, is ill-conceived, confused and unproductive". To this end, one could really agree that the problem appears to lie in the methods that respective teachers deploy when doing practical activities. Lending support to the argument, Millar (2004:13) maintains that a common criticism of practical work in the teaching laboratory is that it becomes 'recipe following' with students often not thinking about why they are doing what they are doing.

In the Namibian context, for example, the challenges are issues such as crowded classrooms where the teacher to learner ratio does not make it possible for the teacher to attend to individual learners. The short time, scarcity of resources and constraints on teacher training skills also have an impact. I think it is a good idea to ensure that learners are made to understand that an error might occur during the process of an experiment, or any practical demonstration, which might be the cause of any unexpected result. When unplanned things happen it might lead to lack of interest in the subject to learners.

2.6.1 The role of the teacher in the science classroom

I am fully aware of the importance of the role of the teacher in the classroom and I believe that there is a space for a traditional teacher talk method. Essentially, there is a need to strike a balance between 'teacher talk' and 'learner talk' in the classroom. For example, Bencze (2000:857) cautions that "certainly... teachers may need to provide insights...otherwise students may arrive at unexpected conclusions".

In learner centred pedagogy, the teacher is viewed as someone who assesses learners' needs and interests. He/she plans learning activities that address learners' needs and build on those interests and needs (Namibia, MEC, 1993:60). Thus, the teacher's role is redefined as he/she comes to see the learners as partners in the pedagogic process.

The concern though, should be more about whether learning occurs and the role of the teacher as a mediator. Potenza (2002:1) argues that being a mediator "requires one to be very sensitive to the diverse needs of one's learners, construct appropriate learning environments and demonstrate sound knowledge of your learning area or subject". We should therefore view the role of the teacher as not merely transferring knowledge to the learners, but one of creating conditions in the classroom where learners can construct different understandings of the concepts being taught. This is what I endeavoured to do in this study.

The emergence of learner centred education (LCE) in Namibia and outcomes based education (OBE) in South Africa, has resulted in the concept 'facilitator' being perceived wrongly. This misinterpretation implicated teachers' perceptions of their classroom roles. In South Africa, part of the confusion was the emergence of a notion that OBE, as Moll (2002:6) puts it, "envisages a learner who is solitary, free-ranging problem solver and thus, a teacher who is simply a facilitator of learning experience". In the same vein, it is certainly possible to misinterpret Piaget's views about learning as recommending leaving children to their own destiny.

Nevertheless, according to Moll (2002:18), "Piaget chides those who interpret his ideas about learning as a suggestion that success would depend on leaving the students entirely free to work or play as they will. It is obvious that the teacher remains indispensable in order to create the situations and construct the initial devices which present useful problems to the child".

Certainly, LCE repositions the teacher away from the centre stage, but imposes greater responsibilities in terms of planning for and facilitating the pedagogic process. LCE further views the teacher as a critical reflective practitioner rather than a passive and unreflective dispenser of the received knowledge (Mayumbelo & Nyambe, 1999:64).

Vygotsky also emphasizes the role of knowledgeable other or teacher in the sense that he argues that learning is co-constructed. Herein lies Vygotsky's (1978) notion of the zone of proximal development (ZPD). Vygotsky situates instruction "at the crux of cognitive development" and emphasizes the central role of the teacher or mediator in leading development through "collaborative activity" (Lunt, 1993:156).

2.7. Theoretical framework

2.7.1 Introduction

This study is underpinned by the constructivist perspective. Constructivism is the belief that meaning is constructed and not discovered (Gray, 2004). Arksey and Knight (1999:19) also argue that this perspective concerns the way that humans individually and collectively interpret their world.

Moll (2002:11) argues that "constructivism or constructionism or indeed any term for the construction of knowledge does not have, nor should it have, only one particular meaning". Atherton (2009) describes constructivism as a set of assumptions about the way human beings learn. In essence, constructivism suggests a move away from the notion that knowledge is given to passive learners to the idea that active learners invent or co-construct knowledge as they engage with it.

Two strands of constructivism are discussed, namely: the socio-cultural perspective, and social constructivism.

2.7.2 Socio-cultural perspective

The socio-cultural perspective according to Traianou (2006:835) is the understanding of concepts and ideas of a particular community in a dynamic process. It results from acting in situations and from negotiating with other members of that community. Furthermore, such understanding is constructed first on a social plane before it is internalised by the learner (Murphy, 1999:20).

Socio-cultural theory also suggests that learning involves enculturating the novice into the practice of a particular community (Traianou, 2006:835) with the support of an expert. The expert should be more skilled than the novice (learners) in terms of having a broader understanding of the important features of a cultural activity, for example making of *Ombike* in the context of my study.

Moreover, Stears, Malcolm and Kowlas (2003:3) argue that although individuals can personally construct the knowledge, it has to be socially mediated as a result of cultural experiences and personal history. They further argue that culture is a contextual lens through which learners view and understand the world and that it has direct influence on learners` cognitive processes and understanding of science.

It is for these reasons that in my study I opted to elicit learners' prior everyday knowledge and experiences and integrate them with practical activities so as to enhance meaning making, conceptual development and understanding of the fermentation and distillation processes. That is, learners had to share what they knew from their homes about making of *Ombike*. Research has shown that recognizing learners' cultural practices may help them to understand the subject matter (Stears, et al., 2003; Oloruntegbe & Ikpe, 2011; Rennie, 2011).

I concur with Rennie (2011:14) who suggests that "scientists and teachers need to work together, often on a regular basis, in a way to enable learners to experience 'real world' science and teachers to stay in touch with a contemporary science outside of school". I can relate a step I took with the suggestion by Rennie, when I involved a community expert to assist me as a teacher on the topics of fermentation and distillation from a cultural perspective. Rennie further asserts that projects that promote science and scientists to schools and their communities can make a positive difference to learners' engagement and interest in science education.

Lemke (2001:301) thus suggests that "learners and teachers need to understand that science and science education are always part of large communities and their culture". Such acquisition of cultural knowledge and extending science beyond the classroom may help learners to make use of what they know in order to be able to overcome any obstacles that would hinder learning of a task.

In the past, the socio-cultural perspective has been ignored in science education (Lemke 2001). As a result, science was viewed as static and absolute knowledge that is disconnected from culture and society and that was how it used to be presented in most classrooms. In contrast, it is proposed in this study that science should be viewed as a human activity. That is in line with Vygotsky's (1978) suggestion that there is a need to consider the social and cultural origin of the learners in the science classroom.

Many studies based on the socio-cultural perspective indicate the use of the qualitative methodological traditions. Here participant observation and in-depth interviews are employed to understand what people do in their everyday situations, and how their perspectives are implicated in their activities (Denzin & Lincoln, 1994; Lave, 1988; Wenger, 1998).

2.7.3 Social Constructivism

According to McRobbie and Tobin (1997:194), social constructivism recognises the social and personal aspects of learning. They argue that in the personal sense, meaning is constructed by the individual as new information interacts with extant knowledge. Learning is personal and subjective and exists in the mind of the knower. In the social sense, however, the constructed knowledge is socially mediated as a result of cultural experiences and interaction with others.

The origins of social constructivism could probably be traced back to the Russian psychologist, Vygotsky. He believed that children are at their highest peak of learning when they are collaborating with more skilled partners (Vygotsky, 1978). He said that the more knowledgeable other helps the learner by intellectually scaffolding them, and this allows the learner to carry out more intricate tasks than when they are on their own (Wertsch, 1985). He also believed that what children do with the help of others today, they are able to do alone tomorrow. Vygotsky (1978) referred to this as the Zone of Proximal Development (ZPD). Moreover, Goos (2004) uses the term scaffolding as associated with the interactions whereby the teacher structured tasks to allow students to participate in collaborative activities.

Within the ZPD, when children are given the opportunity to discover the connection between what they learn in the class and real life (Rennie, 2011), they can apply the knowledge they gain in a way that they can adapt to their everyday lives, which then suggests that learning is taking place (Vygotsky, *ibid*).

Stears and Malcolm (2005:22) maintain that social constructivism provides an appropriate learning theory. To this end, they take an example of Vygotsky (1986) who views the development of the child as proceeding interactively from the social to the individual, in a learning process through which the child connects the spontaneous conceptual domain of the home to the formal conceptual domain of the school (Rennie, 2011).

In essence, there is a tendency in most learners to differentiate between the school science and out of school knowledge (Stears, et al., 2003; Oloruntegbe & Ikpe, 2011; Rennie, 2011). Stears, et al. (2003:3) argue that the science curriculum should be structured in a learning cycle that first takes learners' everyday knowledge into account and use it in building more formalised structures, and then link the formal knowledge back to a particular context in the learners' lives.

However, these different ways of knowing have different requirements of evidence and authority. Therefore, learners must cross between them as part of their science learning. Aikenhead (1996) similarly talks of 'border crossing' between different types of cultural knowledge.

In order to acquire knowledge, learners must become actively involved, or socially participate in a community. Such a community might be restricted to classroom practices, or it might incorporate the out-of-school practices (O'Donoghue, Lotz-Sisitka, Asafo-Adjei, Kota & Hanisi, 2007). Hence, my decision to approach a topic from the community's cultural practice of making *Ombike*.

2.8 Concluding remarks

In this chapter I have explored the literature that informed my research study. In the first instance, I discussed the curriculum issues in relation to learner centred education (LCE). I also argued that indigenous knowledge (IK) and the nature of science (NOS) are two thought systems that are globally debated as to their relevancy, dependence and appropriateness to be part of science curriculum collectively. Unfortunately, there is often a seriously misconceived tendency to position IK in opposition to science. Instead these two knowledge systems need to supplement each other in every situation for learning to take place effectively.

I also discussed the practical activities and the theoretical framework that informed this study, such as constructivism and in particular, the socio-cultural perspective and social constructivism. Lastly I tried to show how these theories impact on teaching and learning.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter describes the methodological framework that guided the research process in this study. I describe and discuss the reasons for selecting an interpretive paradigm and qualitative case-study approach to address my research questions. I further discuss the data gathering techniques I used, the sampling of participants and how the data was analyzed. I end the chapter by looking at and discussing issues regarding ethical considerations, validity and trustworthiness as well as limitations of the study. The chapter ends with some concluding remarks.

3.2 Research paradigm

The concept 'paradigm' refers to the way we think, observe and understand the world and also draw conclusions about the phenomena. Babbie and Mouton (2001) describe a paradigm as a model or framework for observation and understanding, which shapes both what we see and how we understand and draw meanings from it. Paradigms can open up a new understanding about the nature of the world and theorizing about the phenomena.

My research is a case-study, located within the interpretive paradigm (Erickson, 1986). I opted for a case study research with a view to concentrate on a particular cultural practice of making an alcoholic beverage called *Ombike* in order to enhance science learning. Essentially, the activities associated with this cultural practice in conjunction with practical activities constituted my unit of analysis.

3.2.1 Interpretive paradigm

This paradigm seeks to understand the meaning that people give to their own social interactions. It exposes how individual and group interpretations of reality influence both intentions and action. Lincoln and Guba (1985:106) argue that an interpretive paradigm provides "the meanings and purpose attached by human actors to their activities" and thus relies on the observation, explanation and the interpretations of people's action toward a specific phenomenon. According to Cohen, Manion and Morrison (2010:26), "the aim of the interpretive research is to provide rich description of the phenomenon and, if possible, to develop some explanation for it".

An interpretive orientation allows for an opportunity to understand the situation of the phenomenon being studied through the process of interaction. Moreover, Cohen, et al. (2010:22) claims that "interpretive researchers begin with individuals and set out to understand their interpretation of the world around them. Hence, as a researcher and investigator, I was expected to work directly with experiences and understanding of my participants (learners) to build a conceptual understanding of the concepts under study.

According to Terre-Blanche, Painter and Durrheim (2006), an interpretive case-study is characterised by a particular **ontology**, **epistemology** and **methodology**. Ontology specifies the nature of reality that is being studied, and what can be known about it. My ontology in this study is that there are multiple world views and that science is a dynamic human activity. Epistemology specifies the nature of the specific relationship between the researcher and what can be known. Epistemologically, the focus of this study was on learning key science concepts related to the fermentation and distillation processes. Methodology specifies how researchers may go about practically studying whatever they believe can be known. Methodologically, qualitative approaches were used in this study and hence participants' narratives and voices were regarded as important.

The research appropriate to this environment/tradition, assumes that people's subjective experiences are real and should be taken seriously. For researchers to understand that other people's experiences are real they should interact with their subjects and listen to what they tell the researcher. Drawing on the above ideas, the study was designed to provide rich insights and understandings of the participants' views, beliefs and their practice regarding the use of *Ombike*'s brewing process (see Chapters 4 and 5) in science learning. The interpretive qualitative research further helps in understanding in-depth participants' cultural norms, values, experiences and perceptions within their social context.

According to Babbie and Mouton (2001:270), a qualitative research refers to "a generic research approach in social research according to which research takes its departure point from the insider perspective on social action. A researcher using this approach always attempts to study human actions from the perspective of the social actors themselves. Hence, I attempted to study this special cultural activity with the view that it could be used as a catalyst in science lessons to make concepts of fermentation and distillation clear to my learners. Babbie and Mouton (2001:282) further highlight the primary goal of studies using this approach (qualitative case study) as “describing and understanding” rather than explaining human behaviours.

3.2.2 Case Study Method

The study took the form of an interpretive case study method involving two sites being a school (School X) and an *Ombike*’s expert house both in *Omusati* region, Namibia. Ary, Jacobs, Razaviech and Sorensen (2006) state that a case study seeks to understand the whole individual or phenomenon in the totality of its environment. Patton (2002) observes that case studies become particularly important where one needs to understand a particular group of people, particular problems, or unique situations in great depth, and bring out the issue of context and history of the issue under investigation. Stake (2000) explains that a case study enables the gathering of information that is specific to the particular case and that the idea of a case study is to understand a particular case under study.

This study is a qualitative case study undertaken within the interpretive framework (Stake, 2000; Merriam, 2001). I regard it as a qualitative case study as appropriate because case studies are more often used when the researcher is interested in a clearly delineated entity. In my case, I focused on a specific cultural practice of making *Ombike* in order to enhance the understanding of the concepts of fermentation and distillation.

I worked more closely with the learners who were my participants and my unit of analysis was meaning making and the learning that took place. However, Hitchcock and Hughes (1995:322) suggest that the case study approach is particularly valuable when the researcher has little control over an event. This does not necessarily mean distancing oneself from the process, but rather selecting a phenomenon with which one is not much familiar so as to be a participant observer. Also, by involving my learners in searching for information, I led them to have and feel a sense of ownership in the study. That is, they had to take responsibility for their learning as is proposed in the new Namibian curriculum.

As part of my research process, I explored a cultural practice as a case, in order to improve and devise a teaching method for enhancing conceptual development and understanding of it. Moreover, this method seemed most appropriate to my study as according to Hitchcock and Hughes (1995:322), a case study focuses on practices, intervention and interpretation with the aim of improving the situation.

3.3 Research goal

The main goal of this research study was to investigate how the indigenous practice associated with the making of *Ombike* enabled or constrained meaning-making of the **fermentation** and **distillation** processes with Grade 9 Physical science learners.

To achieve this goal, the following questions guided the study:

- **What are learners' prior knowledge and experiences of the indigenous practices associated with the making of *Ombike*?**

To answer this question, I basically conducted a brainstorm session with learners where they shared their general experiences of making *Ombike*. I then presented a lesson where I introduced and explained (taught) the concepts under study. This was done early before the visit to the demonstration site. I analysed the transcribed lessons and also the transcribed observation session of the demonstration.

- **How can the making of *Ombike* support meaning-making of the process of fermentation and distillation?**

To answer this question, focus group discussions were organised where learners were expected to use their scientific explanations regarding the context of *Ombike*, by making use of the questions in the worksheet of the unit of work. I analysed the videos, and the learners' works in groups.

- **How might one integrate the learners' prior and newly acquired knowledge from their experiences of making Ombike into practical activities?**

To answer this question I observed the lessons which were videotaped as learners carried out practical activities. Observation for this was based on learners` skills of doing scientific experiments, handling of apparatuses, following of instructions, and any other findings emanated from these activities.

3.4 Methods of data gathering

The following data gathering techniques were used in this study:

- Brainstorming and discussion;
- Observation;
- Interviews; and
- Worksheets.

A variety of data generation techniques were used with the view to enhance the validity of data through triangulation of methods.

The table below summarises the methods and techniques that was used in this research. It also includes the data gathering method and its purpose.

Table 3.4 Methods of data gathering

STAGES	METHOD	DATA TO BE GATHERED	PURPOSE
Stage 1 RQ.1	Brainstorming and discussion	General explanations on how *Ombike* is made. The data comes in the following form: Observation of video; document analysis of learners' written notes of their prior experience.	To get learners` prior everyday knowledge and experiences on cultural ways of making *Ombike.*

Stage 2 RQ.1	Lesson presentation	Scientific concepts associated with fermentation and distillation. The data comes in the following form: Observation of the lesson video and groups' mind-maps	To introduce the basic concepts of fermentation and distillation processes.
Stage 3 RQ. 2	Observation of Practical demonstration	Data on how *Ombike* is made culturally or indigenously. Learners ` questions and comments. The data comes in the following form: Observational schedule, photos, video, and field notes	To get a detailed picture of the process of making *Ombike* with the aim of understanding its content (stages), context, and its relation to the school science curriculum
Stage 4 RQ.2	Focus group discussion and worksheet (unit of work)	Any emerging comments and legitimate questions requiring in-depth clarifications from the expert. The data comes in the following form: video, photos and journals.	To get the general views on the participants` experience as a way of reflection To view the video showing the demonstration in order to generate more ideas for the aim of linking to their science knowledge
Stage 5 RQ.3	Practical activities (unit of work)	Demonstration skills or any difficulties in carrying out the groups practical activities using readily available materials. (group work) Learners' conceptual understanding of fermentation and distillation processes. The data comes in the following form: worksheets, photos and video	To demonstrate the skill observed in order to make their *Ombike.* To show learners' conceptual understanding of the processes by completing the worksheet as part of the unit of work in groups.

Stage 6 RQ.2	Focus-group interview with the participants	Questions to complement the data already generated. To get views of participants on the inclusion of their prior knowledge, indigenous practices, and also the use of practical activities in the lessons of fermentation and distillation. The data comes in the following form; Personal notes on interview responses, journals	To triangulate the data collected from other techniques. Also to get views and recommendations based on the research findings.

I now discuss each of these in detail below.

3.4.1 Brainstorming and discussions

Brainstorming is understood as a group creativity technique by which a group tries to find a solution for a specific problem by gathering a list of ideas spontaneously contributed by its members. It can also be an activity or a session in which a group of people meet to suggest a lot of new ideas for possible development or for future considerations. This method is more effective than individuals working alone in generating ideas. Thus, it is normally created with intention to reduce social inhibitions among group members, to stimulate idea generation, and to increase overall creativity of the group (Osborn, 1963:135).

I started this study with an application of this method where participants came together to share their general experiences on ways of making *Ombike*. My intention with this method was basically to get the prior everyday knowledge of the participants, mostly learners, based on this cultural practice.

In order to gain more general information, I gave my learners the role of researchers, by giving them a research task to go and probe or enquire for more information from their parents regardless of whether their parents were experts or not. They did this, in their journals which they reported to the class the next day. One implication was that learners could bring much information including some that was irrelevant. Thus, as a researcher, one need to be more focused when working with all the IKs brought in the class by the learners, as Kibirige and Van Rooyen (2006) cautioned earlier (see Section 2.4).

Two lessons were planned mainly to introduce the concepts of **fermentation** and **distillation**, respectively. During these sessions, I invited my critical friend who was also a science teacher to be a participant observer. Hence, this teacher became part of the lesson by contributing to the discussions and also taking the video of the lesson.

Learners were expected to come up with mind maps or concept maps (Maselwa & Ngcoza, 2003) in groups which they had presented in their newsprints. Concept-maps and mind-maps are effective ways of ensuring conceptual development and understanding, because they enable one to explain links between various concepts (Maselwa & Ngcoza, 2003).

In order to ensure understanding of the generated concepts by the learners, they were expected to explain these concepts through presentations. This was done before the observation session of the cultural practice of making *Ombike* by the expert in the community. The intention for this was to introduce learners to some of the key scientific concepts under study which they could later associate with the general explanation they would get from the expert's demonstration. It was also a good approach for them to relate these concepts to their prior everyday knowledge and experiences.

3.4.2 Observation

Observation is one of the techniques I used to gather data. It offered me an opportunity to gather 'live' data occurring in a social situation (Cohen, et al., 2010). I concur with Cohen, et al., (2010) that what people say differs from what they do. This could mean that by observation one would get the real view and sometimes a sense of feeling of what is happening. Similarly, Cooper and Schindler (2001) maintain that observation enables a researcher to look afresh at everyday behaviours that might otherwise go unnoticed.

According to Maxwell (1992:94), “observation can enable you to draw inferences about the perspectives that you could not obtain by relying exclusively on interview data. It is of particular importance to get at a tacit understanding and theory in use as well as aspects of the participants` perspectives that they are reluctant to directly state in an interview”. By observing my participants’ behaviours, interactions and level of participation, it was crucial to understand the context of the phenomena under study and pose more relevant questions on the research topic.

The observation in my study focused on the following:

- Expert’s practical demonstration;
- Lesson presentation and discussions; and
- Learners’ involvement during practical activities.

In my case, a research programme was developed to engage a community member and learners in a learning activity through which I hoped to develop a better understanding of the role of indigenous knowledge and cultural heritages in science teaching. Hence, at this stage participants were taken to a site where they could observe the actual making of *Ombike*. Due to ethical issues, this demonstration could not be done in the school yard but rather, we all had to visit a nearby house where *Ombike* was made.

To increase my data, I provided a note book to each of my participants in which they had to write down any salient information that emerged.

Furthermore, a lot was expected from the participants during the demonstration. Questions and comments from learners and the answers, responses and explanations from the expert were to be recorded. With regard to the language issues, much of the discussions were expected to be done in the vernacular language (*Oshiwambo*) of the expert (Kvale, 1996). The reason for this was basically to give freedom to the participants to express themselves in the language they felt comfortable with.

With the assistance of a critical friend, all the observation sessions were strengthened through the use of audio and video recording devices as well as the taking of photographs, despite the caution by Gray (1995) who maintains that in some instances recording devices tend to affect human behaviours being observed.

3.4.3 Interviews

The research interview has been defined by Cohen, et al., (2010:351) as 'a two-person conversation initiated by the interviewer for the specific purpose of obtaining research-relevant information'. According to Kvale (1996), an interview is an interchange of views between two or more people, on a topic of mutual interest aimed at knowledge production or generation. Similarly, Patton (2002:341) argues that "the purpose of interview is to allow us to enter into another person's perspectives".

Kvale (1996) places several types of interview along a series of continua, arguing that interviews differ in the openness of their purpose, or their degree of structure. For the purpose of my study, I endeavoured to use two types of interviews namely; focus group interview, and semi-structured interview. These have each been expatiated below.

Focus group interviews and discussions

A random selection of learners was done to put them into three main groups each of which consisted of four learners. Care was taken during the organisation of these groups ensuring that a fair allocation of boys and girls in each group was realised. This entails that each group consisted of two boys and two girls. These groups were consistently used in both sessions discussed below.

Focus group is a form of group interview which relies on the interactions within the group who discuss a topic supplied by the researcher (Morgan, 1988:9). It is from the interaction of the group that the data emerge (Cohen, et al., 2010:376). Bourdieu and Wacquant (1992) succinctly summed focus group discussions as offering unique insights into the possibilities of or for critical inquiry as a deliberative, dialogic, and diplomatic practice that is always already engaged in and with real-world problems.

Furthermore, the role of an interviewer or researcher in the interview has been recognised by Wilkinson (2000:50) who claims that, "the questioner in a focus group interview situation plays a role as a facilitator. He/she is responsible for shaping and steering the path the participants themselves have chosen to tread".

In this study, two focus group interview sessions with learners were conducted as follows:

- Firstly, during the lesson presentation to solicit the groups' concept development in order to develop scientific meaning-making. It was also during this session when the learners in their respective groups develop concepts and put them into mind maps as shown in Chapter four; and
- Secondly, during the practical activities session.

In this method, participants were to come together to share and discuss their general views on their experiences of the demonstration. Through the discussions guided with viewing of the videos and photos, this was expected to consolidate the scientific concepts developed earlier and also enable participants to see their relationship with the traditional practice observed.

This discussion was also the right opportunity for me as a researcher and/or a teacher, to clarify and explain the main concepts under study as reflected in this cultural practice. Much of the data were then to be taken from the participants' note books. However, it was also expected that more ideas and more legitimate questions would emerge from the discussions. To answer further questions, a semi-structured interview was planned with the expert for more in-depth information as a way of strengthening and validating data obtained through the observation method.

At another session, all the participants were interviewed to give their own personal views on their experiences, the making of *Ombike,* in particular. Wilkinson (2000:44) argues that open-ended questions allow a respondent to insert his or her own views, ideas or suggestions about the object being observed.

Therefore, a focus group interview was to be conducted with the learners, while with the other participants such as the critical friend (a teacher) and an expert, semi-structured interview were conducted. In order to triangulate data, the same participants were also expected to write in their journals their experiences of being engaged in this study. The aim of this strategy was basically to get more views and recommendations that might be very helpful in strengthening my research data and hopefully give me some directions for further research considerations.

Semi structured interview with the expert and teachers

Two sets of semi-structured interviews were conducted, namely;

- With the *Ombike* expert ; and
- With my critical friend.

The purpose of conducting interviews was to seek more in-depth answers to enrich the data for my research questions. Leedy and Ormrod (2010) state that interviews allow the researcher to investigate and prompt on things that may otherwise go unobserved. They further note that through semi-structured interviews one can probe an interviewee's thoughts, values, prejudices, perceptions, views, feelings, and perspectives. It is in this context that I conducted semi-structured interviews with an expert and the teacher who was my critical friend. I developed an interview schedule (questions) to guide the interview (see Appendices 2B & 2C). Borrowing from Terre-Blanche, et al. (2006) in terms of quality and comprehensibility of the questions I was asking, the interview schedule was pilot tested with another teacher before being used in the actual study.

The expert was interviewed with two aims. Firstly, I aimed at gathering more in-depth information from her on how she made *Ombike*. This was meant to strengthen and validate the data received from the brainstorming session with learners and also from the observation of practical demonstration. The second aim was to get her general views and feelings on the 'making of *Ombike*'.

During each interview, probing was done when the participant did not answer the question or a key point was raised that needed further clarification. The interviews with teachers were done in the afternoons so that I would not interfere with her school activities. On the other hand, the interview with the expert was conducted during the weekend at her house. The duration of the interviews varied from 30 to 45 minutes depending on how the participants responded.

I was aware that an interview has certain limitations as Bell (1999:91) identifies it as "a highly subjective technique and therefore there is a danger of bias". Despite this shortcoming, I found using interviews to be valuable, because they enabled the respondents to have freedom to engage in rich conversation through which they could easily explore their thoughts without fear of being limited by closed questions.

Furthermore, all the discussions or interviews with the *Ombike* expert were done in *Oshiwambo*, which is her vernacular. This has been supported by Kvale (1996) who maintained that in qualitative research the use of the natural language comfortable to all the participants enables one to gather rich and valuable qualitative data.

In order to avoid losing some of the information from each interviewee, an audio-recorder was used with the participants' permission (Clough & Nutbrown, 2007). I used a simple audio recorder of my cell phone, because it would not affect the respondent's expression. Before I transcribed each interview, we listened to the interview together with the respondent. The aim of doing this was to allow the interviewee to listen to her discussion in case she/he may want to clarify or expand on any part.

3.4.4 Worksheet and practical activities

Learners remained in the same groups they had been in during the lesson presentation session. As a teacher and a facilitator, I provided each group with worksheets that was designed (see Appendices 3B, 3C & 3D) and the materials to be used during the practical activities.

These worksheets served as guiding tools for learners to make sense of the science concepts they could find in the cultural practice of making *Ombike*. It guided learners through some practical activities that were intended to enhance understanding of various concepts of fermentation and distillation they had already observed from the expert's demonstration of the making of *Ombike*. I explained the instructions for the activities to the learners in order to ensure that they understood what they had to do. I also had to walk around to facilitate the practical activities and give assistance to each group.

Learners carried out practical activities as was proposed in the unit of work. They then completed the questions in the worksheet for each activity. Data for this stage was based on learners' skills of doing scientific experiments, handling of apparatus, following of instructions, and any other interesting findings from the learners.

The class discussions after each experiment thus highlighted the level of understanding and meanings gained from this social learning method (practical activity). The fact that these practical activities were done by learners contributed to their conceptual understanding of these processes. They had already benefited from the completion of the worksheet. This enhanced learners' self-esteem, self-confidence and also gave them a sense of ownership for being involved in the study.

The learners' conceptual development and their explanations of scientific concepts were realised through using mind-maps (Maselwa & Ngcoza, 2003). These graphics emerged from the discussions and also from responses presented in the completed worksheet and their own practical activities. Mind-maps were an effective way of ensuring conceptual development and understanding because learners could explain links between these various concepts.

3.5 Research site

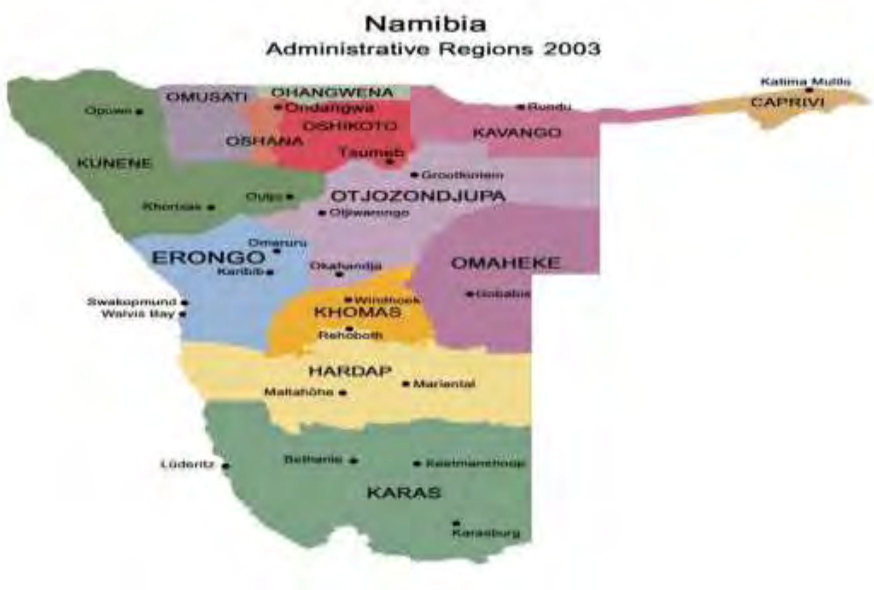
This research was conducted at two sites in *Omusati* region, Namibia. One site is coded as School X, which is a rural combined school with Grade 1-10 situated in the *Eendombe* district, in the northern part of Namibia. The School is about 30 km south of *Outapi* town. I chose the school where I was teaching to be my research site because most of my research participants were my learners and colleagues. All the secondary level Grade 8-10 learners at this school do Physical Science as one of their subjects. Physical Science was a poorly performed subject in this school, despite it being given high priority by the government.

The *Eendombe* area is popular for having many palm trees which the local people use to make their traditional drink, *Ombike*. I then decided to do my research study around this local practice with the intention that both the learners and the community could realise that science is all around them rather than only at school.

The other site was the expert's house, in the same vicinity as the school. This house was purposely selected because it was the closest *Ombike* expert house to the school (about 2 kilometres), where a group of learners who participated in this study could walk to. Due to the fact that this practice was used by the expert for her income generation, the demonstration could not be done at school as that would interrupt her as it would have been risky to carry fragile equipment to school, particularly the clay pots.

The indigenous language of this community, where all my participants belong is *Oshingandjera*. Their first language in school is *Oshindonga* with English as their second language and also as their language of learning and teaching (LoLT). Both *Oshindonga* and *Oshingandjera* are sub-*Oshiwambo* dialects with differences only observed through their pronunciations and accents.

As mentioned above, this research was carried at sites that are located in *Omusati* region which is one of the thirteen political regions in Namibia. This region lies in the northern part of the country, forming borders with the southern part of Angola. This is shown in the map below.



{Source: www.Namibiansafari.com/image/namtravelMAPS/NAMIBIARegions_small.jpg}

Figure 3.5: The 13 administrative regions of Namibia

3.6 Participants

3.6.1 Researcher

My role as a researcher was both one of facilitating the research process as well as teaching during the process of introducing key concepts under study. This implies that I was both a reflective and a reflexive researcher of my own practice.

Apart from securing permissions from all the research stakeholders, I was involved in soliciting my participants to act as co-researchers. Finally, I attempted to transcribe and then analyze all my data, after which I interpreted and presented the findings of my research in a meaningful way.

3.6.2 Learners

A focus group of twelve grade 9 learners (six girls and six boys), served as my main research participants. Initially, I wanted to work with the entire grade 9 class of 25 learners, but this did not materialise as the area experienced a sudden school closure due to heavy rains which resulted in floods. Hence, my decision to only work with 12 learners, that is, those that live on the same side as the expert's house and did not have to cross the river.

Despite the fact that some learners could not participate in the study, they still had time to be taught as these two topics of fermentation and distillation are normally taught in the second term. Unfortunately, they were disadvantaged in that they did not have a chance to learn socially with those involved in the study, apart from their normal classes.

They were all from the same ethnic group ('the Oshiwambo speaking community') and thus their vernacular language 'Oshiwambo'. This made it easier for me to use code-switching during my lesson presentations and interviews. Using learners' vernacular language helped them to understand what was expected of them as well as helping them to express themselves clearly especially during the discussion. However, the translation proved to be a tedious process.

I chose grade 9 because this was the class I was teaching at the time of this study. I believed that I was in a good position to mediate conceptual development through among other things, doing practical activities. Moreover, it was also easier for me to plan well (in advance) all the visits to the expert's place. The main role of these learners was to act as co-researchers. Besides their contributions during the brainstorming sessions, they were critically important for identifying the well-known and popular *Ombike* expert in the community.

Besides being active participants in the group practical activities, the focus group learners were expected to keep journals in which they were asked to record their experiences of each session.

3.6.3 A teacher

I chose a female science teacher from the same school with about 12 years teaching experience. She served as my critical friend throughout the research process. Being with her was also helpful to her as we learned from each other's experiences. She could also learn something from the study that she might also try implement for her learners. In addition to being a participant observer, her other role in this study was to assist in the mechanical tasks of taking photos, and videos.

3.6.4 The Expert.

Together with my learners, we were able to identify a woman in the *Eendombe* community who was deemed to be an expert in making *Ombike* amongst other beverages. Her qualifying factors included being popular in the entire community and being within walking distance of the school. After the consultations with her, she agreed to be one of the main participants of this research study and she played a role of demonstrating and also providing much needed information.

3.7 Data analysis

Data analysis has been explained by Gay, Mills and Airasian (2006) as a process of making sense and meanings in the data, interpreting what has been seen and what has been said. An inductive analysis was applied during the data analysis process. Patton (2002:41) describes inductive analysis as the investigation of data to discover patterns and themes resulting in a creative synthesis. The focus was on how the cultural practice of making *Ombike* could enhance meaning making, conceptual development and understanding of the both the fermentation and distillation processes.

All the interviews with the expert were conducted in their vernacular (*Oshiwambo*) and were thereafter translated into English. They were then transcribed and the transcriptions were interspersed with the corresponding field notes.

Views and ideas from the group discussions between learners and the expert were analyzed with the coding system. Cohen, et al. (2010:480) define coding as the translation of question responses and respondent information to specific categories for the purpose of analysis.

Most often, I have used direct quotations from the participants to enable their ideas to come through in the study. I was able to generate analytical themes which according to Bassey (1999), are based on raw data but speak directly to the research questions.

3.8 Validity and trustworthiness

To ensure validity and trustworthiness in my study I used various methods of gathering data, namely; brainstorming, observation, semi-structured and focus group interviews. The use of multiple methods helped to triangulate and to build on each type of data gathering while at the same time compensating for any potential weaknesses in any single approach (Patton, 2002). Triangulation was used to complement and look for consistency, patterns and discontinuities in the data collected. According to Cohen, et al. (2010:141),

> Triangulation techniques in the social sciences attempt to map out, or explain more fully, the richness and complexity of human behaviour by studying it from more than one standpoint… Triangulation is a powerful way of demonstrating concurrent validity, particularly in qualitative research.

As far as validity and trustworthiness are concerned, the audio and video recordings were shown and played back to the participants, so that they could consolidate and validate the data. The transcription of both audio and video materials afforded me the opportunity to reflect on what transpired in the focus group, class or interview session, in reasonable detail. I was thus able to describe the situation in sufficiently rich, 'thick' detail so that the reader could "draw their own conclusions from the data presented" (Leedy & Ormrod, 2010:100).

Using these follow up discussions and member checking of interview transcripts also gave me an opportunity to share the interpretations with my participants and hence that improved the validity in this study. The transcripts of the interviews and summary of discussions were also given back to the respondents to verify their responses so that they could check for any misinterpretations. This is called member check (Lincoln & Guba, 1985:314). I also asked my critical friend to read through my data and thereafter she provided me with some feedback.

3.9 Ethical considerations

The ethical issues included being conscious about ensuring voluntary participation and obtaining informed consent from my participants. Merriam (2001:213) argues that, "in qualitative studies, ethical dilemmas are likely to emerge with regard to the collection of data and in the dissemination of findings".

Prior to doing the research, I sought permission from the principal of the school, the expert and the parents of the learners (see Appendices 1A, 1B & 1 C). I also made sure that the identities of my participants including that of the school were not disclosed, hence pseudonyms were used. I was also aware that since our sessions were done after hours, hunger and thirst might affect the learners, so I made an effort to provide some juice every time we had an excursion session.

Due to the nature of my research focus, I also considered the following two ethical cases;

- Prior to go to the *Ombike* site, I strongly instructed all my learners about the danger of alcohol, so that they could not be tempted to taste it.
- In order to avoid any conflict of interest that might arise between my research study and the Ministry's policy of prohibition of alcohol in the school premises, I decided not to invite the expert to come to demonstrate the making of *Ombike* in the school property but rather at her own place, despite being granted permission by the principal.

3.10 Limitations

There were limitations to this study that needed to be taken into consideration. My two research sites (my school and the expert's house), that I selected for this study do not represent the population of all the combined schools in Namibia, nor all the other experts' houses. Therefore, the findings cannot be generalised to the larger population of Namibia.

The other limitation might be due to the fact that much of the explanations and interview responses with the expert were done in the vernacular (*Oshiwambo*), thus, some of the salient information might be lost through the process of translation.

Apart from these ethical issues there were also some critical dilemmas faced during the entire research process.

- During the *brainstorming session*: I could not find a person very familiar with the video recorder. That is why the video was imperfect although the sound was audible.
- I also found that learners felt *uncomfortable* when being recorded *using the video recorder*, this was the reason why I used my cell phone for the later interviews with the expert and the learners.
- *Language barriers* to both learners and expert: Since English is a second language to all our learners, both their verbal and written expressions were sometimes not clear, hence the use of both languages was allowed in order to get sufficient information.
- *Natural factor of floods*: initially I wanted to work with the entire grade 9 class but this did not materialise as the area experienced a sudden school closure due to heavy rains which resulted in floods, hence my decision to only work with 12 learners, those that live on the same side as the expert's house and did not have to cross the river.
- While in the middle of my research process I encountered the biggest challenge of *changing my working environments*. Although this was almost at the end of my data collection process I still had to do the practical activities with the learners. This was costly because I had to travel back to the school on some days.
- During the days when I had to *travel back*, sometimes even if I had made arrangements, urgent matters intervened. For example, some learners had to attend disciplinary sessions, urgent staff meetings for a critical friend or extra mural

activities. But in the end I managed to finish although not within the intended duration.

- Conflicting obligations of study versus work were a limitation of this study as sometimes I had to miss contact sessions with the supervisors when I was expected to attend work related workshops.
- Due to factors such as time constrains I found myself doing the practical activity lessons in a rush which even resulted in me forgetting to give my learners the chance of making predictions. When using the PEEOE approach as proposed by Maselwa and Ngcoza (2003), learners were supposed to do predictions and then give explanations for their predictions. The purpose in this is basically to develop the learners' ability of think critically. I regard this as an area for improvement in further research.

3.11 Concluding remarks

In this chapter I described the research design I used to generate insights that illuminated my study. I also discussed the data gathering techniques used to generate data in order to answer my research questions. Analysis of documents, interviews and observation were used as the main techniques for generating data in this study. I reported on the consideration of the ethics, triangulation methods and limitations of the study, and explained the method of data analysis and how data was interpreted to draw conclusions from the findings. In the next chapter I present the data as findings from the research methods reported on here.

CHAPTER FOUR

DATA PRESENTATION AND ANALYSIS: PHASE ONE

4.1 Introduction

In this chapter, I present and analyse data sets derived from the brainstorming session, observation of lessons and the demonstrations. This data was aided through the viewing of recorded videos and photographs. Analysis of data presented on newsprints and participants' journal notes also served as sources of data. In this chapter, I present my data in four stages as follows:

- Stage 1: Learners' experiences on making of *Ombike*;
- Stage 2: Presentation of key concepts under study;
- Stage 3: Discussion of observation of the expert demonstration; and
- Stage 4: Meaning making using *Ombike* practices.

I now discuss each of these below.

4.2 Stage 1: Learners` experiences on making *Ombike*

4.2.1 Brainstorming session in the classroom

During this lesson, I initiated discussions through probing learners to generally reflect on how *Ombike* is made. I did this to establish learners' prior everyday knowledge and experiences of this traditional practice. During this lesson learners were allowed to discuss in any language. Some learners were a bit nervous to be part of the discussion since they had never seen the demonstration of making *Ombike*. However, the discussion became interesting because some learners had observed this practice before, some at their homes and some at their neighbours. Following is the summary of the discussions of the brainstorming session.

Teacher: *Ole tetu fatululile nkene Ombike hai ningwa*? (Freely translated: Who can explain to us how *Ombike* is made?)

Learner 1 (boy):

Ngele opo to tameke lwotango, oto tula iipambu yeendunga mehemele ndele toyi moteke nomeya. Otayi vulu oku kala mo uule wiiwike iyali, oshoka iilongitho iipe na ina yi igilila. Opo ihe iikando tayi ka landula otayi vulu oku kutha owala oshiwike shimwe. Aakuluntu otaa ti, ngele owa tulamo osuuka, otashi ku etele otiibii.

(Freely translated: When you start *Ombike* for the first time, you have to crush the palm fruit into the water and it will stay there for two weeks. The reason is because the instruments are still new. Next time when making *Ombike* is when it can only last for one week in the pot or bucket. Parents are saying if you add sugar, it will cause TB, Tuberculosis).

Learner 2 (girl):

Materials to be collected first are makalani palm fruits, clay pots, a trough (*okatemba*), metal pipe (*okanyome*). With all the apparatus available, start by crushing the makalani fruits. Put the 'crushed' fruit in a container with water. It stays there for one week. Thereafter get firewood for fire. Put the mixture in a clay pot that you should cover on top with a wet clay or mud (*elowa*). The metal tube will then be stuck into the mud which will collect the gas *Ombike* into (*okatemba*) a trough. As it boils you put a small grass stem or a small piece of palm leaf at the end of tube and the other end into the bottle where *Ombike* collect. This piece of a leaf will direct the liquid into the container, so it does not spill over.

Learner 3 (girl):

First you take the palm fruits, and then you hammer it into pieces. Take these pieces into the basket and close it nicely without any hole. Leave it for one week. When it reaches for cooking you will see bubbles if you open it. Take a clay pot; put that mud thing (rotten mixture) into the clay pot, then you make *Ombike*.

The learners who had never seen *Ombike* being made were curious and thus asked some questions for clarity. Here are some of these questions:

Question 1*: Otaa vulu oku volonganitha iiyimati mbika?* (Freely translated: Do they mix these fruits or are done separately?)

Group responses: *Ngele oya hala otaa vulu, oshii kwa telela owala kuwindji yiiyimati*. (Freely translated: If they want, they can mix them, if they want they can do it separately. It depends on the availability of the fruits).

Question 2: Is *Ombike* from different fruits differs?

Group responses: They differ, the one from berries is sweeter (according to what they hear) than all other fruits, while the one from palm fruits (most liked) is stronger than all.

Question 3: Who normally drinks *Ombike*?

Group responses: Mostly adults (both men and women) but not children. However, we use to hear some villages closer to the borders of Namibia and Angola where *Ombike* is their everyday drinks it can even be taken by children. But this is not a case in our community.

Question 4: Is there a way of speeding up the process of making *Ombike*?

Group responses: Some people say if you add sugar (crystals) it will be quicker. However it can cause problems like; liver problem/cirrhosis (*eshuli*) and TB.

Contributions by the critical friend

I should start with making more *Ombike*. You know if you add sugar the more sugar you add, the faster it gets. They also add the bran (*uushutu*) from mahangu seeds before it ferments.

Especially those doing it in towns for money, they can still re-use the already used mixture by adding sugar, because they do not want to wait for another fermentation of another fruits which can last for a week. All they do is just to add a little mixture of berries or palm fruits to give *Ombike* the needed flavour. This is commonly known as non-genuine *Ombike* (*Omangelengele).* Instead of the clay pot used by the villagers, the town brewers use metal drums and their other ingredients include; old shoes, old clothes, car tyres. About *Ombike* from grapes, it is apparently fermenting faster when made – maybe because it is sugary or not so hard when fermenting. People are saying this is so strong (alcoholic).

With regards to the effect of adding sugar, my critical friend did not really have much information about it and she commented “unless we can ask the consumers or experts but they normally say it is dangerous to drink”. She further said that *Ombike* made from the addition of sugar, if you shake it, it will form more bubbles than the one where no sugar was added. Meaning that this is the way people use to differentiate between the two types of *Ombike.*

About the duration of the fermentation process, the critical friend explained that;

If you are fermenting for the first time, fruits have to be crushed so that these crushed fruits could ferment well (to be ready for preparing *Ombike*). Also, if it is for the first time, you know that the container has not been used for fermentation, so it will take approximately two weeks. But then, the next times when you soak it, now the containers used for soaking do not need to be washed. The reason is for it to become used for faster fermentation so then it will be able to last for a week.

What emerged from these data?

During this discussion I realised that learners were misinterpreting some of the scientific concepts for example; they were referring to liquid as gas (see Learner 2 above) and also being unable to say crush but rather say hammer. This might give a different meaning to their statement. Furthermore, as the critical friend was given the chance to add her contributions she often used the concept ‘fermentation’ in her explanations. This was new to some learners, and I thus asked her to explain it.

4.3 Stage 2: Presentation of concepts under study

Based on the knowledge and experiences gained from the brainstorming session above, I was able to introduce scientific concepts of fermentation and distillation to the learners. The intention for this was to equip learners with basic key concepts before they visited the expert’s site where the practical demonstration was going to take place. .

The lesson was designed in a social situation that allowed all the participants to engage. A random selection of learners was done to put them into three main groups each of which consisted of four learners. Care was taken during the organisations of these groups ensuring that fair allocation of boys and girls in each group is realised. This entails that each group consisted of two boys and two girls. Each group was then expected to develop scientific concepts emerging from some excerpts from my unit of work (see Appendix 3A).

These excerpts were part of the explanations for the concepts under study guided by the teacher/researcher. After I had explained each extract I gave a few minutes to each group to discuss all the scientific concepts they could see and they then continued until all key concepts were developed.

The collection of all the concepts developed or that emerged from each excerpt made it easier for the learners to organise them into meaningful ways through using mind-maps (see Section 4.3.3). After each extract, learners were expected to discuss and write down all the scientific concepts they found, so that later on they could put them into a mind maps.

Following are the excerpts from the unit of work (Appendix 3A) on how the lessons of introducing scientific concepts (teaching) went:

4.3.1 Lesson 1: Fermentation

Excerpt 1:

Fermentation is a process involving the breaking down/decomposing of organic materials (sugar/glucose) by microbes (e.g. yeast) to form alcohol (ethanol) and carbon dioxide gas in the absence of oxygen.

Concepts that emerged from this excerpt:

- Decomposition/ breakdown;
- Organic materials (sugar/ glucose);
- Microbes/ micro-organisms (bacterial and yeast);
- Products: Carbon dioxide and alcohol; and

- Anaerobic respiration.

Excerpt 2:

This reaction is catalysed by chemicals (enzymes) from the yeast which uses sugar for energy to decompose into carbon dioxide and alcohol (ethanol).

Chemical equations for fermentation:

In words: Glucose $\xrightarrow{(yeast)}$ ethanol + carbon dioxide

In symbols: $C_6H_{12}O_6 \xrightarrow{(yeast)} 2C_2H_5OH + 2CO_2$ (balanced equation)

At industrial level, the process is used to make wines and beers using fruits. Other wine makers opt to add sugar to act as a catalyst to their reactions or to increase productivity. However the addition of excessive sugar has an effect of producing a poisonous alcohol, methanol, (CH_3OH), instead of ethanol (C_2H_5OH). Methanol is not recommended for human consumption due to its poisonous effects such as, eye problems and others.

Concepts that emerged from this except:

- Catalyst: - speed up of reactions;
- Chemical equations (word & symbols);
- Symbols: glucose ($C_6H_{12}O_6$), ethanol (C_2H_5OH), methanol (CH_3OH) and carbon dioxide (CO_2);
- Balancing equation; and
- Reactants and products.

4.3.2 Lesson 2: Distillation

Excerpt 1:

Distillation is a process that separates a substance or mixture of substances from a solution through vaporization. It involves boiling a liquid and then condensing the vapour that forms a distillate. This process is carried out in an apparatus called a still which consists of:

- A boiler – where the mixture is put to boil;
- A condenser – where the vapour changes to liquid; and
- A receiver – where the liquid collects.

Concepts that emerged from this excerpt:

- Vaporisation;
- Mixture;
- Solution;
- Vapour;
- Boiling;
- Liquid;
- Condense/condenser; and
- Distillate.

Excerpt 2:

Fractional distillation separates mixtures of liquids that boil at different temperatures (boiling points). Take note, alcohol boils at approximately 78°C whilst water boils up to 100°C.

Those substances that boil off first are the ones with lower boiling point and those with higher boiling point take longer to boil. As a result, when making alcohol, always the first distillate contains a larger proportion of alcohol than water.

Concepts that emerged from this extract:

- Fractional distillation; and
- Boiling points (water 100°C and alcohol 78°C).

Fractional distillation makes beverages of higher alcohol (spirits), for example, whiskey and brandy. Interestingly, all these spirits are primarily made from fermented fruits that underwent the boiling process as the last stage.

4.3.3 Mind maps developed by learners

Using the concepts developed in the previous lessons, learners were expected to device a way of presenting these concepts in a meaningful way, which is through use of mind maps. By introducing mind maps to my learners I had hoped it would make it easy for these concepts to be understood.

Learners' mind maps are presented below.

The first two maps are for concepts under fermentation process.

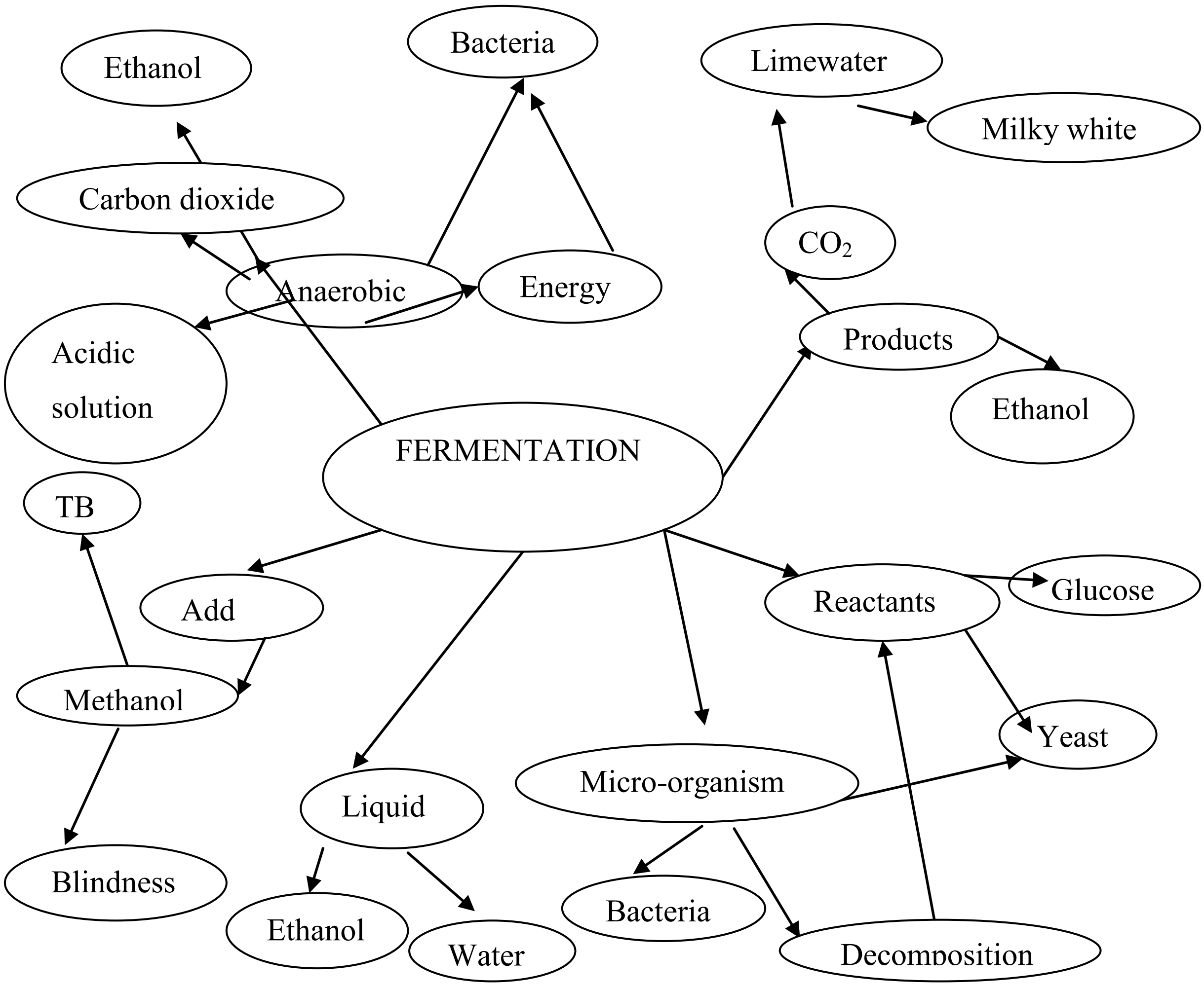


Figure 4.3.3a: Mind map 1, Group 1, Fermentation

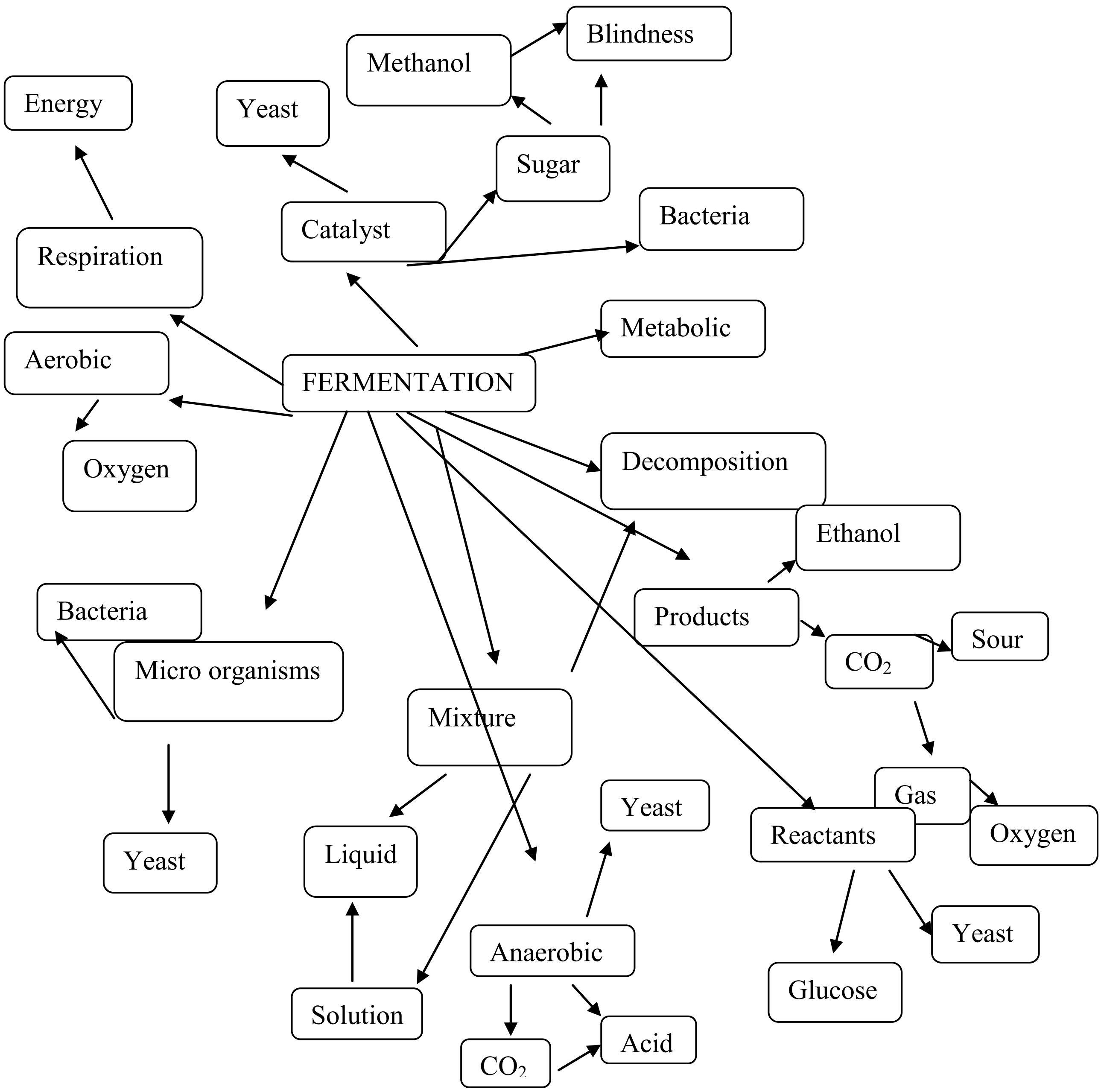


Figure 4.3.3b: Mind map 2 Group 2, Fermentation

The next two mind maps are for concepts derived from the distillation process.

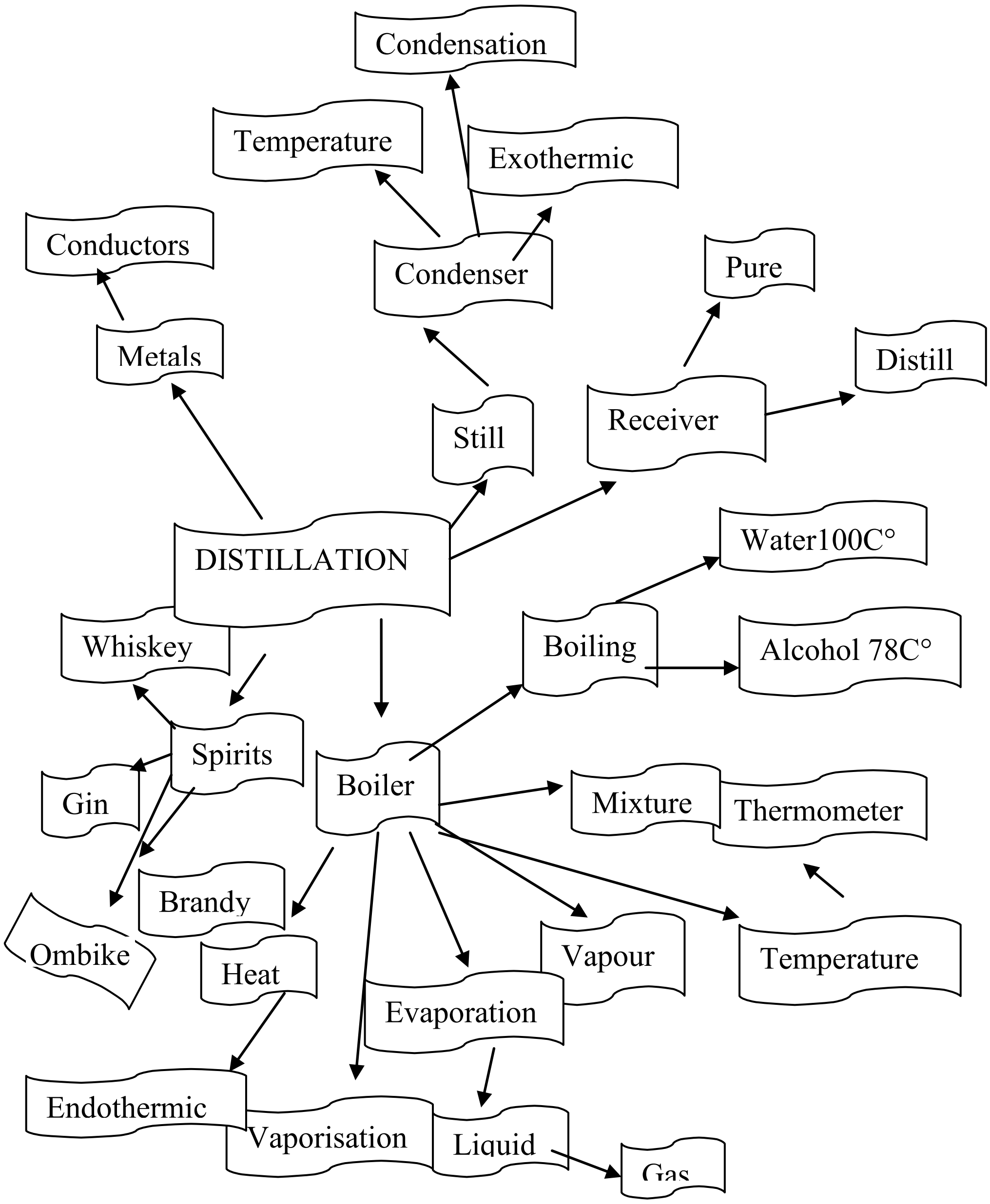


Figure 4.3.3c: Mind map 3 Group 1, Distillation

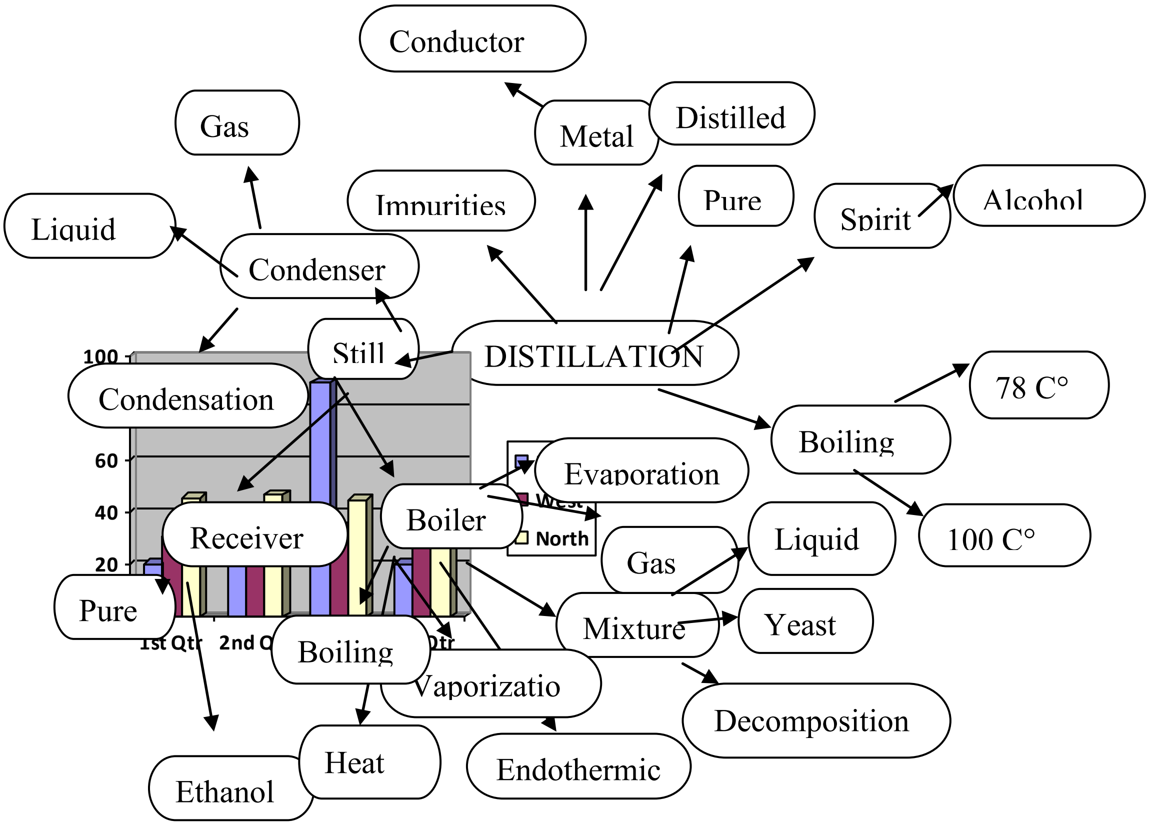


Figure 4.3.3d: Mind map 4 Group 2, Distillation

The mind maps drawn by learners showed that the concepts of fermentation and distillation could be explained using a number of concepts. Learners developed many concepts as shown in the maps. I realised that these maps could easily be converted into concept maps where links between concepts could be shown with linking lines. There were times where some learners had written a particular concept more than once which shows that a concept could be linked to other concepts in more than one way. Herein lies the importance of mind or concept maps.

Through the presentation of the concepts in the mind maps, it emerged that learners found it easy to split concepts into sections. For example, in mind map 4, one can see under distillation other key concepts such as boiler, condenser and mixture are classified and presented with further concepts under them again.

4.4 Stage 3: Data gathered during the practical demonstration by the expert

4.4.1 Fermentation

General information

An appointment was made a week in advance with an expert in order to show the team of participants the process involved in making *Ombike* at her house. As per arrangement and agreement, we made our way on foot from the school to the expert's house. As the house was approximately two and a half kilometres from school it took us almost half an hour to the house. This happened in the afternoon, when the school was out.

Since this was our first day, we found the expert waiting for us with all the materials and apparatus ready displayed for the practical demonstration.

On the first day there was some anxiety in both the expert and the learners. First, the expert was a bit nervous for being approached by a group of learners together with their teachers, something she was not used to. Her fear was most probably that maybe she would be asked many difficult questions. Likewise, learners were not really free due to the *Ovawambo* tradition for showing respect and polite behaviour toward elders especially those they are not familiar with, despite them being informed to be free to ask the expert for clarity.

Following is my analysed notes from the participants' journals and videos taken while observing the demonstration at the expert's place.

Fruits used:

The fruits mostly used are:

- Palm fruits (*Eendunga);*
- Buffalo thorn fruits (*Eentantahe*); and
- Plum fruits (*Eembe*).

These are all local fruits that are sugary.

We were also shown the trees from where these fruits were taken, since these trees are found scattered around in the villages. We also discovered that these fruits are not necessarily for making *Ombike* only, but are used for many other purposes. For instance, apart from being edible to people, palm fruits (*Eendunga*) also serve as food for animals such as donkeys especially during dry seasons.

It is believed that by choosing these kinds of fruit amongst others are due to their sweetness with good flavours. Both *Eentantahe* and plum fruits *Eembe*, can apparently be used whether dry or not. However, this does not apply to the palm fruits, which are only used after they become dry. Asked on the reason for this, the expert explained that the sweet taste of the palm fruits (*Eendunga*) becomes more pronounced only when they are dry and when they are still fresh they are bitter. This is different from the other fruits.

Apparatus used and shown included:

- **A plastic bucket**

This is the container where the soaked/wet fruits are kept for some days and allowed to ferment before being boiled.

- **A clay pot (**see photo in the Appendix 4)

This is the pot which is used during the boiling process. It is especially made for this process with a small gap left on its mouth where a metal tube is placed to collect the vapour which ultimately turns into liquid *Ombike*.

- **A wooden trough (**see photo in the Appendix 4)

This is specially designed with a metal tube inserted through it. It has an open part where a metal tube is exposed and is also where the cold water is added. Learners asked whether there are special trees that are most suitable for making this trough. The expert explained that all strong tree trunks can be used, but highlighted that the most common trees used to design a trough are the trunks of palm trees. Palm tree trunks have been previously used to make large drinking troughs for animals in this community.

- **Fire wood**

Fire wood is needed for making fire.

- **A collecting bottle**

This can be any bottle or container where the distillate will drop into to be collected as the boiling goes on. After the discussion on all the instruments or apparatus used, it was now time for the demonstration.

Preparations for fermentation:

Following is an explanation on how the expert started with this process of making *Ombike*. As this was the first stage of making *Ombike*, the expert started off by first crushing the palm fruits using a strong stick. The crushed fruits were then mixed or soaked in water and then placed in the plastic bucket. This plastic bucket was covered for five days when it was ready for boiling. When asked on the reason '*why the mixture has to be covered all along*?' the expert made it clear that *"Oku suukula sukula ehemele lyombike ota shi etitha ombepo yi yemo yo oyo tayi ka yonagula iiyimati. Shika osho hashi ke etitha oku ninga Ombike oshona".*

(Freely translated: "too much frequent opening of the bucket will allow more air to enter the bucket, thus in the end spoiling the mixture, and hence reducing the amount of production of *Ombike*").

The bucket was left just outside in a shade of a tree inside the yard but not inside the hut or room. This was done for the reason that "*momuzile gwomuti omo muli nawa oshoka omuna ombepo tayi pepe nawa yo oyo nee tayi keelele uupyu wapitilila nenge uutalala wa pitilila kehemele*" (Freely translated: a tree shade is a moderate place for there is air blowing which prevents excessive heat or too much cold weather which is not needed by this process).

Very interestingly, as we were about to leave, one of the learners proposed that we should also measure the temperature changes of the fermenting mixtures throughout the fermentation process. As a researcher, I was aware of the implications that this might have since too much opening of the container was not allowed. I told the expert about this, and she explained that *"kashishi lela uupyakadhi, kehe ike tashi ningwa meendelelo. Ongaye mwene tandi ka kuthamo noku ka tulamo natango, shandje okuka pa owala omuleshi. Otandi shiningi owala nomukalo ngoo handi longitha oku tala ngele oya pya. Ashike omeendelelo lela*". (Freely translated: "It is not really a big problem as long as it is me who opens it quickly and gives that instrument to the reader. I have to remove it, because I will do it the same way I use to check its condition. So, it is done very quickly").

A consensus was reached, and it was decided that a learner from the expert's house is tasked under the expert's supervision, to systematically record the temperature using the thermometer. This was done three times a day (morning, afternoon and sunset). We left a thermometer inside the bucket, touching the fermenting mixture.

The results are shown in the table below:

Table 4.4.1 Temperature of the fermenting mixture

	Wednesday	Thursday	Friday
Morning	23°C	22°C	19°C
Afternoon	32°C	25°C	21°C
Sunset	35°C	20°C	29°C

On the first day of the recording which was the second day after the mixture had been placed into the plastic container, the temperature recorded in the morning was 23°C. It kept on increasing through the day with about nine degrees to 32°C in the afternoon. As the day progressed, the temperature was visibly rising even up to 35°C at sunset.

On the second day of recording, the morning temperature was almost the same as that of the previous day morning, down by one degree (22°C). During the day, it increased with three degrees to 25°C, as compared to a rise of 9°C on the previous day at the same time. By sunset, the temperature dropped to 20°C, unlike what had happened on the first day at the same time.

On the third day, the temperature started slightly lower at 19°C in the morning. During the day it rose slightly by 2°C up to 21°C. It again kept on rising steadily to 29°C by sunset.

Critical areas of interest emerged from this table that may raise the eyebrows in relation to established scientific explanations:

- Overall, the temperature was seen decreasing as the fermentation of the fruits proceeded; and
- The temperature at the sunset, except on the second day was seen to be higher than in the mornings and afternoons.

However, one cannot let it go without mentioning the effect on the temperature reading due to weather condition such as cold and windy conditions. It is thus expected that the temperature in the clay pot would rise towards the afternoon especially as there was no wind. The seemingly anomalous readings for Thursday may have been caused by a cold wind blowing.

As much of the preparation for fermentation was done on day one and we had also obtained much of the information about the first stage, I advised the group to go there on the day of distillation process as well in order to observe the boiling activity.

4.4.2 Distillation

On the fifth day, I took my participants to the expert's house again in order to observe the remaining process of making *Ombike*. This happened in the afternoon as usual because I did not want to interfere with the learners' lessons at school. Following is the data collected during the demonstration of the second stage of making *Ombike*.

Materials used for distillation:

- Clay pot;
- Clay soil mud;
- Trough made of wood;

- A copper metal tube passed through the trough (when the learners asked why the expert was using copper tubes, she responded) *"opo Ombike inayi kala yina oongaga dholusu. Okatenda haka ihaka ningi olusu".* (Freely translated) "Because they do not get rusty or corrode, also to avoid the colouring or dying of *Ombike*");
- Clock and thermometer;
- Fire wood;
- Glass bottle as receiver; and
- Cold water.

How was the distillation process done?

First, the expert poured the fermented mixture from the container into the clay pot where it was going to boiled. She then covered the pot with a piece of broken clay pot (*okakangwa*) which she mounted with mud. Before completely sealing the entire pot with the mud, she inserted the metal tube that went through a wooden trough.

Before she placed the container on the fire, the critical friend (science – teacher) advised the group to try to get any information regarding the temperature change as the boiling went on as we did with the fermentation process. So, we inserted a thermometer into the mixture through the wet mud. The reason given for this was basically to see if we could make any comparison or get any temperature which may come in the close range of the alcohol's (ethanol) boiling point of 78°C.

After the entire set up was complete, the expert made a moderate fire and kept on monitoring it. For instance, as the fire got hotter, she reduced it by removing some fire wood. One of the learners asked her, "*Omolwashike to kuthapo iikuni yimwe*?" (Freely translated: Why do you remove some firewood?)", and the expert replied that; "*ngele otwa tulapo iikunu oyindji, Ombiga otayi ka fuluka unene, ndele tayi koshoko nelowa ndii lya thila*", (Freely translated: "should she allow more fire level, the boiling process would be fiercer and uncontrollable thus may even come to an extent of washing off the covering mud. She further explained that should this happen, "there would be a lot of air passage, and the vapour would escape into the atmosphere and this means wasted effort".)

When the temperature started to increase and the vapour could be seen coming out from the metal tube, she poured cold water onto the trough which covers the metal tube. The reason was actually to condense the vapour into a distillate which is *Ombike*. The temperature of water in the trough had to be continually monitored in order to get the desired results. For instance, once the water got hot or warm, it had to be removed and quickly replaced with coldwater.

The process took approximately two and a half hours for the mixture in the container of approximately 10 – 12 litres which made almost 750 ml of *Ombike*. The starting time recorded for this was 15:08 and the entire process lasted until 17:38.

The summarised table (below) shows how the temperature changes with time as the boiling was going on. Below this is a brief discussion of the data presented in the table.

Table 4.4.2: The temperature change during the distillation process

Time / min	0	22	33	65	90	120	130	140	150
Temp (°C)	30	90	93	93	93	95	96	97	97

After about 22 minutes, the mixture started boiling at 90°C. This kept on increasing until after about 33 minutes when we first saw the distillate dripping out of the tube at 93°C.

Furthermore, the expert told us that *"Ombike yotango oya kindja unene, na otayi vulu oku ku kolitha ngele oweyi nu yapitilila"* (Freely translated: "the first *Ombike* distillate is too strong and can make one drunk when taken in large quantities"). It is the one liked by many male elders. She also explained that she normally uses three different collecting containers. One is to collect the first *Ombike*; the second is for the moderate *Ombike* which is liked by most people including women. The third container was meant to collect the last distillate known as *omatshatsha*- meaning most diluted *Ombike*. This one is different from the rest because it contains more water and a very little percentage of alcohol.

This process requires close monitoring especially when separating the first, second and third portions as most do this by testing the drips using the fingers. However, one thing we discovered was that, as the time went on, the rate of the drops into the container kept on increasing.

Some of the transcribed questions asked by the learners as the expert did the demonstration

Learners were also advised to feel free to ask any questions or clarifications from the expert. Most of the questions presented below were based on what interested them and also in relation to the questions they were discussing during the brainstorming session. The discussions were done in *Oshiwambo* and the free translations are given below.

Learners-expert conversation:

Learner: *Opena eoloko pOmbike yeembe naandjono yeendunga?* (Freely translated: Is there a difference between *Ombike* made from berries and that of palm fruits?)

Expert: *Aawe, okayooloko okeli owala pezimba lyiiyimati* (Freely translated: Not really any difference. I haven't heard any complain unless the smelling or flavours).

Learner: *Omatshatsha oshike*? (What is omatshatsha?)

Expert: *Ombike ya hugunina* (The last, tasteless (distillate) *Ombike* when it is getting finished).

Learner: *Iipambu mbika yalonga, otayi vulu oku longithululwa*? (These residues, can they be re-used?)

Expert: *Aawe, paife iikulya yiingulu owala nenge tayi ningi uushosho mepya (*No it is no more useful as it is now the food for the pigs or used as fertilisers in the field).

Learner: *Okugwedhamo osuuka oshina uupyakadhi washike*? (What effect does sugar has if added?)

Expert: *Inandi yilongitha nale, onkee kandina uuyelele musho* (I have never used it, so I have no idea about it).

Learner: *Oushi eyooloko pokati kombike yatulwa osuuka naandjono inaamu tulwa sha? (*Do you know any difference between *Ombike* made with addition of sugar and that without any sugar added?)

Expert: *Shaashi iha ndi mu, na ishewe ihashi ningwa ko kutse, onkee katu shuwa sha. (*Because I don't drink and also is not a practice in our community we cannot know any).

Learner: *Paife oto shi tseya ngiini kutya oya pya?* (Now how do you know it is ready or fine or not fine?)

Expert: *Otandi ithana gumwe megumbo eye a lole.* (I call someone in the house to come and have a taste).

Learner: *Opena omukalo goku endelelitha (*Is there a way you use to make it faster (last a few days?)

Expert: *Aawe, ongele owala itoo lundulula iilongitho, noye itoyi kosho. Mbyoka iipe otayi kutha ethimbo ele.* (No, you only need to frequently do it using the same instruments that should not be washed after use. New ones will take longer).

Learner: *Ohaanu ngiini* (How do they drink it, can they dilute it?)

Expert: *Oyendji ohaa tulamo onamunate yo sprite (*Many like it pure but some mix it with a Sprite cool drink).

Learner: *Ongiini ngele owa pitilititha omasiku giipambu shoo yili mehemele?* (What if you exceed and forget and leave the fruits in the container for more days than required?)

Expert: *Ombike otayi yonuka na thimbo limwe otakuzi owala omeya* (It will be spoiled and spoiled *Ombike* will come out sometimes is just as pure water).

From these questions and answers, it emerged that learners were highly curious to know more about this cultural practice. They were trying to get clarity on most of the questions they were discussing during the brainstorming session. It was very clear to me that although some learners can observe this cultural practice at their homes or neighbours, their curiosity was not stimulated as they had no one to ask for explanations.

During the brainstorming session, the critical friend explained that there are many ways of making *Ombike*, and that depends on the context where it is made. If it is made in towns, then sometimes the process is altered through various additives. This is so because urban brewers are in fact after money. In contrast, the rural experts are of different belief. They believe in the perfect and appropriate method of making *Ombike* in an efficient manner.

When asked about the addition of sugar, she replied that *"ka ndina uuyelele musho, oshoka oshinima oshipe na ihashi ningwa mo momudhingoloko gwetu*" (Freely translated: I have no idea about it because it is not a practice in our community"). When asked about any method of making the process go faster, all she could say was to avoid washing the apparatuses although the expectation was for her to say something in line with addition of sugar or yeast.

4.5. Stage 4: Scientific meaning-making of *Ombike* practices

In addition to the above discussions between learners and the expert, another session was organised with the learners where the intention was mainly to use the knowledge gained from the previous session in order to enhance the understanding of the concepts under study. Two discussion sessions were planned; one for questions about the fermentation process and the other one were for questions about the distillation process.

Despite that plan the questions were more on the *Ombike* practice. I had expected these sessions mainly to solicit the learners' scientific responses to the cultural practice.

The same groups as those that developed the mind-maps (Section 4.3) were used during this session and the following codes were used:

- **T**: for the teacher/researcher;
- **G1**: for focus-group 1 responses;
- **G2**: for focus-group 2 responses; and
- **G3**: for focus-group 3 responses.

4.5.1 Fermentation of Ombike in the plastic container

Here are the responses recorded from the participants against the questions posed.

Question 1: *Explain why it is not advisable to frequently open the fermenting container of Ombike?*

G1: Air will oxidise some species in the yeast to carbon dioxide and water instead of alcohol.

G2: - If oxygen is passed through the bucket where there is the mixture, it will no more produce ethanol (C_2H_5OH), but only carbon dioxide (CO_2) and water (H_2O).

G3: - Oxygen will spoil the mixture by making the liquid produced become tasteless.

Question 2: *After some days of fermentation of the palm fruits in the container, decomposition has started, and you will observe some bubbles form.*

i. *Name the gas that could probably be in the bubbles.*

G1, G2, G3: Carbon dioxide gas

ii. *Explain the scientific chemical tests of the gas in the bubbles.*

G1: Bubble carbon dioxide gas into clear lime water, lime water will change from colourless to whitish.

G2: Pass the gas in the lime water then the result will be; limewater turns to milky white or cloudy.

G3: Use clear water and put in a gas that collects. Shake it and see if it changes to milk white then it means the gas collected was carbon dioxide.

Question 3:- *We have learnt that some wine makers opt to add sugar to their fermenting Ombike fruits. Explain why is it not advisable to add sugar to the fermenting fruits aimed to make alcohol like Ombike?*

G1: The products will no longer be the needed alcohol-ethanol, but a poisonous alcohol called methanol which has a negative health effect to the consumers.

G2: It will no more produce ethanol alcohol, but a dangerous alcohol methanol.

G3: Sugar causes blindness (*misconception*) and chest pain which can be associated with TB to the people who drink these liquid.

Question 4:- *Write the scientific chemical equations happening inside the covered fermenting container, and then in symbols write the equation above in symbols.*

G2: Sugar (fruits) $\xrightarrow{\text{(yeast)}}$ ethanol + Carbon dioxide

$$C_6H_{12}O_6 \xrightarrow{\text{(yeast)}} C_2H_5OH + CO_2$$

4.5.2 Distillation process or boiling process to produce Ombike

After the fermentation process was completed, all the apparatus needed for boiling were prepared as shown in the diagram below. The fermented mixture was then boiled in the clay pot. As it boiled, then the distillate which is an alcohol called *Ombike* in *Oshiwambo* was collected at the end of the metal tube into the collecting container.

Figure 4.5.1: Ombike traditional distillation equipment

Question 1- *What do you think is the function of the metal tube used in this activity?*

G1: To be an entry for the evaporating steam inside the boiler

G2: Is where Ombike moves from the clay pot to the collecting bottle

G3: To transport the gas that is converted to liquid to the receiver. It is also where condensation takes place.

Question 2:- *Explain what would happen if the boiling pot is not sealed properly*.

G1: Ombike will pass out in the form of water vapour and could not reach the receiver.

G2: The traditional alcohol will be less because some water vapour will pass out through those cracks into the atmosphere.

G3: Ombike will evaporate through those openings and could not be collected through the condenser.

Question 3:- *The cold water is always put in the trough over the metal tube in the trough. Once the water becomes hot, it is quickly removed and replaced with cold water again*.

a) What is the reason of putting cold water over the metal tube in the trough?

G1: So that the vapour will change into water droplets which will turn to *Ombike*.

G2: To cool down the metal tube so that *Ombike* will condense and come out in the form of liquid.

G3: To cool down the vapour that pass through the tube and then for that vapour to condense.

b) Explain how and why does this water get hot?

G1: the water will get hot because the gas which is coming out from the pot is hot causing the metal tube to be hot too because metals are good conductors of heat.

G2: Because of the heat in the vapour from the boiler, as it touches the tube, the tube becomes hot and then passes on the heat to the water.

c) *Explain what could happen if no cold water was placed in the trough.*

G1: No condensation process will take place. *Ombike* will evaporate in the form of gas to the atmosphere. So no liquid comes out, only a smoke you can see.

G2: Most of *Ombike* would escape in a gas state.

Question 4: Give *the scientific explanations or reasons for the following statements;*

- *Crushing the fruits into very small pieces:*

G1: So that the water will mix nicely and at the end the *Ombike* produced will taste stronger.

G2: Fermentation starts at this stage, thus it will make it easier when mixing them with water so that there will be a taste.

G3: In order for fermentation to take place faster by increasing the surface area.

- *Covering the mixture in a plastic bucket for about four days:*

G1: For oxygen not to enter into the mixture, because once it enters water will be the product instead of ethanol.

G2: For the carbon dioxide produced not to escape because it will be needed in dissolving the taste of the mixture into acidic taste since it is an acidic gas.

G3: To prevent the entrance of oxygen and also to make the temperature range constant.

- *The last distillate of Ombike is found to be weak and tasteless compared with the first distillate:*

G1: The first distillate is pure *Ombike* and as the alcohol get finished then it becomes weaker because now it is now moves toward water.

G2: The first is pure *Ombike* and the last one is *omatshatsha* which contains little alcohol and more water.

Based on the questions and responses above, I realised that many learners were able to fully make use of and incorporate the knowledge that they had gained from the previous session. The sessions that most contributed to these responses were the brainstorming, discussion with the expert, and the session about the introduction of the concepts under study. Learners were thus able to use the needed scientific understanding in answering the posed questions.

Responses given for not frequently opening the container were more scientifically appropriate to the level of these learners (grade 9). Learners had to translate the responses given by the expert when the same question was posed to her. Although the expert explained concepts such as 'air will spoil the mixture', scientific concepts such as; oxygen, oxidises, water and carbon dioxide were evident in their explanations.

Although most literatures recommend the use of IK in the science classrooms, it is important to note that not all community knowledge is relevant. It is therefore a good idea to create a platform to correct any misconceptions that might exist in the community. I am relating this to some of the responses given by learners which could be beliefs they had heard from their community. For example, when asked to explain why the addition of sugar to the fermenting fruits was not recommended, learners in group three (G3), replied that 'it causes TB'. This might be confusing and as it requires more clarification on how sugar causes TB.

I also realised that teachers need to emphasise to the learners the importance of integrating topics in science. I found from learners' responses that they were able to use knowledge from other topics to explain certain concepts. For example, in the responses given, I could see the use of other topics used in this context of making *Ombike* such as; matter (states, condensation, vapour...), conduction (heat, metals...), chemical reactions (equation), health (effects of adding sugar).

4.6 Concluding remarks

This chapter presented and analysed the findings from the brainstorming, discussions, practical demonstration and lesson observations. It is clear from the presentations that the elicitation of learners' prior knowledge is something of crucial importance. It formed a strong foundation which could give a clear direction to the teacher to know the kind of learners he/she is working with.

The data revealed that the use of community knowledge and experiences could be a remedy in schools where teaching and learning materials are not available. The explanations from the expert showed that, despite their low academic background, the knowledge of the community and their cultural practices might well be usable; hence studies like thses are needed.

In the next chapter I present the second phase of data presentation and analysis.

CHAPTER FIVE

DATA PRESENTATION AND ANALYSIS: PHASE TWO

5.1 Introduction

In this chapter, I present and analyse the data from the observation of the lessons on practical activities as well as the worksheets. As a continuation to the previous chapter, I thus present the data from the two remaining stages of the research process, namely:

- Stage 5: data from practical activities; and
- Stage 6: data from the interviews on the participants' evaluations and recommendations.

I now discuss each of these below.

5.2 Stage 5: Data from practical activities

5.2.1 Experiment 1: Fermentation of sugar in fruits by yeast

The aim of this activity was mainly for my learners to explore and experience more on the concept of fermentation. In addition to the knowledge and experience gained from the observation of the practical demonstration of making *Ombike* by the community expert, I let my learners experience this concept further through doing practical activities themselves.

The learners were arranged in groups where each group had to follow the procedures given in the worksheet (see Appendix 3B), and then discuss the questions raised in the worksheet.

Procedure for experiment 1

Three same sized conical flasks labelled Flask A, Flask B, and Flask C were used as shown below.

Flask A Flask B Flask C

Figure 5.2.1a: Three flasks at the beginning of experiment 1 -fermentation

Crushed fruits of palm trees (*Eendunga*) were put in each flask. These were the same fruits used to make *Ombike*. But the different treatment given to these three flasks was that in flask A and B the fruits were soaked or mixed with water (to form a mixture), while flask C, only the dry crushed fruits were used. The difference between flasks A and B was that in flask B some yeast was added.

The three flasks were each covered with a soft transparent and deflated plastic bag, which was tightly tied on the flask mouth with a rubber band as shown in Figure 5.2.1a.

The experiment was then left overnight until the next day for the learners to record and discuss their findings or observation as a group. The learners wrote their observations into their individual note books.

Results of experiment 1

FLASK A: In this flask the fruits were soaked in water and then sealed as described above.
Learners' observations:

Learner 1: After two hours, there was no change to both solutions and plastic, but the next day, more bubbles were seen in the solutions and also the plastic was also rising but very slowly.

Learner 2: The change was slow, may be because a catalyst of yeast was not added.

Learner 3: In A, only a little gas of carbon dioxide was produced slowly perhaps because no catalyst was added. This makes it to rise a bit.

Learner 4: The plastic rises because of the gas inside it which came from the fruits as they decompose. But this is not more than Flask B, because no yeast was added to it.

Based on this data presented by the learners, it shows that most of them presented almost the same information. Looking at the responses, it shows that with this experiment, a slight change was observed and this change caused a little rise of the plastic. One could make an inference that; perhaps fermentation was happening in this experiment at a very slow rate. This happened because there were probably some conditions for fermentation missing.

FLASK B: In this flask, the fruits were soaked in water and yeast was added. Thereafter, the flask was covered with a transparent plastic bag.

Learners' observations:

Learner 1: The plastic on this flask rises more than all the other plastic on the other two flasks and it made more bubbles faster also.

Learner 2: In B, a lot of gas was produced faster making the plastic to rise more than all. The gas present is now carbon dioxide which replaces oxygen which was there at the beginning.

Learner 3: The solution was bubbling with more gas faster because of the yeast which is a catalyst present. This causes the plastic to become bigger in size or expand.

Learner 4: The solution is mixing faster and there is more carbon dioxide gas in the plastic.

Learner 5: The fermentation became faster than all the other solutions and I think this way more ethanol is produced.

In this experiment, all the conditions set for fermentation were present. Learners were asked to point out the results of the change they observed and if possible give scientific clarifications on the causes. An analysis of the responses shows that the addition of the yeast to the reaction had affected the fermentation process. This was done to make the fermentation process faster than in the other two flasks.

FLASK C: In this flask, only dry crushed palm fruits were added and the flask was then covered with a transparent plastic.

Learners' observations:

Learner 1: No change was seen in this solution. The plastic did not raise either, but we could only see a very small amount of moisture or drops of vapour inside the plastic.

Learner 2: Nothing has changed to the solution and the plastic, because no water and no yeast were added. Reaction happens more when in solution form.

The results for flask C showed that no change was observed. This experiment served as a control. With this, certain conditions were missing in order to be able to make a comparison with the other flaks.

In short these were the results of the three flasks

Flask A Flask B Flask C

Figure 5.2.1b: Three flasks at the end of experiment 1 of fermentation

Lastly in this experiment, learners were asked to individually come up with concluding remarks regarding this practical activity.

Findings from experiment 1

Learner 1: This means that fermentation can be made faster if a catalyst like yeast is added and this speeds up the production of more carbon dioxide gas and probably more alcohol too.

Learner 2: This has showed me that there are different processes whereby alcohol can be made in a short period of time, although there might be some side effects later.

Learner 3: It means that there are many conditions one should always think of first before just starting making alcohol. These might include;

- Time- should I add a catalyst or not;
- Mixture- should I add water or not; and
- Air or Oxygen- should it remain open or closed.

5.2.2 Experiment 2: Determining the boiling points of liquids

One of the scientific methods used to classify and determine whether *Ombike* is an alcohol or not was done through experimenting to find its boiling point. The method was based on the theory that alcohol boils at approximately 78°C whereas water boils at 100°C (see Appendix 3C for the worksheet used).

Procedure for experiment 2

Using two test tubes A and B, where in each test tube a different liquid was placed, *Ombike* and tap water respectively. The temperature was recorded by placing a thermometer into the stopper of each test tube.

The learners were asked to complete a time against temperatures table for each test tube as the liquids were brought to the boil. A liquid volume of 20 ml was used in each test tube. The time interval of each recording was done after every thirty seconds.

A stop watch was used to record the time against the temperature reading from the thermometer. This was being done every 30 seconds because the volume of the liquids used was very little and boiling could happen very quickly.

Results of experiment 2

During the boiling of these two liquids, something unexpected happened. I could attribute this to the fact that I did not practice the experiment before taking it to the learners. This was a good experience for me, hence my decision to include it in my data.

This is what happened:

The stoppers that we put on the test tubes had one hole which was meant for the thermometer only. When the boiling started, the stopper on a test tube with *Ombike* popped off up to the roof as a result of its violent boiling and broke. Fortunately, this did not touch or spill onto any learner or a teacher.

Everybody was now left with two biggest questions to answer.

- Why did this happen in the test tube containing *Ombike* but not in the test tube containing water?
- How should we proceed with our activity? And what do we need to change?

We reserved the first question until the end of the activity and concentrated more with the second. A suggestion was made that instead of using a one hole stopper, we rather use a double-hole stopper. The reason being that, with the double-hole stopper, one hole could be used for the thermometer and the other one left open, so that some gas produced as the liquid boiled could be released. In this way the popping off of the stopper and the thermometer could be avoided.

It was then observed that *Ombike* started to effervesce or bubble before the water.

The table below shows the results recorded during the activity for the test tube with *Ombike* and the discussion about it follows beneath.

Table 5.2.2a: Test tube A, *Ombike*

Time/min	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5
Temperature/°C	24	31	45	53	65	79	80	82	82	82	83	84

With regards to ***Ombike***, the initial temperature recorded was 24°C. I had to use this as our initial temperature because we could not get hold of ice to bring down the temperature to zero degrees.

After about two minutes the liquid *Ombike*, visibly started to produce small bubbles at 65°C. After three and a half minutes the real boiling started at 82°C becoming more violent as time went by with some liquid even spilling out.

The class came to the conclusion that the boiling point of this liquid was approximately 82°C, because we observed that this temperature lasted for about two minutes at this reading and not changing a 20 ml volume of liquid. It started rising after the fifth minute but very slowly, and this was thought to be moving towards the boiling points of other liquids with impurities.

As the discussion went on, we related this finding to the practice of making *Ombike* when it was previously discovered that *Ombike* comes into three kinds, namely; strongest, moderate and diluted forms. Now does this mean that after five minutes the proportion of alcohol in *Ombike* was becoming depleted and now it was moving toward the boiling point of other impurities including water?

After all these, learners were also expected to answer the following question;

Teacher: 'With such data, can we regard *Ombike* as an alcohol or not?'

Following are some responses provided by individual learners.

Learner 1: I am personally convinced that *Ombike* is an alcohol. If the boiling point of alcohol ethanol at room temperature is approximately 78°C, and our result is 82°C, there is not much difference here.

Learner 2: Yes, because the boiling point that we suggested is very much closer to that of ethanol.

Learner 3: Yes, because if you look and think at the way it is made, processes are really similar to how the stronger alcohol is made in industries, and that it makes people to get drunk.

The table below shows the results from test tube B where water was placed. The discussion about it follows beneath.

Table 5.2.2b: Test tube B tap water

Time/min	0	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5
Temperature/°C	24	43	56	77	87	91	93	94	94	94	96	97

With regards to **water**, the same initial temperature of 24°C as of *Ombike* was used. After about two minutes, the 20 ml of tap water was also visibly starting to produce bubbles slowly at around 87°C. After three minutes, the water started to boil violently at 94°C. It constantly boiled at this temperature for about three minutes. From there it started to rise upward very slowly.

Most interestingly, when it boiled at 94°C, it was not as violent as it was with *Ombike*. This observation raised several questions in the minds of participants.

One learner remembered one property of a certain gas that makes a pop sound as a way of testing it: hydrogen. This was a most interesting experience as it made the entire group to think more and look at the chemical formulas of the two liquids under study; water (H_2O) and alcohol (C_2H_5OH). Looking at the number of hydrogen atoms in these formulae made them think of its significance in this context of a stopper being popped off the test tube with *Ombike* liquid.

However, the claim raised by the learners above is a misconception that needed to be corrected. Upon boiling, whole molecules of alcohol escape into the vapour phase. Molecules do not break up into their constituent components. Thus, evaporation is a physical process while decomposition into components is a chemical reaction.

5.2.3 Fair (control) experiment

When planning any scientific experiment, one needs to first think of how that experiment could be made to be a fair experiment. A fair (control) experiment is the one with certain common conditions, of which one or two can be changed in order to make some comparisons. Based on the two experiments discussed above, a fair test was involved and the following table shows what the learners saw as a reason for fairness**.**

Table 5.2.3: Frequency table for a fair test

Aspect of fairness identified by learners.	**Learners responded**	**Total/ frequency**
Start at the same time	L1, L3, L4	3
Same volume of *Ombike* and water	L3, L4, L5, L6, L7, L8, L9	7
Same starting temperature	L10, L12	2
Same kind of instruments/apparatuses	L1, L2, L3, L4	4
Stoppers with the same number of holes	L5, L6, L7, L9, L11	5
Same level of heat/fire	L1, L2, L8, L10, L11	5
Same place/condition	L2, L12	2
Have a stopwatch	L1, L12	2

5.3 Stage 6: Interviews with the participants

All participants were interviewed to give their feelings and views on being members of this research study. The reason of this data gathering was to give my participants an opportunity to provide me with any other important information that might have not been otherwise explored.

The three categories of participants (learners, the teacher, and the expert) were asked similar questions. I transcribed and then translated their responses especially that with the expert which was done in her vernacular, *Oshiwambo.*

5.3.1 Data from learners and the teacher

Question 1: *Do you think community members should or not be involved in the teaching of science?*

Teacher's responses:

- They should, because this will make it easier for the parents to assist their children at home regarding educational matters.
- Community members might have expertise in specific practices that can be helpful to teachers in explaining a specific concept.
- They also practice science unknowingly at home, this is also very important to them.

Learners' responses:

- **Learner 1**: They should, because they can feed us with more knowledge which will make it easier for us-learners to relate with what we have learnt in the classroom.
- **Learner 2**: Parents are also learning new things/skills as they are being involved in discussions with both teachers and learner.
- **Learner 3**: Parents will realise that what they do is important and much useful.
- **Learner 4**: This knowledge can be important to learners especially after school, one can get recruited in various brewing factories, and then this will serve as a foundation stage.
- **Learner 5**: Maybe one day somebody in future will have ideas of improving and bring up the standard of our culture like industrialising *Ombike*.
- **Learner 6**: Learning our own things is good; especially that it is from our parents or community members. It makes you to recall very well everything in the examination.

Question 2: *Should teachers always consider learners prior every day experiences when teaching sciences?*

Teacher's responses:

- Learners learn better when they base their studies on what they usually do or see at home in their everyday lives.
- This will allow learners to express what they know and the teacher will determine the level of learners' current knowledge as to ensure their starting point.

Learners' responses:

- **Learner 1**: Yes, to see if learners already possess or know anything in the topic to be introduced. Also for it to be easier for the teacher to avoid teaching a boring topic which learners already knows.
- **Learner 2**: To give learners an opportunity to think deeper about any topic or question posed, or to find out if learners have had new ideas additional to that of the teacher.

Question 3*: Are practical activities necessary in science?*

Teacher's responses:

- Practical activities are very important because it allows learners to concretely interact with the materials being learned, thus this brings reality and better understanding in the classroom.
- Let learners to keep it in their long term memory and use it in future e.g. in the examination.

Learners' responses:

- **Learner 1**: Sometime if a teacher explain a certain (difficult) topic or concept, for example fermentation which you do not understand without showing or let you do some experiment on it, you may not understand it and also sometimes you may not really believe it.
- **Learner 2**: So that we should see and feel what we are being taught or told.
- **Learner 3**: Sometimes they are not good, because they waste time and also some learners like to dominate others in groups.

Question 4: *As a learner, was it a waste of time or helpful action taken to explore how Ombike is made?*

- **Learner 1**: Helpful, because lately I undermined these kinds of things called culture as not important comparing the current way of life. Through this project I came to learn many science concepts even those I did not understood before now they are clear.

- **Learner 2**: This was never a waste of time. What I have learnt was important and I can even teach my parents or other people about the danger of methanol. You know, we children like sugary or sweet things of which we like to add sugar every time either in our drinks or food. Now I know why parents are always preventing us from doing so.
- **Learner 3**: Through this project I can now see my future direction (career- interests) as to why science is so important and is everywhere.
- **Learner 4**: To me this was very helpful. I never saw or have had any experience in how *Ombike* is made, only hearsays. Now I feel a dream comes true and saved by this project to get the chance of seeing it done physically.

Question 5: *What are your feelings to be a member of this study/project?*

- **Learner 1**: Very proud because I have learnt a lot from this project especially more about the two concepts of; fermentation and distillation. I think as I proceed to the next grades this subject (physical sciences) will never be difficult to me.
- **Learner 2**: I feel happy to be a member of this study sir. We have learnt many good things about studying for example the use of concept maps.
- **Learner 3**: I feel very happy to be a member of *Ombike* project, because I now know what the real *Ombike* is and how to recognise it. I have also learnt about the negatives and positive effects that *Ombike* might have on people.

What emerged from these interviews?

Pulling together the ideas that emerged from the interviews with the teacher and the learners, I found out that both supported the idea of involving the community member in teaching science. Learners maintained that parents will also realise the value of their practices in the education of their children. Some learners said that it would be a co-learning platform as parents would also learn from these involvements. Some learners commented that they would in future show respect for their culture and they hope to develop or industrialise it as learner 5 above said. The teacher also realised that this would create a good relationship between teachers and parents which would help learners both at home and at school.

In consideration of learners' prior everyday knowledge, the teacher made it clear that it gave her a clear picture of the learner she is working with, so as to determine the starting point of teaching. Learners on the other hand felt that the elicitation of prior everyday knowledge was a good practice because it prevented lessons from being boring. They claimed that in most cases the teacher started by presenting a topic without realising that it was already known by them.

With regards to the use of practical activities in science classrooms, the teacher felt that this helped learners learn concretely rather than abstractly. Through the handling of the materials, teachers believe that this knowledge would remain in learners' long term memories. The learners had the same perception too. However, there were a few learners who felt uncomfortable with group work during practical activities highlighting that if the teacher distanced himself/herself from the group, some group members tended to dominate others reducing them to passive observers.

In association with the positive feelings of participants at being involved in this project, they all felt ecstatic and wished that it could continue in the years to come. They maintained that they had learnt many things that were important to their studies and also how to help and advise other people in the community regarding the practice of making *Ombike*. They felt happy especially those learners who had now witnessed the practice of making *Ombike* for the first time. As learner 4 expressed it; "*Now I feel my dream comes true and saved by this project to get the chance of seeing it done physically*".

5.3.2 Data from the semi-structured interview with an expert

Researcher*: Omauwanawa no mauwinayi geni oshidhungomwa shino shina moshitopolwa shika?* (Freely translated: What positive and negative impacts does this practice have in the community in general?)

Expert:

***Omauwanawa (*Positives)**

Aadhungi otaa lalakanene oku monamo iiyemo. Oha shilongithwa woo uuna ookuume nenge aashiinda taa i uvitha nawa, mokuya pamwe noku kundathana woo oohapu dhawo nenyanyu. Oshoholelwa, ngele opena omusamane gwontumba eku ningila sha oshi wa nawa ngaashi ekupululila ngaa nando epya lyo ye ohompe nduno Ombike. (Freely translated: "A brewer aims to get income. Also if she wants to entertain with friends or neighbours they drink this. As a pride to any old men who did any good thing to her, for example, after ploughing her fields. To the consumers – it brings people together, where they can chat and discuss various issues as they enjoy drinking it").

***Omauwinayi (*Negatives)**

Oshiponga uukolwe unene tuu maanyasha. Shino otashi ulike nale kutya kayena we onaku yiwa ya yela. Oha shi etitha nee omaupyakadhi ga yooloka niiponga ngaashi; okulwa, oku piyaganeka noku hepeka aanegumbo. Kwaa mbono haanu onkukutu, otaa vulu oku kwatwa komikithi ngaashi; otiibii, nenge eshuli. (Freely translated: "Drunkenness, especially amongst the young ones is the main problem. This may result in various problems and accidents such as fighting, disturbing and abusing family members especially after over drinking. For those who drink it hard, dry and undiluted they stand a high risk of getting various diseases like TB and liver problems. Children also get a chance of becoming drunkards and this will mean no future leaders and more crimes as a consequence").

Researcher: *Pamaiuvo goye, aakwashigwana yomoshotopolwa oya pumbiwa ngiini moku kutha ombinga meilongo lyaanona yawo unene tuu mboka taya ilongo uudhindoli?* (Freely translated: Do you think community members should be involved in the education of their children? Especially science learners?")

Expert: *Shino osha pumbiwa noonkondo, oshoka omauyelele ogendji unene giinima ngaashi okuninga Ombike ogeli maakwashigwana, na otaga vulu okulongithwa meilongo lya nona. Omayele gandje ogo ngaka mpaka kutya aavali naa ninge haa ithanwa kosikola opo ya fatulule iinima mbika kaanona yo ya vule oku yelekanitha naashono taa longwa moclass* *dhawo.* (Freely translated: "Very much needed, because they are a source of knowledge especially when looking at cultural practices like this one of Ombike, our children also need to know how to make it. I even suggest that parents be often called to explain certain issues to learners in the class so that learners can compare laboratory activities to those done at home.")

***Researcher**: Opwakala ngaa ekwatathano pokati koskola nomukunda mpono aalongi hayeya ngaa nando oku pula sha kune?* (Freely translated: Has there been any connection between school and community where teachers come to the community to ask or do researches?)

Expert: *Oweete kutyaa pethimbo lyonale, aalongwantu oyakala noku dhina omuthigululwa kalo gwetu, onkee sigo opaife omukithi ngoka inagupwamo muyo. Ando nokuli oosikola otadhi kala nomi sholondondo dhii kwamuthigululwakalo mbyoka yili momu dhingoloko gwawo*. (Freely translated: You know since the old education system our African cultures have been undermined, and that disease still exists. Those educated people have long perceived us that we are not knowledgeable and see no value to anything of us. My view is that at least a local school should have at least one local cultural practices expert who can be visited or questioned on any interesting topic as you have done.)

***Researcher**: Owuuvite ngiini shoo tatu ilongo oshidhungomwa shoye mosikola?* (Freely translated: How do you feel that we are studying your cultural practice in school?)

Expert: *Esimano enene shaashi ondi lwete nani kutya omithigululwakalo gwetu oguna woo ongushu, na oshyela kutya natse woo otatu vulu oku kutha ombinga meilongo lyaanona yetu. Onduuvite woo nawa shoo oshigwana sho ngashiingeyi shoo tashi dhidhilike uuthike pamwe mongushu yomithigululwa dhetu aaluudhe noshowo aaeuropa*. (Freely translated: It is an honour, because I can now realise the value that our culture has. This means that we can also stand in position to contribute to the education of our children. I am also happy that people are now realising the strength and value of both European understanding as equal to that of ours.)

***Researcher**: Owuuvite ngiini oku kala omudhani nkandangal nomugandjimayele mo projecta ndjika?* (Freely translated: Being one of the key participants of this project, what are your feelings?)

Expert: *Etumba enene kungaye oku kala woo oshilyo. Ondi i longamo oshindji naashika otashi pendje omukumo opo ndi tsikile noku dhunga Ombike yandje. Ondiwete kutya nani nomukalo nguka otandi humitha woo omuthigululwa kalo gwetu komeho nokuuvithako woo aanona yetu kesimano lyomuthigululwakalo gwetu*. (Freely translated: I feel proud to be a member. I have also learnt a lot, with the little experience that I have, this is even encouraging me to continue with my practice as I hope more teachers will again come for my experience in future. I see myself as an asset here in promoting our culture as this can be a way to also convince our children on the values of cultural practices.)

Researcher*: Okuuka pehulilo mpaka, oshike ishewe wapumbwa okulombwelandje?* (Freely translated: Toward the end, is there any other thing or comment you would like to offer?)

Expert: *Otandi pandula molokampito haka. Omayele gandje oongaka kutya natuyambulenipo omuthigululwa gwetweni woo unene tuu oku pitila muunona wetu. Napamwe komongula onatu kaadha ngaa tuna ofabulika yombike tayi wilikwa ku gumwe gwomuunona wetu. Onkee oshinima shika osha pumbiwa woo oku longwa meesikola.* (Freely translated: I would just like to thank for this opportunity and my suggestion is that we need to develop our local products, cultures amongst our children. Maybe one day we will see an industrialized factory for brewing Ombike being managed by one of our children. Local culture should really be promoted and be part of the school curriculum.)

What emerged from this interview?

The interview with the expert also produced much information. With regard to the question on the positive and negative impacts the practice might have, I later felt that the question was sensitive. However, I was very happy with my expert who expressed her ideas freely and without any hesitation. She maintained that this practice is one of their sources of income. It also produced the drink that brings people together as part of socialising. But she pointed out very clearly the negative impact especially that of drunkenness among the youths who are also taking it secretly.

Concerning the link between the school and the community, the expert expressed that she has never seen teachers coming to community members asking anything such as this. She even suggested that local schools should know and have a list of various cultural practices in their communities so that everyone should be fully involved in the education of their children.

Lastly, the expert expressed her happiness at being part of this project and hoped that more teachers would continue visiting her for observations and discussions. Through this platform, she made it clear that she has also learned a lot from the discussions she made with the group.

5.4 Concluding remarks

This chapter presented the data obtained through observation of the practical activities lessons and the worksheets used. The knowledge gained from these practical activities made it easier for the learners to correctly complete the worksheets which contained some science – stimulating questions.

Through the interviews, I came to realise that elicitation of prior everyday knowledge, the use of practical activities and the involvement of community members are valuable to science education and deserve serious consideration in future.

In the next chapter I discuss and interpret the analysed data in relation to the literature reviewed in Chapter 2.

CHAPTER SIX

DATA ANALYSIS, INTERPRETATION AND DISCUSSIONS

6.1 Introduction

This chapter deals with the analysis, interpretation and discussion of the data that was gathered and presented in Chapters 4 and 5.

For analysis purposes, I developed analytical themes in relation to the data sources as well as the research questions described in Chapter 3. In my discussions I also link the findings to the literature reviewed in Chapter 2.

The themes that emerged from my analysed data are summarised in the table below.

Table 6.1: Analytical themes

Data sources	Themes	Research questions
Brainstorming, discussions, semi-structured interviews and observation.	* Cultural experience of making *Ombike* * Prior everyday knowledge and experiences. * Making use of the community knowledge and practises	• What are learners' prior knowledge and experiences of the indigenous practice associated with the making of *Ombike*?
Discussion, focus group interviews, lesson presentation, Journals/notes, Worksheets.	* Active learner engagement * Scientific meaning making using *Ombike* practice	• How can the making of *Ombike* support meaning-making of the fermentation and distillation processes?

Observation, Practical activity worksheets, Videotaped lessons	* Scientific meaning making using practical activities	• How might one integrate the learners' prior and newly acquired knowledge from their experiences of making *Ombike* into practical activities?

The themes that emerged from the analysed data were further developed by looking at the research questions to be answered.

The following section discusses the themes that emerged from the analysed data.

6.2 Theme 1: Cultural experience of making *Ombike*

6.2.1 Learners' prior everyday knowledge and experiences

Through the analysis of the data that I gathered from my participants, I could draw an inference that there are two kinds of *Ombike*. These depend on how the *Ombike* is made. They are; **genuine** *Ombike* and **non-genuine** *Ombike* (locally known as *Omangelengele*). A genuine *Ombike* is made from indigenous fruits without any additives, while a non-genuine *Ombike* is altered by certain additives. Any additive to *Ombike* is actually going to alter the entire process and might make it unfit for human consumption (see Section 4.2.1).

Genuine Ombike

Ingredients needed:

The data gathered from the demonstration by the expert revealed that *Ombike* is made from indigenous fruits through two main stages which in sciences are referred to as; fermentation and distillation respectively (see Section 4.4). Initially, *Ombike* was only made from palm fruits (*eendunga*) but recently the *Ovawambo* women tried to use various local fruits. Thus, the common fruits used by *Ombike* makers in the northern part of Namibia include jackal berries (*eenyandi*), buffalo thorn fruits (*eentantahe*), bird plumes (*eembe*), cluster figs (*eenkwiyu*), makalani/palm fruits (*eendunga*) and grapes (*omandjembele*). It is most interesting that, all the fruits used to make this beverage are those that contain a certain degree of sweetness or natural sugar.

Processes involved:

Drank by the rural poor and popular in the rural areas, *Ombike* is believed to be a low-skilled but labour intensive product whose alcohol content is determined by the type of fruits used (see Section 4.4).

The data presented in Sections 4.2 and 4.4 in this thesis has shown that the process starts with the collection of fruits in large quantities, drying them, crushing them and mashing them before fermentation.

It emerged from the data that the **fermenting** process takes about five to seven days depending on the weather and also the instruments used (new or old). It takes longer in winter compared to summer. After three to four days the brewer will stir to mix well the soaked pieces of fruit. When there is no scum or lather or bubble, then that means it is ready for cooking. After fermentation, the process of distillation starts.

Distillation follows a unique traditional process, which includes fire and using mud to attach a wooden trough (*okatemba*) with a copper metal tube through it on to the pot before adding the fermented and mashed fruits to the pot. The reason for using a copper tube was apparently because it does not rust or corrode easily; otherwise the distillate would emerge coloured by rust (see the reason by the expert in Section 4.4.2).

Once the well-sealed pot starts boiling, the steam escapes from the pot through the metal tube to the bottle placed outside to receive the liquor. The metal tube passes through the wooden trough which is filled with cold water immersing the tube. The cold water cools the hot vapour in the tube into a gin like alcohol which is *Ombike.*

According to the expert, the purpose of the cold water in the trough is to cool the pipe/tube to prevent the steam of *Ombike* from remaining in a gaseous form due to the intense heat as she said, *"Ouna oku kotokela uupyu womeya mokatembe opo oshikumwa shoye inashi pepwamo* *dho nee nkondo dhoye dhi hepe*" (Freely translated: You have to constantly monitor the temperature of the water in the trough otherwise your liquor will just dry up and your effort will go to waste") she said. This is done by frequently removing the water as it gets warmer with a cup and quickly replacing it with cold water.

Another thing I realised from this study is that *Ombike* can easily be made in batches (see Section 4.4.2), despite lack of appropriate instruments possessed by local experts. They are able to make a strong *Ombike*, a moderate *Ombike* and a diluted *Ombike* (locally known as *omatshatsha*). The strong one is the first distillate and the diluted ones are condensed later. Pointing to the same understanding, Earl and Wilford, (1998) explain how the distillation of alcohol depends on the different boiling points of the liquids being heated (see distillation in Section 2.5.1).

Taking the example of boiling a mixture of ethanol (boiling point) and water (boiling point), ethanol will be seen to boil off first then water. This in essence means that the constituent with the lowest boiling point comes off before the one with highest boiling point. So, the last distillate, *omatshatsha*, is diluted because it was collected when the proportion of ethanol was depleted so now the distillate moves toward that of water.

From the interview with the expert (Section 5.3.2) I found out that long ago *omatshatsha* was given to young boys either to mix with their porridge which they had to eat or it was given to them to even drink it. There was no fear of any effect because it is not the real *Ombike* but what they liked most was the smell or flavour. However, in the end it was discovered that these children later became addicted to drinking when they were old. In addition, the first *Ombike* was the most liked especially by old men. The moderate one was the one for people like women and other men who do not like the 'hot' and strong *Ombike*.

The brainstorming sessions revealed that this traditional practice is the main source of income for most brewing experts, it maintains their livelihood and enables them to support their families financially.

Moreover, this alcoholic beverage is not only made for income generation, during the semi-structured interview, the expert explained with the example of wives who sometimes do it for their husbands, or as a means of thanking someone for a favour. Sometimes, a husband can drink it by only taking a shot or two of *Ombike* a day if he is alone. However, if he has a visitor or friends they can enjoy drinking and end up getting drunk.

Based on the data from the semi-structured interview with the expert (see Section 5.3.2), many people have different ideas on drinking *Ombike* including the following:

- They want to be sober;
- As a drink for the house owner who only takes a shot a day;
- Some say it eliminates malaria from the body;
- Some believe that during cold weather, it makes them feel hot; and
- Some believe it is a medicine for intestinal problem of elders.

Although women also drink *Ombike*, this traditional beverage is very popular among *Ovawambo* men. In contrast, some youths secretly drink it though they are totally prohibited from doing so.

Non-genuine *Ombike* (*Omangelengele*):

The liquor produced by women at the villages is more trusted than the ones in towns, since some brewers in towns where the indigenous fruits are scarce use additives (as explained by the critical friend in Section 4.2.1) in the production of the liquor. Shaanika (2012) found that they do this with the intention of producing more alcohol over a short period of time to make money quicker. It also emerged from the brainstorming session with the learners where the critical friend highlighted that the *Ombike* made in this way is referred to as '*Omangelengele*' (moonshine) (see Section 4.2.1). The additives in *Omangelengele* are considered harmful and can be poisonous. Instead of the clay pot used by the villagers, the town brewers use metal drums and their ingredients include; old shoes, old clothes, car tyres and sugar. A little bit of indigenous fruits is then added to the mix for flavour. Under normal circumstances, *Ombike* drinkers are able to tell the type of fruits used by the brewer. Thus, *Omangelengele* brewers are clever enough to add a bit of fruit to confuse the *Ombike* lovers.

In this study, I could not go so far as to find the scientific tests used to determine the level of alcohol percentages in both *Ombike* and *Omangelengele*. However, as of the ingredients such as additives raised above, I conclude that *Omangelengele* is more potent (excessively powerful and dangerous) than a genuine *Ombike* and thus a nation especially town brewers, needs to be made aware on potential effects this may cause.

With regards to the addition of sugar to the fermenting solution, some people use a strategy to identify whether this *Ombike* was made through the addition of sugar or not (Section 4.2.1). They do this by shaking it in a container. If it forms many bubbles, then it means sugar was added and it is not fit for human consumption.

Moreover, Shaanika (2012) reports that "in countries like Kenya, the government has banned the production of moonshine as it is considered very strong and contains high level of alcohol that could cause poisoning. The type of alcohol found in these types of traditional liquor is more suitable for industrial purposes rather than human consumption". It is believed that such liquors could easily cause blindness and loss of memory, amongst others especially to old people. This could be related to the effects of 'methanol' discussed in Section 2.5.1.

6.2.2 Making use of the community knowledge and practices

Throughout the analysis of the data for this study it emerged that generally there is a vast amount of important community cultural knowledge and practices that goes unrecognised though it could be most useful in science learning such as the making of *Ombike*. Ignoring this could probably be one of the attributing factors of the recent rapid decline and loss of the local cultural values and its heritages (O'Donoghue, Lotz-Sisitka, Asafo-Adjei, Kota & Hanisi, 2007). The data from the semi-structured interviews conducted with the expert revealed that community members are always willing to assist and contribute towards the education of their children. When asked whether local school teachers have been coming to do researches with them, she said that it has never happened.

Analysing the discussion with the expert (see Section 5.3.2), it came out clearly that the link between the community and the school sciences has never existed practically. This is the reason why the expert maintained that "*Oweete kutya pethimbo lyonale aalongwantu oyakala noku dhina omuthigululwakalo gwetu, onkee sigo onena omukithi ngoka inagupwamo muyo.* (Freely translated: You know, since the old education system, our cultures have been undermined, and that disease still exists. Those educated people have long perceived us that we are not knowledgeable and see no value to anything of us).

Stears, Malcolm and Kowlas (2003) found that different communities have different views regarding science and the nature of its interaction with society. They maintained that the social context of science especially the local one, is largely ignored in mainstream teaching. It is evident from the practical demonstration by the expert and also through the later discussions with the learners that there are a lot of scientific implications in the *Ombike* practice despite the lack of its recognition and documentation. Linkson (1999) is of the view that teachers and the curriculum developers need to work collaboratively to write materials that are culturally appropriate and inclusive. Stears and Malcolm (2005) too propose that teachers and learners should be involved with the development of learning and teaching support materials (LTSMs) that are relevant. These views are supported by my study.

6.2.3 Active learner engagement

During the teacher-directed phase (class discussion) of the lesson, most learners engaged freely with the teacher especially when discussing school science content. I found that the learners were more freely engaged when the teacher allowed or brought in issues from their cultural backgrounds and home environment as part of their prior everyday experiences (see Section 4.2.1).

In their study about the use of everyday knowledge in science classroom, Stears, et al. (2003) similarly found that teachers and learners generally have little difficulty in making transition between their everyday knowledge and the structured science knowledge of the classroom. It may be well be that learners are often not aware of the extent to which they do this.

Learner engagement was observed during the phase of practical activities because it made them socially free to learn through handling and interacting with the materials. Learner engagement was also observed during the practical demonstration by the expert where they got curious and started asking more questions freely (see the learners-expert conversation in Section 4.4). This could be attributed to the fact that their conversation with the expert was in their vernacular, *Oshiwambo*. Thus, Kvale (1996) advised that sometimes learning in association with critical thinking tends to be effective when done in the immediate language and more importantly with the inclusion of the prior everyday experiences (Oloruntegbe & Ikpe, 2011).

This in essence concurs with the description by Jegede (1995) who explained that depending on the content, experience and the social context, learners sometimes engage in ‘border crossing’ that retains both the cultural and science knowledge, thus engaging in the processes of collateral learning.

The data further revealed that through the social situation of group work, learners were able to develop concepts associated with the fermentation and distillation processes thus making links which I could relate to meaning making.

6.3 Theme 2: Scientific meaning making

6.3.1 Analysis of mind-maps developed by learners

As shown in stage two of Chapter 4, a conceptual development strategy was used to enhance meaning-making of the two main concepts under study, namely; **fermentation** and **distillation**. The mind maps drawn by learners (see Figures 4.3.3a-d) are in line with the concept maps proposed by Maselwa and Ngcoza (2003) and served as the shortest and quickest method of note taking or summarising concepts associated with fermentation and distillation. Spotting key concepts made it clear for the learners to link and explain the relations between concepts. With these graphics, one would already tell how easy it could be to understand a broader concept.

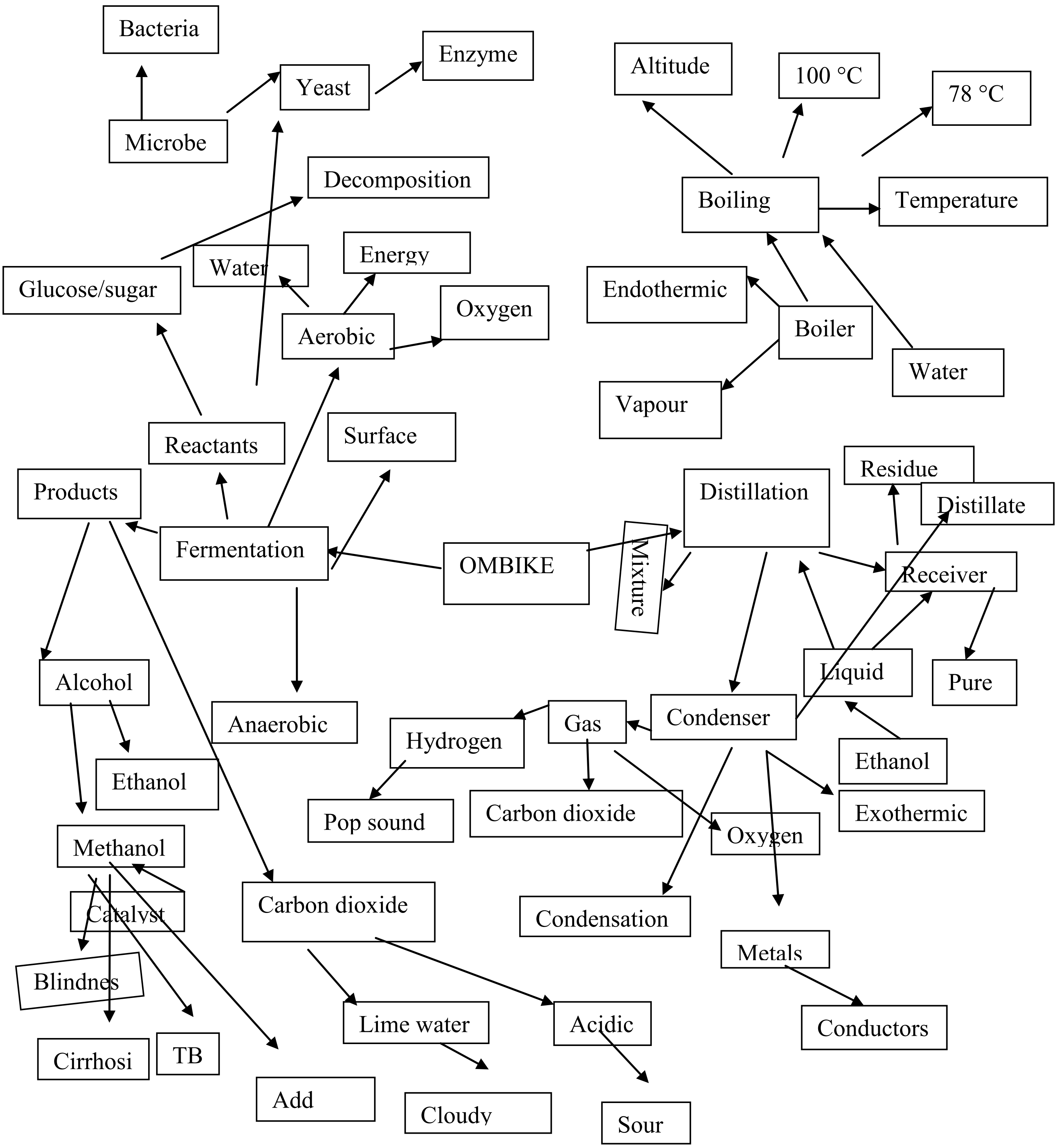


Figure 6.3.1 Mind map 5. Analysed mind map

6.3.2 Conceptual understandings that emerged from the study

Choosing the cultural practice of making *Ombike* was indeed an effective approach to enhance conceptual development and meaning making of the fermentation and distillation processes with my grade nine learners.

Stage four of Chapter 4 presents the questions that were designed to probe and solicit the scientific understanding from the learners (see Section 4.5). The questions were set in such a way to contextualise science teaching (Oloruntegbe & Ikpe, 2011; Rennie, 2011) especially in rural schools where there is a lack of teaching and learning resources. According to Stears, Malcolm and Kowlas (2003), culture as a contextual lens through which learners view and understand the world, has direct influence on learners' cognitive processes and understanding of science. The responses given by the learners on these questions were mostly scientific. Most learners were able to explain using the scientific concepts developed earlier (see Section 4.5.1). Thus, in the next part I analysed and discussed the scientific concepts under study by extracting key factors involved in fermentation and distillation.

Discussions about fermentation:

- ***Oxygen and fermentation***

According to the explanations given by the *Ombike* expert, the container where the fruits are put to ferment should not be frequently opened. The reason given was that the entrance of air into the mixture would spoil the entire process (see Section 4.4.1). I believe this reason requires more scientific discussion.

The scientific explanation for this caution could be that the fermentation of fruits needed for making alcoholic beverages like *Ombike*, does not tolerate the presence of much oxygen (anaerobic respiration preference). Geoffrey (2003) made it clear that during the fermentation process, oxygen will cause some species of yeast to completely oxidise to carbon dioxide and water instead of carbon dioxide and ethanol. Symbolically, this is expressed below:

- Fermentation of glucose (anaerobic):

$$C_6H_{12}O_6(s) \xrightarrow{\text{(yeast)}} 2C_2H_5OH(l) + 2CO_2(g)$$

- Oxidation of glucose (aerobic):

$$C_6H_{12}O_6(s) + 6O_2(g) \xrightarrow{\text{(yeast)}} 6CO_2(g) + 6H_2O(l)$$

Supporting the arguments, Ackland (2012) explains that during the fermentation process, the presence or absence of oxygen has got some effects on the yeast. He explains that if there is oxygen available, yeast will be able to reproduce rapidly. If there is only limited oxygen available, it will produce ethanol and other products.

In simple terms, this means that oxygen causes the yeast or bacteria to convert sugar or glucose into carbon dioxide, water, and energy because this is purely aerobic respiration. Thus, the control of dissolved oxygen in the fermenting mixture is of crucial importance.

Ackland (2012) maintains that there is one stage when oxygen exposure on the macro-level is actually quite beneficial to any wine development, and that is during the fermentation itself. He says when correctly applied, oxygen reacts with both the yeast and the wine in such a way that yeast is improved and strengthened and hence fermentation encounters less problems and the resultant wine quality is often improved with fresher aromas and tastes than before.

- ***Sugar in fermentation***

The data from the interview with the expert revealed that the addition of sugar to the fermenting fruits is not supported when making *Ombike*. The elicitation of prior everyday knowledge session with the learner and the critical friend (Section 4.2.1) also identified the negative effects associated with adding sugar to the fermenting solution.

Keeping in mind the process of fermentation where sugar is scientifically understood to be the key concept, one wonders why do we say that ‘fermentation’ is involved in *Ombike* production, where sugar is not added? After some thought, I came to conclude that ‘yes’ the process is still fermentation because the sugar to be fermented is the natural sugar present in the fruits since the data showed that only naturally sweet tasting fruits are used. The natural sugar in the fruits will be decomposed by the natural yeast or bacteria already present on the skin of these fruits.

Geoffrey (2003) points out that there are fermentable sugars and non-fermentable sugars. He cautions that non-fermentable sugars in the solution will remain after fermentation and will result in a sweeter end product. In cases where the amount of sugar in the solution is found to be too high, this can actually prevent further fermentation. According to Ackland (2012), some wine recipes suggest adding the sugar in stages throughout fermentation rather than all at the beginning. This is especially true if the brew is aimed at producing a high level of alcohol.

- ***Temperature for fermentation***

Many home brewers, including *Ombike* makers know the best seasons to brew it. In most cases, temperature plays a crucial role for fermentation to take place. I recall very well one of the questions asked by the learners to the expert "*ehemele lyiipambu otali tulwa peni? Omomuzile nenge omomutenya?"* (Freely translated: where should the container with the fermenting mixture is placed? Is it in the shade or on the sunny exposure?). The expert's response was that "*momuzile gwomuti omo muli nawa oshoka omuna ombepo tayi pepe nawa yo oyo nee tayi keelele uupyu wapitilila nenge uutalala wa pitilila kehemele*" (Freely translated: the tree shade is a moderate place for this, because there is a blowing air which prevents excessive heat or cold weather which is not needed by this process).

As far as the analysis of the findings are concerned, I infer that the fermentation process does have certain temperature limits where it can work efficiently. In his study on fermentation, Geoffrey (2003) discovered that the appropriate temperature limit for fermentation is between 15°C and 27°C. The temperature that is greater than 27°C kills the yeast cells and less than 15°C results in the yeast activity being too slow. Hence, this could be one of the reasons why the container where the *Ombike* fermenting was neither put in a hot spot nor in the cooler place but rather in a shade of a tree.

Moreover, Slaa, Gnode and Else (2009) did an experiment on the fermentation process by measuring the release of carbon dioxide at temperatures of 20°C, 25°C, 30°C, 35°C, and

40°C respectively. They concluded that an optimum temperature for the fermentation process was 35°C.

Fermentation conditions

With regards to the findings on fermentation process raised above, it could be deduced that the fermentation of sugar to alcohol is promoted by the following conditions:-

- The sugar being in the solution (fruits);
- The presence of yeast (which contains enzymes);
- A temperature of approximately 35°C; and
- The exclusion of air (which provides low oxygen concentration).

Once the concentration of ethanol reaches 14% to 15% by volume, the yeast can no longer survive, and the fermentation process stops (Ackland, 2012).

Discussion about distillation:

- ***What happens in the boiler?***

Britz and Mutasa (2008) defined distillation as a method of separating mixtures which in this case was used to separate liquids; *Ombike* and water from a solution of fermented fruits. It mostly involves boiling the solution and leading the vapour into a condenser where it forms a liquid.

During the practical observation of making *Ombike*, it was observed that the mixture of the fermented fruits was put in the pot at a level slightly more than a half (three-quarter level) of the pot. The pot should not be filled because as boiling occurs, some unwanted liquids or other substances may flow through the metal tube and may eventually block the pipe, or spill out into the receiver (see Section 4.4.2).

As the boiling occurs, the mixture/solution on top of the pot evaporates into gas form. Since the pot is completely sealed, there is no any other exit for the vapour except through the metal tube. This tube then takes the hot vapour through the condenser where it is condensed by the cold water in the trough.

- ***Monitoring the temperature of water in the trough***

The water in the trough needs to be replaced with cold water every time it gets warm. The reason for this is simply to condense the vapour in the metal tube into liquid form. Another thing one might want to know is why the water becomes warmer. The responses to this question given by G1 and G2 in the teacher directed session (see Section 4.5) was sufficient answer. They all responded correctly as it is caused by the heat from both the pot and the hot vapour in the metal tube. The metal tube is attached to the pot, so it conducts the heat through it until it reaches the water. This water also heats due to the hot vapour passing through it simply because metals are good conductors of heat.

Once the vapour reaches the water, it condenses and liquid *Ombike* collects into the receiver.

6.4 Theme 3: Scientific meaning making using practical activities

One of the goals of this research study was to integrate the learners' every day experiences into practical activities. Hence, two experiments (see Section 5.2) were conducted with the focus mainly on enhancing conceptual understanding of the fermentation and distillation processes. The cultural practice of making *Ombike* thus served as a learning context in these practical activities.

Gott and Duggan (1996) view the purposes of practical activities as a means to; motivate by stimulating interest and enjoyment, enhance the learning of scientific knowledge, acquisition of laboratory skills and gained insights into scientific skills.

The teacher I interviewed revealed that practical activities through observation of practical demonstration and hands-on activities make learners learn concretely rather than abstractly. Through the handling of materials, it is believed that the knowledge they get would remain in their long term memories (see Section 5.3.1). The findings resonate with what Gott and Duggan (1996); Maselwa and Ngcoza (2003); and Millar (2004) found in their studies. Maselwa and Ngcoza (2003) also caution that science teachers should be careful not to equate activity with learning.

Therefore, the findings of this study indicate that an activity can have greater potential for meaningful learning if it is carefully designed to focus on the key scientific concepts to be developed and how these concepts are linked. This is congruent to Maselwa and Ngcoza's (2003) findings.

Eliciting learners' prior everyday knowledge and experiences in conjunction with practical activities as done in this study facilitated learners' understanding and they were able to generate their own summaries in a form they could easily understand.

6.4.1 Analysis of experiment 1 on fermentation of sugar by yeast

As was presented earlier in Chapter 5, this activity was done to explore how fermentation occurs, this time using local fruits that were used in making *Ombike*.

Fermentation happens where there are micro-organisms such as yeast and bacteria that decompose the sugar into alcohol and carbon dioxide. This is evident by the results of experiment 1 done in this study. Furthermore, the sugar present in the fruits was slowly decomposed by the natural yeast already present on the skin of the fruits. This was the reason why the plastic over Flask A was observed to have been slightly inflated. However, it was hoped that if it had been left for two or more days, more carbon dioxide [CO_2] gas could have been produced as fermentation was not assisted by a catalyst. However, Earl and Wilford (1998) caution that if there is more ethanol produced in the solution the yeast cells are killed and that eventually stops the fermentation process.

6.4.2 Analysis of experiment 2 about the boiling temperatures of Ombike and water

One of the scientific methods used in this study was to determine the boiling points of the two liquids under study, namely, *Ombike* and water. As we have already learned that the boiling points of ethanol is 78°C and that of water is 100°C, the idea behind this experiment was to demonstrate that *Ombike* boiled at a lower temperature than water.

Using two same sized test tubes labelled test tube A and test tube B, Ombike was placed in one test and water in the other test tube. Because we wanted to determine their boiling temperatures, a thermometer was placed into each test tube stopper. Temperature was recorded at time intervals of 30 seconds.

As reported earlier, the approximate boiling point of *Ombike* was found to be 82°C and that of the tap water which served as a control of this experiment was 94°C. Consider the table below:

Table 6.4.2a: Boiling point of liquids

Liquids	Boiling points (°C)
Ethanol	78
Ombike	82
Water (pure)	100
Water (tap)	94

Together with the learners, this table was used to compare the boiling points of the liquids under investigation; *Ombike* and tap water, with the already known liquids such as ethanol and water (pure).

The point of discussion came when there were differences from the expected readings of 78°C and 100°C respectively. With these I speculate that certain conditions such as weather and altitude need to be considered as they might also affect the results.

With regards to ethanol and *Ombike*, despite that they are all alcohols perhaps further investigation regarding their chemical properties was required. Alcohols differ, as Earl and Wilford, (1998) presented the boiling points of three alcohols shown in Table 9 below. In fact, the observed boiling point of *Ombike* is more difficult to explain. *Ombike* is assumed to belong somewhere between ethanol and propanol alcohols. Moreover, it might also be scientifically understood as primarily a mixture of ethanol and water with fruit flavours in small amounts. A mixture of water and ethanol will distil as an azeotrope at 78.1°C at sea level, but slightly lower at higher altitudes. Impurities (flavour components) in solution will thus cause a boiling point elevation (colligative properties). Peter and Julio (2001) explain colligative properties of a solution as those depending on the number of dissolved particles in a solution, but not on the identities of the solutes.

Table 6.4.2b: Boiling point of alcohols

Alcohol	Formula	Boiling point (°C)
Methanol	CH_3OH	64
Ethanol	C_2H_5OH	78
Propanol	C_3H_7OH	97

The tap water used recorded a temperature of 94°C compared to 100°C expected for pure water. Pure water naturally contains no other substances. However, the tap water used was not a pure substance. Many chemicals were probably added in its treatment, so this might also have affected the results.

Similarly, with *Ombike* and ethanol, the altitude where the experiment was carried out was not at sea-level. Ackland (2012) clarifies that the boiling point of a liquid is lower at a high elevation because the atmospheric pressure decreases as the altitude increases. Supporting this argument, I downloaded the graph shown below from the engineering tool box website to strengthen my arguments.

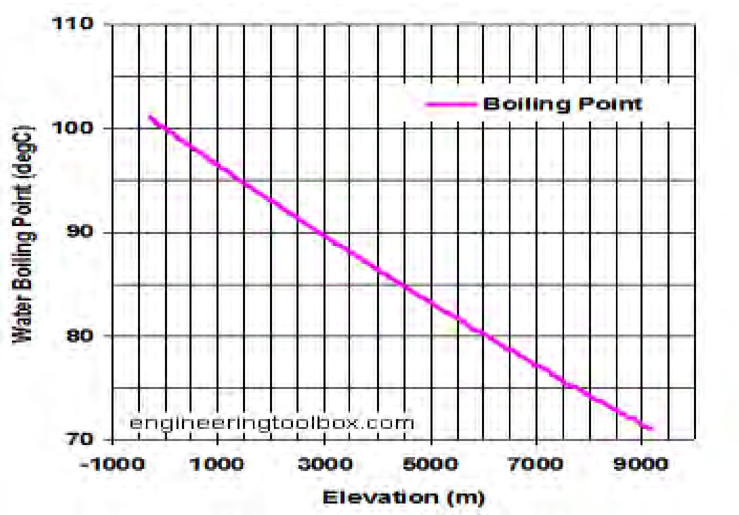


Figure 6.4.2: Water boiling point against elevation (altitude) [Downloaded on December 28, 2012 from: www.engineeringtoolbox.com/boiling-points-water-altitude-d_1344.html

As can be seen on the graph above, at zero metres (at sea level), the boiling point is in the range of approximately 100°C. At 3000m the estimated boiling point of water will be at exactly 90°C. As you go higher above the sea-level up to 9000m above the sea level, water is expected to boil at around 71°C or 72°C.

Moreover, Outapi as one of the closest town where this study was carried out and it is estimated that it is 1113.8m above sea level. With this elevation or altitude, the expected boiling point for water is 96°C according to Fig 6.4.2. Hence, this might need to be considered when doing any boiling experiment in this area.

In general, the above graph is presenting the relationship between the boiling point and the altitude that they are inversely proportional to each other. This means, as you go higher above the sea level, the boiling point of the liquid decreases and vice-verse.

6.4.3 Fair test

It is important for any science experiment to be a fair test. A fair test occurs when you change only one factor/variable and keep all the other conditions the same. Thus, I needed to ensure that a fair test was presented and considered in all the experiments 1 & 2 done in this study (see Table 6).

In experiment 1, where three flasks were investigated, in flask A and B for instance, similar conditions included; same sized flasks, same type and levels of quantities, same condition and place and so on enhanced fair test experiment. The difference was only seen on the variable of yeast which was added to one flask but not to others. This served as a control of the experiment.

In experiment two, which was about determining the boiling points of liquids, all the conditions were similar, except that the liquids differed. Thus, because the emphasis was mainly to focus on *Ombike*, so water served as a control to the experiment.

6.5 Concluding remarks

This chapter has provided an interpretation and discussion of the data as presented in Chapters 4 and 5 using literature reviewed in Chapter 2. Insights were captured and reported according to a set of themes that were discussed in detail. Through comparing my findings to those of other researchers, I found commonalities to do with the acquisition of new scientific concepts and border crossing between cultural and scientific ways of knowing. However, the approach of concept development used in this study is not only vital to the fermentation and distillation processes as such, but it could be used more broadly in other topics in science as well.

The next chapter discusses a summary of the findings, makes some recommendations and suggest some areas for future research and provides my personal reflections and conclusion.

CHAPTER SEVEN

SUMMARY OF FINDINGS, RECOMMENDATIONS AND CONCLUSION

7.1 Introduction

In the previous chapter I analysed, interpreted and discussed the findings of the data presented in Chapters 4 and 5. In this chapter I present the summary of the research findings, recommendations and areas for future research. I also discuss my personal experiences throughout this study.

7.2 Summary of findings

This study revealed that the brainstorming session where learners were given an opportunity to discuss their everyday experiences about making *Ombike,* was highly productive. Their experiences created a clear direction for the teacher to set and determine the starting point for the teaching and learning process (Roschelle, 1995).

As pointed out in Section 2.3, prior everyday knowledge fosters a theoretical shift to viewing learning as a conceptual change (Ryder, 2001). Ignoring prior everyday knowledge of making *Ombike* for instance, would not make it easier for a rural learner to understand the scientific concepts of fermentation and distillation learned in the classroom. Thus, the exploration of local and cultural practice of making *Ombike* formed a foundation for learning new scientific concepts (Namibia, MEC, 1993). This agrees with the explanation given in Section 2.2.

The study further revealed that exploring the cultural practice of making *Ombike* can enhance meaning making in science learning. The two scientific concepts: **fermentation** and **distillation** were both presented and demonstrated to learners through exploring the cultural practice of making *Ombike*.

Through analysing the data gathered in this study, I came to realise that *Ombike* is one of the best cultural practices to contextualise science learning. It can be used when teaching fermentation as a food preserving process and also as a process of making alcohol. *Ombike* can also be used when teaching methods of separating mixtures, in particular, distillation. This cultural practice can thus be useful in areas where it is being practised and especially where there is a lack of learning and teaching support materials (LTSMs) (Czerniewicz, Murray & Probyn, 2000).

In addition to the goal of this study, it was also found that it created an opportunity for participants including parents to develop critical minds by analysing possible effects that their practices might have and how they can remedy these effects. Moreover, it was a very rare opportunity for the participants to come together and clear misconceptions that might exist in the community.

I have also discovered that the community needs to be highly aware and informed on various practices that might have hazardous effects on their livelihood. This awareness can be raised through studies such as mine. Looking at one example, some brewers (in town) are said to add harmful substances such as sugar, dirty materials *etcetera* with the intention of speeding up the process because all they think of is making money. However, severe health problems created by the production of methanol arise in this way and may lead to many alcohol related conditions such as blindness, chest pain and liver complications.

With regards to the mind maps drawn by the learners, I found these to be useful in showing the links between the concepts developed and they also showed that learners have different ways of learning. Woolnough, McLaughlin and Jackson (1999) suggest that a variety of teaching and learning strategies are essential. The study also found that having learners working collaboratively in small groups gave them an opportunity to share ideas and construct understanding of knowledge, supporting Johnson, Monk, Watson, Hodges, Sadeck, Scholtz, et al. (1999). In contrast, some learners pointed out that group work was not effective when some learners dominate, forcing others to be passive observers. Hence, it is very important for the teachers to be equipped with skills to ensure active participation of all learners in various groups (Maselwa & Ngcoza, 2003).

More data about the concepts of fermentation were solicited through the practice of making *Ombike*. It was found that there are factors and conditions that may affect the fermentation process, namely; temperature, presence of oxygen, addition of sugar, and the presence of yeast (see Section 6.3.2). These are crucial factors for consideration when one intends to do an experiment involving fermentation.

With regard to distillation, a crucial finding was that science has been practiced all along in our communities. Our local community members have been able to classify beverages with different alcohol percentages. They knew that the first distillate of the alcoholic distillation is stronger than the last one. This is related to our experiment of determining the boiling points of liquids (see Section 5.2.2).

Through the experiments done in the study, it was found that the approximate boiling point of *Ombike* was about 82°C. This was investigated together with tap water which served as a control of the experiment. Earl and Wilford (1998) determined the boiling points of common liquids; ethanol, propanol and water at room temperature (sea-level) to be 78°C, 97°C and 100°C respectively. These values can change however depending on factors such as; altitude, atmospheric pressure and the ingredients added to the liquid.

While investigating the discrepancy between the known boiling point of water and that observed in our experiment, it was found that the boiling point of a liquid is known to be lower at a high elevation because the atmospheric pressure decreases as the altitude increases. This relation is shown in figure 6.4.2. Also, ingredients that might have been added to the liquid could have an effect of altering their boiling point especially that of the tap water as some treatment chemicals might have been added to it.

Regarding practical activities, the findings of this study indicated that these maximise learner participation and engagement too (Reiner & Gilbert, 2004). As was shown in the previous chapter, practical activities gave learners an opportunity to co-construct knowledge, manipulate equipment, acquire some scientific skills, facilitate understanding and reduce memorisation of important facts, supporting Zion and Slezak (2005).

It emerged, however, that learners learn in different ways. This was evidenced by the very different mind maps drawn by learners as presented in Chapters 4 and 5. Thus, if learners are given the chance to bring in their ideas about science and engage in 'hands-on', 'words-on' and 'minds-on' activities (Maselwa & Ngcoza 2003), they are indeed likely to learn in their own styles.

7.3 Recommendations

In this section I present the recommendations drawn from the insights gained from this study.

- In this study, I established that community members have been underestimated in terms of knowledge possession although they might be knowledgeable in certain topics and are also willing to contribute to the education of their children. In contrast, the curriculum does not encourage science teachers to continually make use of the community knowledge and practices in enhancing conceptual understanding of most science concepts. In essence, contextualising science knowledge in this way provides an opportunity to clear misconceptions that may exist in the community. Thus, it is highly recommended that the Namibian curriculum be designed to provide flexibility to teachers to be more open to consult and freely make use of the community's knowledge and expertise in their classrooms.
- I recommend that science teachers need to be more creative and innovative in improvising with local available materials and develop learning and teaching support materials (LTSMs) that are relevant to the learners' everyday lives as proposed by Czerniewicz, et al. (2000).
- The topic of fermentation is currently presented shallowly in the curriculum. I see this as constraining, restricting or limiting the chances of our children`s future careers despite the fact that the country needs more chemists. I therefore recommend the expansion of the topic on fermentation in the curriculum in order to enhance broader understanding of the concept by the learners and it should be taught across the secondary phases.

7.4 Areas for future research

From the findings and insights of this study, I suggest the following areas for future research:

- Further studies should be conducted about the cultural beverage under study, *Ombike,* by further determining its alcohol content;
- Further studies could be done on the same topic, but expanding it by including experts from both rural and urban areas;

- It will also be interesting for future study to chemically characterise the main components of *Ombike*;
- The brewing expert should be invited to come to school so that many other learners and other teachers too could get the opportunity to observe. This would enable the researcher to get more data even from non-participants;
- Analysis of data from semi-structured interviews with the learners revealed that many learners were in favour of practical activities. They felt it reduced memorisation of concepts and thus promoted conceptual understanding. In contrast, a few learners claimed that doing practical work in groups may not promote learning as some learners dominate others in groups forcing them to be passive observers. I therefore recommend that this aspect is worth researching in future.
- Namibia is striving towards being a developed nation through industrialisation (see Section 2.2). Studies such as this could contribute to this realisation. I therefore recommend that a similar study should be done, which will see this cultural practice of making *Ombike* being taken further, documented and developed into becoming an industrialised or commercialised alcoholic beverage.

7.5 Research limitations

There were also some limitations observed during the execution of this study. These are presented in Section 3.10. However, if I were to do this study again I would encourage my learners to make some predictions during the experimentation process as proposed by Maselwa and Ngcoza (2003) in their PEEOE approach (see Section 2.6).

7.6 Personal reflections

I joined Rhodes University in 2009 as a post graduate student where I was registered for a degree of Bachelor of Education with Honours BEd(Hons). At the beginning I was a bit worried if I would ever make it. I thought things would be tough for me as at that stage my computer skills were minimal. One of the limitations I was faced with was my working environment. I was working at a rural school where there was no electricity, and no cell phone network (you had to climb on a tree to make a phone call).

Because of strong confidence and all the encouragement I received from the people around me, I was able to make it.

It was through commitment and hard work that I managed to successfully complete this study. Despite the pressure from either direction, both my workload and study occupied the biggest sectors of the pie chart of my daily activities.

Fortune and success do not leave each other behind. After I completed my BEd(Hons) course, I applied for admission into the master's course where I was accepted to continue with my study for Masters in Education (MEd) in the same institution. This was for the duration of 2011-2012. Gratitude is given to my supervisor for his unending motivation that I would make it one day.

It was a dream coming true for me to reach this level in my twenties, although the road was still full of many challenges ahead. Motivation was still high so I had to work very hard until the end. It was not at all easy to come up with a research topic. I scratched my head and thought back home, that is, when I came up with the idea of *Ombike*. I realised that it was going to be one of my best options. Despite this, the struggle became tough as I found myself handing in the ninth proposal which was approved by the Education Higher Degrees Committee at Rhodes University. To me this was like winning a battle, but not a war.

Through the process, many things happened. I remember one time after I had collected my data, I almost lost hope. My study coincided with many work related activities such as conferences, workshops and the day-to-day activities. It took me almost three months before I could start working with my data. My supervisor became anxious about my progress, because it took me three months without communicating with him via e-mails. I recall the e-mails he used to send... "sir, your silence is making a lot of noise in my ears...". I thought I could not make it any more perhaps I was very far behind my classmates.

It was until one day when I dreamt as if I was listening to somebody talking to me, "....(*name*), wake up, go and proceed with your study,... you are not behind, but you are about to finish...". I have never told anyone about my dream. The next day I started to continue with my study and from that point on I regained my momentum.

Discussions with my colleagues and also with the supervisor made everything possible for me. The research design course I attended in Grahamstown was an eye-opener for me into the academic world where researching was high on the agenda. My interest in the cultural practices caught the eyes and minds of many people. This led me to develop an interest in continuing with my studies until 'the sky is the limit'.

I wish to publish some articles so that I could share my knowledge with many other interested people all over the world.

7.7 Conclusion

In this chapter, I provided a summary of the research findings. The main findings of this study concluded that the use of learners' prior everyday knowledge is essential as a starting point during teaching and learning. The study further concluded that the use of cultural practices promotes meaning making in fermentation and distillation. Also meaning making can be made easier through the incorporation of mind maps and practical activities.

I have also provided some recommendations based on the findings. These lead to some areas of future research.

REFERENCES

Ackland, T. (2012). *Oxygen requirements for fermentation*. Retrieved December 27, 2012 from http://www.homedistiller.org.html.

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

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

Arksey, H., & Knight, P. (1999). *Interviewing for Social Scientists*. London: Sage Publications.

Ary, D., Jacobs, L.C., Razaviech, A., & Sorensen, C. (2006). *Introduction to research in education* (7th ed.). USA: Thomson Learning Academic Resource Centre.

Atherton, J.S. (2009). *Cognitive constructive: Teaching and learning*. Http://www.learningandteaching.info/learning/constructivism.htm/ Retrieved on 17 November 2012.

Babbie, E., & Mouton, J. (2001). *The practice of social research*. New York: Oxford University Press.

Baloi, M. (1994). Ideas about nature: Traditional interpretation of thunder and lightning in Catembe and physics teaching. In P. Geddes (Ed.), *Explorations in ethno-mathematics and ethno-science in Mozambique* (pp. 62-67). Maputo: ISPM.

Bassey, M. (1999). *Case study research in educational settings*. Buckingham: Oxford University Press.

Bell, J. (1999). Doing your research project: A guide for first time researcher in education and social science. Buckingham: Open University Press.

Bencze, J. (2000). Democratic constructivist science education: Enabling egalitarian literacy and self – actualisation. *Journal of Curriculum Studies, 32*(6), 847-865.

Bernstein, B. (1996). Pedagogy, symbolic control and identity: Theory, research, critique. London: Taylor & Francis.

Bourdieu, P., & Wacquant, L. (1992). *An invitation to reflexive sociology*. Oxford: Polity.

Breidlid, A. (2003). Ideology, cultural values and education: The case of Curriculum 2010. *Perspectives in Education, 21*(2), 83-102.

Britz, I., & Mutasa, N. (2008). *New Physical Science: Grade 9*. Zebra Publishing, Windhoek.

Brown, A. L., & Ferrara, R. A. (1985). Diagnosing zones of proximal development. In J. V. Wertsch (Ed.), *Culture, communication, and cognition*. Cambridge: Cambridge University Press.

Clough, P., & Nutbrown, C. (2007). *A student's guide to methodology: Justifying enquiry* (2nd Ed.). London: Sage publications.

Coetzer, I.A. (2001). A survey and appraisal of progressive education in the USA. *Educare, 30*(1), 33-49.

Cohen, L. Manion, L., & Morrison, K. (2010). *Research methods in Education* (6th ed.). London: Routledge.

Cooper, D.C., & Schindler, P.S. (2001). *Business Research Methods* (7th ed.). New York: McGraw-Hill.

Czerniewicz, L., Murray, S., & Probyn, M. (2000). *The role of learning support materials in curriculum 2005.* National Centre for Curriculum Research and Development (NCCRD). Pretoria: Government Printer.

Delpit, L. (1995). Other people's children cultural conflict in the classroom. New York: The New Press.

Denzin, N.K., & Lincoln, Y.S. (Eds.) (1994). *Handbook of qualitative research*. Thousand Oaks, CA: Sage Publications.

Earl, B., & Wilford, L.D.R. (1998). *GCSE: Chemistry*. London: John Murray

Erickson, F. (1986). Qualitative Methods in Research on Teaching (3rd ed.). In M. C Wittrock (Ed.) *Handbook of Research on teaching* (pp. 119-61). New York: Macmillan.

Gay, L.R. Mills, G.E., & Airasian, P. (2006*). Educational research: Competencies for analysis and applications* (8th ed.). USA: Pearson Prentice Hall.

Geoffrey, C.P. (2003). "*Fermentation*." Encyclopaedia of Food and Culture. Retrieved April 9, 2012, from http://www.encyclopedia.com/doc/1G2-3403400221.html

Goos, M. (2004). Learning Mathematics in a classroom community of inquiry. *Journal for Research in Mathematics Education, 35*(4), 258-291.

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

Gray, D.E. (2004). *Doing research in the real world*. London: Sage Publications.

Gray, L. (1995). *Findings and locating information*. London: Longman.

Hitchcock, G., & Hughes, D. (1995). *Research and the teacher*. London: Routledge.

Hodson, D. (1990). A critical look at practical work in school science. *School Science Review, 70*(250), 33 – 40.

Hodson, D., & Hodson, J. (1998). From constructivism to social constructivism: A Vygotskian perspective on teaching and learning science. *School Science Review, 79*(289), 33–41.

Jegede, O. (1995). Collateral learning and the eco-cultural paradigm in science and mathematics education. *Studies in Science Education, 25*, 97-137.

Johnson, S., Monk, M., Watson, R., Hodges, M., Sadeck, M., Scholtz, Z., et al. (1999, January). Researching teacher development in large science classes in the Western Cape. In J. Kuiper (Ed.), *Proceedings of the 7th Annual Meeting of the SAARMSE Conference* (pp.204-212), Harare, Zimbabwe.

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

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

Kvale, S. (1996). *Interviews.* London: Sage Publications.

Lave, J. (1988). Cognition in practices: Mind, mathematics, and culture in everyday life. Cambridge, England: Cambridge University Press.

Lave, J., & Wenger, E. (1991). *Situated Learning: legitimate peripheral participation*. Cambridge: Cambridge University Press.

Lederman, N.G. (1992). Students' and teachers' conceptions of the nature of science. A review of literature. *Journal of Research in Science Teaching*, *29*, 331 – 359.

Leedy, P., & Ormrod, J. (2010). *Practical research: Planning and design*. New Jersey: Upper Saddle River.

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

Lincoln, Y.S., & Guba, E. (1985). *Naturalistic inquiry*. Beverly Hills, CA: Sage Publications.

Linkson, M. (1999). Some issues in providing culturally appropriate science: Curriculum support for indigenous science. *Australian Science Teachers' Journal, 45*, 41-48.

Lubben, F., Campbell, B., & Dlamini, B. (1996). Contextualising science teaching in Swaziland: Some student reactions. *International Journal of Science Education, 18*(3), 311-320.

Lubben, F., Campbell, B., Maphalala, T., & Putsoa, B. (1998). Science curriculum material development through teacher-industrialist partnership: Industrialists` perceptions of their role. *Research in Science & Technology Education, 16*(2), 217-230.

Lunt, I. (1993). The practice of assessment. In H. Daniels (Ed.), *charting the agenda: Educational activity after Vygotsky* (pp. 145-171). London: Routledge.

Maselwa, M.R., & Ngcoza, K.M. (2003). 'Hands–on', 'minds–on' and 'words–on' practical activities in electrostatics: Towards conceptual understanding. In D. Fisher & T. Marsh (Eds.), *Proceedings of the Third International Conference on Science, Mathematics and Technology Education* (pp.649-659)*,* Rhodes University, East London Campus, South Africa.

Maxwell, J.A. (1992). Understanding and Validity in qualitative research. *Harvard Educational Review, 62*, 279-301.

Mayumbelo, C., & Nyambe, J. (1999). Critical inquiry in pre-service teacher education: Some initial steps toward critical, inquiry, inquiring, and reflective professional in Namibian teacher education. In K. Zeichner & L. Dahlstrom (Eds.), *Democratic teacher education reform in Africa: The case of Namibia* (pp. 64-81). Oxford: Westview.

McRobbie, C., & Tobin, K. (1997). A social constructivist perspective on learning environment. *International Journal of Science Education, 19*(2), 193 – 208.

Meier, C. (2005). The development and application of progressive education in the Netherlands and some implications for South Africa. *African Education Review, 2*(1), 75-90.

Merriam, S.B. (2001). *Qualitative research and case study application in education.* San Francisco: Jossey-Bass Publishers.

Millar, R. (2004). *The role of practical work in the teaching and learning of science*. Paper prepared for the Committee: High School Science Laboratories: Role and Vision, National Academy of Sciences, Washington, DC.

Millar, R., Le Maréchal, J.F., & Tiberghien, A. (1998). *A map of the variety of lab work: Lab work in Science Education (LSE) Project. Working Paper I*, European commission TSER programme project PL 95 – 2005.

Moll, I. (2002). Clarifying constructivism in a context of curriculum change. *Journal of Education, 27*, 5-32.

Morgan, D.L. (1988). *Focus group as qualitative research.* Beverly Hills, CA: Sage Publications.

Murphy, P. (1999). Supporting collaborative learning: a gender dimension. In P. Murphy (Ed.), *Learners, learning, and assessment*. London: Paul Chapman Publishing.

Namibia, Ministry of Basic Education, Sport and Culture & Ministry of Higher Education, Training and Employment Creation. (1998). *The broad curriculum for the Basic Education Teachers Diploma*. Okahandja: NIED.

Namibia, Ministry of Education (MOE). (2009). *The national curriculum for basic education*. Okahandja NIED.

Namibia, Ministry of Education and Culture (MEC). (1993). Towards Education for all: A development belief for education, culture and training. Windhoek: Gamsberg.

Namibia, National Institute for Educational Development (NIED) (2003). *Learner–centred education in the Namibian context. A conceptual framework.* Windhoek: AfriLa.

Nyambe, J.K. (2008). Teacher educators' interpretation and practice of learner-centred pedagogy: A case study. An Unpublished Doctoral Study. Rhodes University, Grahamstown.

O'Donoghue, R., Lotz-Sisitka, H., Asafo-Adjei, R., Kota, L., & Hanisi, N. (2007). Exploring learning interactions arising in school-in-community contexts of socio-ecological risk. In A.E.J. Wals (Ed.), *Social learning towards a sustainable world: Principles, perspectives, and praxis* (pp. 435-447). The Netherlands: Wageningen Academic Publishers.

Ogawa, M. (1995). Science education in a multi-science perspective. *Science Education, 79*, 583-593.

Ogunniyi, M. B. (2007). Teachers` stances and practical arguments regarding a science–indigenous knowledge curriculum. *International Journal of Science Education, 29*(11), 963-986.

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

Oloruntegbe, K.O., & Ikpe, A. (2011). Ecocultural factors in students' ability to relate science concepts learned at school and experienced at home: Implications for chemistry education. *Journal of Chemical Education, 88*(3), 265-271.

Osborn, A.F. (1963). Applied imagination: Principles and procedures of creative problem solving (3rd ed.). New York: Charles Scribner.

Parkinson, J. (2002). *Reflective Teaching of Science* (pp. 11 – 18). New York: Continuum.

Patton, M.Q. (2002). *Qualitative research and evaluation methods* (3rd ed.). Thousand Oaks: Sage Publications.

Pea, R.D. (1993). Learning scientific concept through material and social activities: conversational analyst meets conceptual change. *Educational Psychologists, 28*(3), 265–277.

Peter, A. & Julio, P. (2001). *Physical Chemistry* (7th ed.). New York: W.H. Freeman.

Philips, G. (1998). *Science and technology encyclopaedia*. London: George Philips.

Pomuti, H. (1999). Learner-centred education and democratic teaching: Constructing common understanding of learner-centred education. In T. Sguazzin & M. Van Graan (Ed.), *Education reform and innovation in Namibia: How best can changes in classroom practices be implemented and supported?* Proceeding from the 1998 NIED Education Conference (pp. 14-17), Okahandja: NIED.

Potenza, R. (2002). *The seven roles of the teacher.* Retrieved 14 August, 2012, from http://ace.schoolnet.org.za/cd/uknzcore2a/documents/core2a.curriculum-matters.htm

Ramsden, J. (1994). Context and activity-based science in education: Some teachers' views of the effects on pupils. *School Science Review, 75*(272), 47-51.

Reiner, M., & Gilbert, J.K. (2004). The symbiotic roles of empirical experimentation and thought experimentation in the learning of physics. *International Journal of Science Education, 26* (15), 1819–1834.

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

Richardson, V. (1997). Constructivist teaching and teacher education: Theory and practices. In V. Richardson (Ed.), *Constructivist teacher education: Building new understandings* (pp. 3-14). London: Falmer.

Roschelle, J. (1995). *Learning in interactive environments: Prior knowledge and new experience*. Retrieved April 13, 2010 from http: //www.exploratorium.edu/ifi/meseumeducation/priorknowledge/.

Roth, W. (1998). *Designing communities*. Netherlands: Dordrecht Kluwer Academic Publishers.

Ryder, J. (2001). Indentifying science understanding for functional scientific literacy. *Studies in Science Education, 36*, 1-42.

Semali, L.M., & Kincheloe, J.L. (1999). What is indigenous knowledge and why should we study it? In L.M. Semali & J. L. Kincheloe (Eds.), *What is indigenous knowledge? Voices from the Academy.* London: Falmer Press.

Shaanika, H. (2012, October 26). Ombike-a potent traditional brew. *New Era*, P.3.

Slaa, J., Gnode, M., & Else, H. (2009). Yeast and fermentation: the optimum temperature. *Journal of Organic Chemistry,* 1-3.

Stake, R.E. (2000). Case studies. In N. K. Denzin and Y. S. Lincoln (Eds.), *Handbook of qualitative research* (2nd Ed.), Thousand Oaks: Sage Publications.

Stears, M., & Malcolm, C. (2005). Learners and teachers as co-designers of relevant science curricular. *Perspectives in Education, 23*(3), 21-30.

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

Terre-Blanche, M. Durrheim, K., & Painter, D. (Eds.) (2006). *Research in practice: Applied methods for the social sciences* (2nd ed.). South Africa: university of Cape Town Press.

Thompson, P. (2012). Learner-centred education and 'cultural translation'. *International Journal of Educational Development, 33*(2013), 48-58.

Torrance, J. (2005). *Standard Grade: Biology* (3rd ed.). Italy: Hodder & Stoughton.

Traianou, A. (2006). Teacher's adequacy of subject knowledge in primary science: Assessing constructivist approaches from a socio-cultural perspective. *International Journal of Science Education, 28*(8), 827-842.

UXL Encyclopaedia of Science. (2002). "Distillation.". *Encyclopedia.com.* Retrieved: 9 April 2012, from http://www.encyclopedia.com.

Vhurumuku, E., & Mokeleche, M. (2009). The nature of science and indigenous knowledge systems in South Africa, 2000 – 2007: A critical review of the research in science education. *African Journal of Research in Mathematics, Science and Technology Education*, Special Issue, 96 –114.

Vygotsky, L. (1978). Mind in society: The development of higher psychological processes. Cambridge, MA: Harvard University Press.

Vygotsky, L.S. (1986). *Thought and language.* Cambridge, MA: MIT Press.

Wenger, E. (1998). *Vygotsky and the social formation of mind.* Cambridge, MA: Harvard University Press.

Wertsch, J. (1985). *Vygotsky and the social formation of mind*. Cambridge, MA: Harvard.

Wilkinson, D. (Ed.) (2000). *The researchers tool kit: The complete guide to practitioner research*. London: Routledge.

Woolnough, B.E., McLaughlin, S., & Jackson, S. (1999). Learning by doing two classroom studies of pupils' preferred ways of learning science. *School Science Review*, *18*(294), 27-34.

www.engineeringtoolbox.com/boiling-points-water-altitude-d_1344.html.

www.Namibiansafari.com/image/namtravelMAPS/NAMIBIARegions_small.jpg.

Yakubu, J. (1994). Integration of indigenous thought and practice with science and technology: A case study of Ghana. *International Journal of Science Education, 16*(3), 343-360.

Zion, M., & Slezak, M. (2005). It takes two to tango: In dynamic inquiry, the self–directed student acts in association with the facilitating teacher. *Teacher and Teacher Education, 21* (7), 875 – 894.

APPENDICES

Appendix 1: Permission letters

Appendix 1a: Permission letter to the principal

Enq: Mr K. Uushona
Cell: 0812974240

P O BOX 110
Tsandi
Uukwaluudhi
Namibia
07-03-2012

The school principal
School X Combined School
Ogongo circuit
Omusati region

Dear Madam

Re: Permission to conduct a research project in the school

I, Kleopas Ipinge Twegathetwa, Uushona am currently a science and mathematics teacher at this school who is also a part-time student with Rhodes University, South Africa. I am hereby requesting a permission to conduct my MED research study in your school. I am doing a science related research project which is proposed to be done with 12 learners from grade 9 including one teacher whom I will be working very close with.

Choosing this school as my research site and these grade 9 learners in particular will be on the advantageous side as my project focuses on topics which is part of their curriculum: fermentation and distillation.

Moreover, this project is planned to be extended into the community where these learners are also expected to attend for several days. In order to avoid disruption of classes, the activity is to be carried out in the afternoon (after classes). Hence, permission is also sought in this regard.

As part of my ethical considerations I will make sure that the identity of my participants including those of the school will be kept confidential, hence pseudonyms will be used in the thesis.

Your cooperation in this regard is highly appreciated.

Yours in education

KUushona

Please put your recommendations in the space below;

....
....
....

Appendix 1b: Permission letter to the expert

Enq: K.Uushona

Cell: 0812974240

School X CS

P.O.Box 739

Outapi

12 March 2012

Dear Madam [*omusimanekwa*]

Permission letter: making Ombike [*eindilo*]

I, Kleopas Ipinge Twegathetwa, Uushona am currently a science and mathematics teacher at the above mentioned school who is also a part-time student with Rhodes University, South Africa. I am hereby requesting a permission to from you to be a member or a participant of the research project I will be conducting together with some learners. I am doing a science related research project which is proposed to be done with 12 learners from grade 9 including one teacher whom I will be working very close with.

[*Ngame, Kleopas Ipinge Twegathetwa, Uushona, Ondili omulongiskola poskola yatumbulwa pombanda. Ondili woo omwiilongi mo Rhodes University ya South Africa. Otandi ningi eindilo kungoye opo ukale omudhani nkandangala moproject tandi keyi ninga naalongwa 12 yomondondo 9 pamwe nomulongi gwao gumwe.*]

Since we will be concentrating more on 'making of Ombike', your main role will mostly be to explain, demonstrate, and answer questions that will be posed to you by either learners or any other participant. Choosing Ombike means I want to use it as a cultural practise to enhance and make it easier for learners to understanding Physical sciences in general.

[*Molwaashono otatu ka ikwatelela nkene Ombike hai ningwa, ngoye owategelelwa ashike uka fatulule, okuulika nosho woo oku yamukula omapulo tagaka pulwa. Elalakano lyandje unene oku longitha Ombike mo kuuvithako aalongwa unene moshilongwa shuudhindoli (Physical science)*]

I will make sure that any identity of my participant will be kept confidential. [*Otandi koleke mpaka kutya uukwatya waakuthimbinga ayehe owa gamenwa na itau ka longithwa paukililo*.]

Hence, I request you to indicate your choice by ticking [√] in the appropriate box below. [*Ulika epitikilo lyoye mu kamwe komuukolo mbuka.*]

Agree [*ndapitika*] ☐

Not agree [*Inandi pitika*] ☐

Signature [*eshainokaha*]..

Your cooperation is highly appreciated.[*tangi kelongelo kumwe*]

Yours in education [*gweni melongo*]

Teacher: K. Uushona

Appendix 1c: Permission letter to the parents

Enq: K.Uushona

Cell: 0812974240

School X CS

P.O.Box 739

Outapi

12 March 2012

Dear Parent/ guardian for: [*Omuvali/Omutekuli gwa:*]..

Permission for being a participant [*Epitikilo lyuukwashilyo*]

I, Kleopas Ipinge Twegathetwa, Uushona am currently a science teacher at the above mentioned school. I am here by submitting my request to you as a parent or guardian, to permit your child to be a participant of my research study amongst others. [*Ngame, Kleopas Uushona, omulongi poskola yatumbulwa pombanda, otandi idile nesimaneko enene epitikilo opo omulongwa atumbulwa pombanda akale gumwe gomaalongwa yahogololwa owina mokati kayakwawo.*]

These learners will participate in a science related project I am doing through Rhodes University where I am a student. The project aims at researching more about Ombike, how it is made culturally, and how we can use it in the classroom. [*Aalongwa mbaka oya hogololwa shina sha nokuninga oproject yoshilongwa shuudhindoli, shono tandiningi meilongo lyandje no university ya Rhodes ya South Africa. Oproject ndjika otayi ka pekaapeka uuwanawa nomukalo gwokuninga Ombike.*]

Being members of this group, I believe it will be beneficial to this child in progressing well with understanding of this subject even in future grades. [*Moku kala mongundu ndjika oshina uuwanawa owundji, mboka tashi vulika uka kwathele omunona nguka mokuke sheenditha nawa komunona nguka nokoo ngundu dhokomeho.*]

I am therefore apologising in advance that, since this project will be done in the afternoon, Hence they might not arrive on time home.*[Otandi gandja ombili mpaka, shoo tashi vulika omasiku gamwe taye keya kwatoka , omolwetompelo ndika kutya ayihe otai ningwa konima yeetundi.]*

Hence, I request you to indicate your choice by ticking [√] in the appropriate box below. [*Ulika epitikilo lyoye mu kamwe komuukolo mbuka.*]

Agree [*ndapitika*] ☐

Not agree [*Inandi pitika*] ☐

Signature [*eshainokaha*]..

Your cooperation is highly appreciated.[*tangi kelongelo kumwe*]

Yours in education [*gweni melongo*]

Teacher: K. Uushona

Appendix 2: Research tools

Appendix 2a: Brainstorming and discussion session: Guiding questions

During this session, the following questions will be given or posed to the learners who are my research participants in this study. The intention behind this is actually to elicit and obtain learners' prior everyday knowledge and experiences about the cultural process of making *Ombike*. Thus, by calling them guiding questions, it means much of the discussions will be directed by the responses given by learners.

BACKGROUND

Ombike is one of the cultural drinks most commonly made by the *Oshiwambo* speaking people in Namibia. As a child who grew up in this *Eendombe* community where *Ombike* has been, and is still being made, it is requested of you to answer through group discussion the following questions. These discussions will then be presented on the flipcharts as a work of the group.

The questions are:

a) In your own knowledge or experiences, explain how *Ombike* is made (give the step by step procedures).
b) What apparatus are needed in order to make *Ombike*?
c) Is it men or women who normally make *Ombike*, why or why not the others?
d) Approximately, how long does it take to make *Ombike*? Any reason?
e) Is there any way to speed up the process of making *Ombike*? Any comments?
f) Who drinks *Ombike*? When? Any restrictions?
g) Any scientific concepts you could think of that are associated with the making of *Ombike*?
h) Do you think the making of *Ombike*, is a good practise or not in the community? Why or Why not?

Appendix 2 b: Questionnaire (interview questions) to learners

1. Do you think community members should be or not involved in the teaching of science? Is their knowledge relevant?

   ____
   ____
   ____

2. Do you think science teachers should always consider learners prior everyday knowledge/experiences when teaching science?

   ____
   ____
   ____

3. As a science learner can you say it is/was helpful or waste of time to explore how Ombike is made culturally?

   ____
   ____
   ____

4. Is /are practical works necessary in science? Motivate your answer.

   ____
   ____
   ____

5. How do you see or find the way of learning by developing all the concepts and come up with a concept map or a mind map? Is it a good way of learning? Comment

   ____
   ____
   ____

6. Tell me something about the unit of work (chapter) designed for this project. Was it easier to understand? How are the worksheets and questions?

   ____
   ____
   ____

7. How do you feel to be a member or a participant of the Ombike?____

____

____

____

__Appendix 2c: Interview questions: teachers__

1. Do you think science teachers should consider or not, learners prior every day knowledge/experience when teaching science? Why?

   ____

   ____

   ____

   ____

2. Do you think community members should or not be involved in the teaching of science? If yes how why?

   ____

   ____

   ____

3. When exploring these concepts of fermentation and distillation in schools, do you think it is helpful or a waste of time to explore how Ombike is made culturally?

   ____

   ____

   ____

4. It is argued that "practical works are very important when teaching and learning science". Would you agree or not agree with this statement? Motivate your answer.

   ____

   ____

5. What comment do you have on the way concepts were developed using the "concept map" or "mind-map"?

   ____

   ____

   ____

6. A unit of work on fermentation and distillation was developed which was used as a tool in ensuring conceptual development and understanding of these two themes.

   After gone through it, how do you evaluate it? Is there any comment or ideas you would want to give to the author or researcher?

   ____

   ____

   ____

   ____

7. Any general comment you would want to give?

____

____

____

Appendix 3 Unit of works sections

Appendix 3a: Lesson content (excerpts source)

A learning unit of work: *fermentation and distillation*

Introduction

Fermentation is defined as a chemical process that break down organic materials e.g. sugar or glucose or starch, by microbes e.g. yeast or bacteria, to produce carbon dioxide gas and ethanol/alcohol. It is the yeast that break-down the sugar during anaerobic respiration. At industrial level, this process is commonly used to make beverages like bears and wines of different flavours depending on the type of fruits used. However, the fermented solution can also be used to make the more strong alcoholic beverages which will requires an additional process of distillation.

Ombike is a traditional alcohol beverage made by *Owambo* people in the northern part of Namibia. It is culturally prepared from local fruits and has similar characteristics to that of the Western spirits (brandy, whiskey, gin, etc.). Hence it is one of the very hot and strong alcoholic drinks. It is very much inspiring by the way it has been prepared locally by the experts who are unaware that they are practising various scientific techniques in this practice.

This chapter is a unit of work designed as a learning tool which aims to enhance the conceptual development and understanding of concepts in fermentation and distillation processes. As a way of localising and contextualising the teaching and learning process, an attempt on how *Ombike* is made was found to be more convincing and helpful as it caters all the aforesaid processes.

Therefore, this chapter is divided into several sections. The first section provides a scientific background of the two concepts under study; fermentation and distillation. After this, there comes a section of practical works that can be used by any science teacher in teaching the aforesaid topics. In the last section, there is a worksheet designed to assess learners` level of understanding obtained from the entire experience they went through.

Fermentation

Fermentation is one of the oldest known food preservation techniques. Along with drying and salting, fermentation was a key method of extending the life of foods, allowing them to be available and eaten safely, in times of scarcity or seasonal non availability. It has also been the process previously and also presently used to make various alcoholic beverages.

Hence, **fermentation** is defined as a chemical process that break down **organic materials** e.g. sugar or glucose or starch, by microbes e.g. yeast or bacteria, to produce carbon dioxide gas and ethanol/alcohol

It is a process that breaks down organic materials by **microbes** (e.g. bacteria and yeast). It is an energy yielding metabolic process by which **sugar** or **glucose** [$C_6H_{12}O_6$] molecules are decomposed to **carbon dioxide**, [CO_2] and **alcohol/ethanol** [C_2H_5OH] in the absence of air**- anaerobic respiration**.

With the understanding of anaerobic concept, it seems that fermentation does not require **Oxygen**. According to Geoffred, (2003) the presence of oxygen will cause some species of yeast to <u>completely **oxidise** to carbon dioxide and water instead of producing ethanol</u>. This could possibly be one of the reasons to why the local winemakers not like to frequently open the fermenting mixture.

It involves the bio-chemical reaction brought about by micro-organism (yeast) which acts as a **catalyst** to the reaction. A catalyst is a chemical substance added to a reaction with the aim of speeding it up, and at the end of the reaction it remains unchanged. The catalysts in the yeast use sugar for **energy** during anaerobic respiration to produce alcohol and carbon dioxide gas.

The overall process of fermentation is to convert glucose/sugar (C6H12O6) to alcohol (C_2 H5OH) and carbon dioxide gas (CO2). The reactions within the yeast cell which make this happen are very complex but the overall process is shown by the following chemical equation:

Balanced and symbol: C6H12O6 ====> 2(C2H5OH) + 2(CO2)
In words: Sugar ====> Alcohol + Carbon dioxide gas
(Glucose) (Ethyl alcohol)

Despite the effect of oxygen to the process of fermentation, there is also an interesting fact about the presence of yeast in the alcohol. Yeast can only tolerate a specific amount or level of alcohol (about 5%). Beyond that, it dies (**denatured**) and then it can no more continue with fermentation.

As another factor again, there is also a specific **temperature limit** for fermentation to continue in a normal way. In his study on fermentation, Geoffred (2003) discovered an appropriate temperature limit for fermentation which is between 15 °C and 27 °C.

At an industrial level, fermentation is the process used to make wines and beers of different flavours, depending on the fruits used. However, some wine makers choose to add sugar for varieties of reasons. One of the reasons for this is apparently **to speed up** the process in order to increase the productivity over a short period of time. However, it has been discovered that, the product of these reactions will no longer produce the pure ethanol but rather **a poisonous** alcohol called **methanol** which is having a health effect to the consumers as it sometimes causes **blindness**.

Based on the description from The Columbia Encyclopaedia (2011), methanol has been expanciated as follow;

> Methanol, or methyl alcohol CH_3OH, is a colourless, flammable liquid that is miscible with water in all proportions. It melts at -97.8°C and boils at 67°C. Methanol is a fatal poison. Small internal doses, continued inhalation of the vapour, or prolonged exposure of the skin to the liquid may cause blindness. As a result, commercial use of methanol has sometimes been prohibited.

Other wine makers opt not to add either, believing that they will use **the natural sugar** in the fruits and also **the natural/wild yeast** present on the covers or skin of the fruits. Hence, this process takes a bit longer time (days).

In short, based on the paragraphs above, one could easily deduce that, there are four factors that could affect fermentation process especially in relation with 'alcoholic fermentation'. These are;

a) addition of **sugar ,**
b) temperature,
c) presence of yeast in a specific alcohol level, and
d) Presence of Oxygen.

Due to the fact that different alcohols are made differently, it means that some are made straight through this process of fermentation, for example wines and beers. However, for the more alcoholic and strong beverages like; spirits, whiskey from beers, brandies from grape wines, **arrack** from palm or rice wine and **Ombike** from palm fruits, a further stage of boiling these fermented mixtures have to be applied through a process called distillation.

Distillation

It is a process <u>that separates</u> a substance or a mixture of substances from a solution through **vaporization**. It usually involves **boiling** a liquid and then **condenses** the **vapour** that forms. In this technique two or more substances with different **boiling points** are separated from each other.

For example, fresh water can be obtained from seawater (water that contains salts) by distillation. When seawater is heated, water turns into a vapour that can be condensed and captured. The salts in the seawater remain behind.

In contrast to the preceding example, distillation is most commonly used to separate two or more liquids from each other. Let's follow the example below;

Imagine a mixture of three liquids, A, B, and C. Liquid A has a boiling point of 30°C; liquid B has a boiling point of 40°C; and liquid C has a boiling point of 50°C. The three-liquid mixture described above is added to a distillation flask, the mixture in the flask is heated by a Bunsen burner or some other apparatus. The temperature of the liquid mixture rises until it reaches the boiling point of any one liquid in the flask. In this example, Liquid A begins to boil when the temperature in the flask reaches 30°C. It turns into a vapour at that temperature, rises in the distilling flask, and passes out of the flask arm into the condenser.

Distillation is carried out in an apparatus called a **still** (*fig.1*). A still consists of a **boiler**, a **condenser** and a **receiver.**

PICTURES OF A STILL AND Ombike

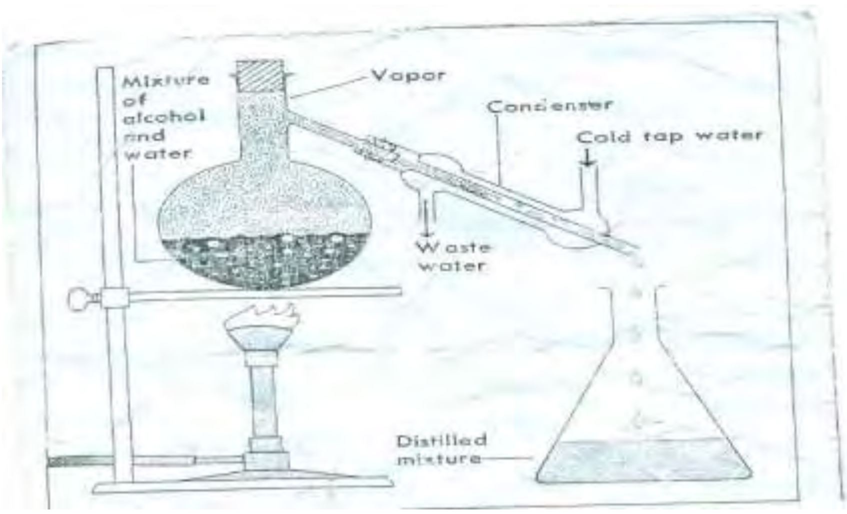


Fig.1. Distillation process: a still

Fig. 2: *a setup showing a cultural distillation of Ombike*

The mixture to be vaporised is heated in the boiler. The substance with **low boiling point** vaporizes first into **vapour** (gas form). This will enter the condenser where it **cools (condenses)** and becomes **a liquid** called a **distillate**. The distillate then collects in the receiver.

The condenser consists of a long tube surrounded by a larger tube. The outer tube contains water, which enters near the bottom of the condenser and leaves near the top. The water passing through the outer jacket of the condenser cools the vapour passing through the inner tube. The vapour loses heat and condenses (meaning it changes back to a liquid). It flows out of the condenser and into a receiving container—a flask or beaker placed in position to capture the liquid. The liquid (A) is now known as the **distillate**, or the product of the distillation. (UXL, Encyclopaedia of science, 2002)

Heat added to the liquid mixture is used to vaporize liquid A, not to raise the temperature of the mixture. That temperature will begin to rise only when liquid A has completely boiled away. By watching the thermometer, therefore, an observer can know when liquid A has been completely removed from the liquid mixture. At that point, the receiver containing pure liquid A can be removed and replaced by a new receiver.

Once liquid A has boiled away, the temperature in the distilling flask begins to rise again. When it reaches 40°C, liquid B begins to boil away, and the sequence of events observed with liquid A is repeated. Eventually, pure samples of A, B, and C can be collected.

The stronger alcoholic beverages like spirits, arrack (where *Ombike* is hopefully included), are made from the fermented alcohol through the distillation process. In contrast to fermentation, distillation is a physical process. According to Torrance (2005:224), it begins when the fermented mixture is heated, turning the alcohol into vapours. The vapours are collected and then cooled back into a liquid that is more alcoholic than the fermented liquid.

However, there are many methods of distilling liquids. One of them is **simple distillation** where a common method called **fractional distillation** fall part of. Fractional distillation separates **miscible** substances that boil at different temperature. Moreover, Earl and Wilford (1998:22) talk of fractional distillation which relies upon the liquids having different boiling point. When the mixture is heated, the vapours of ethanol and water boil off at different temperatures and can be condensed and collected separately. Ethanol boils at 78 °C, whereas water at 100 °C. This means that, when the mixture is heated, the first vapour is mainly ethanol because it boils first before water. This is preferably what is happening when *Ombike* is being prepared.

When this mixture is heated in the boiler, the alcohol vaporises faster than water. This is attributed by the difference that they have in terms of their boiling points. As a result, the first distillate collected has a larger proportion of alcohol than the last proportion. Thus, it is through fractional distillation process whereby high alcoholic liquors known as spirits are made. The examples of spirits are; gins, whiskey, Ombike, etc.

Appendix 3b: Worksheet experiment 1

Fermentation of sugar by yeast

Instructions:

- You need to be in groups of maximum five learners
- Follow all the steps and then answer questions asked later collectively as a group.

APPARATUSES:

- 3 flask or test tubes
- 3 Soft transparent plastics
- 3 rubber bands
- Yeast
- Water
- Solution of crushed fruits, e.g. palm fruits or berries

METHOD:

1. Label the two flasks, A, B, & C.
2. In flask A and B, put in the crushed fruits and then add a little water to form a solution.
3. In C, put only the dry crushed fruits.

4. In flask B, add yeast to the solution and gently mix it in the solution.

5. Cover the three flasks with inverted plastic over the mouth of the flasks. Deflate the plastics to ensure that there is no air in them. Tightly, bind the plastics on the flasks with the rubber bands.

6. Observe these experiments for some hours, and then let it overnight until the next day. Record all your observations.

A

B

C

Now answer the following questions;

1) Which test tube or flask is the control in this experiment? Give the letter of the test tube-----------------------

2) What did you observe to both flasks? (plastics and the solution)

A--

B--

C--
----

3) What conclusion can you draw from these results?

----

4) A catalyst is a substance which alters the rate of the reaction by speeding it up, without actually being changed at the end. State the substance that acted as a catalyst in this experiment.

----

5) It is expected that a change will be seen on the plastics covering the flasks. This change is possibly caused by a gas, carbon dioxide, [CO_2] which is a by-product of fermentation process. Explain how one can chemically test this gas in the laboratory.

----

6) Respiration is a process whereby glucose is decomposed to produce energy. It can either be 'aerobic'-with the presence of oxygen, or 'anaerobic'-with the absence of oxygen. What kind of respiration was involved in this experiment as sugar was decomposed by yeast? Explain.

----

7) What are the key or main concepts associated with the process of fermentation that one can use when explaining or describing the process?

Appendix 3c: worksheet experiment 2

Determining the boiling points of liquids

Instructions:

- You need to be in groups of maximum five learners
- Follow all the steps and then answer questions asked later collectively as a group.

One of the scientific methods used to classify and determining whether a certain liquid is an alcohol is by finding its boiling point. In science, we have learnt that alcohol boils at 78 C° whereas water boils at 100 C°. Can this be one of reasons that "the first distillate of *Ombike* is stronger than the late distillate"?

AIM: To determine the boiling point of alcohol *Ombike*.

APPARATUSES:

- 2 beakers
- 2 burners
- 2 thermometers
- 2 tripod stand and gauzes
- Tap water
- *Ombike* (Alcohol)
- A syringe

METHOD:

- Label two beakers A and B.
- Using the same syringe, pour the same volume of the two liquids into each beaker (A-*Ombike* and B-water).
- Initially ensure that both the two liquids were kept at the same place to ensure that the starting temperature of the both liquids is the same.
- Set up the apparatuses as shown in the diagrams below. At the same time, put a thermometer in each beaker and record their starting temperatures.
- Light up the burners of both experiments at the same time.
- After each minute, record the temperature changes in the two beakers. Do this up to ten minutes.
- Record your results in the tables below;

Beaker A- *Ombike*

Time/min.										
Temperature/C°										

Beaker B – water

Time/min.										
Temperature/C°										

- Using the data in the two tables above, plot or draw two lines on the same graph (combined). Label the two lines A and B respectively.

- Now answer the following questions

a) With reference to your two graphs above, what are the boiling points of these two liquids used in this experiment?

Ombike: --

Water: --

b) Would you think that this experiment is sufficient to convince one that *Ombike* is a type of alcohol? Explain.

....
....
....

c) Giving reasons, which experiment acted as a control (A or B)?

....
....
....

d) Give any three things that made this experiment fair.

....
....
....

Appendix 3d: meaning making worksheet

General knowledge on fermentation and distillation

Instructions: -

- You need to be in group of maximum five learners
- As a group, discuss first the answers to each question before each one answers in your worksheet.

PART 1. FERMENTATION

After all the apparatuses have been prepared very well, fruit are crushed onto very small pieces before mixed with water to form a solution. This is then put into a container which is covered for about four to five days. If one opens this mixture after four days, one will observe the bubbling of a gas which will turn the mixture to be more acidic when it dissolves in the mixture, though it is advised not to keep on opening this bucket many a times.

Due to lack of oxygen, moulds and bacteria form and these use the sugar for energy. Some of the energy will then be converted to heat, thus temperature rises.

a) Fermentation can be described as a process of breaking down sugar by microbes such as yeast into alcohol and carbon dioxide gas.

i) Write down the chemical equation/reaction for the fermentation process in words.

....
....

ii) Re-write and balance the above equation using symbols.

....
....

iii) From the reaction above, write down all the;

Reactants:...
....

Products:..
....

iv) Describe the chemical test of carbon dioxide gas.

....
....
....

b) It is advised that sugar should not be added to the solution of the fermenting *Ombike.* What could be the reason for this?

....
....
....
....

c) It is claimed that fermentation process does not require Oxygen. In other words it prefers anaerobic respiration. Explain the effect that Oxygen has on fermentation process.

....
....
....
....

PART 2- DISTILLATION

After the fermentation process has been completed, all the apparatuses needed for boiling are prepared. The fermented mixture is then boiled in the clay pot. As it boils, then the alcohol (*Ombike*) is collected at the end of the metal tube into the collecting container.

Answer the following questions

....
....
....

a) Explain what you think would happen if the pot was not sealed properly?

....
....
....
....

b) The cold water is always put in the trough over the metal tube. Once the water becomes hot, it is quickly removed and replaced with cold water again.

i) What do you think is the reason for putting cold water over the metal tube in the trough?

....
....
....
....

ii) Explain how and why does this water get hot?

....
....
....
....

iii) Explain what could happen if no cold water was placed in the trough.

....
....
....
....

c) On the diagram above, there are letters labelled A, B and C.

In what state of matter are these at?

A:...

C:...

d) Give the scientific explanations or reasons for the following statements:

i) Crushing the fruits into very small pieces.

....
....
....
....

ii) Covering the mixture in a plastic bucket for about four days without frequent opening it.

....
....
....
....
....

iii) The last distillate of *Ombike* is found to be weak and tasteless than the first distillate.

....
....
....
....

Appendix 4: Photos

***Ombike* photos**

Picture 1: Trough with a metal tube

Picture 2: Palm fruits are edible

Picture 3: Donkeys eating palm fruits

Picture 4: Making Ombike –distillation

Picture 5: A boiler (pot)