Mobilising the indigenous practice of making *Oshikundu* using an inquiry-based approach to support Grade 8 Life Science teachers in mediating learning of enzymes

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By

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Declaration of Originality

I, Ester Shinana, declare that this thesis is my own original work that is submitted at Rhodes University and has not been submitted at any other university. All ideas and citations used in this study derived from other people are acknowledged and indicated in the list of references.

Signature:

Date: 25 November 2019

Abstract

The Namibian curriculum encourages Life Science teachers to integrate indigenous knowledge into their science lessons. Additionally, it also encourages teachers to promote scientific inquiry in their science classrooms. However, it is not clear how Life Science teachers should go about doing this. As a result, science is taught in decontextualised ways and inquiry-based methods are neglected. It is against this background that this study sought to mobilise the indigenous practice of making *oshikundu* to mediate learning of enzymes and to promote inquiry-based methods. Essentially, an attempt was made to mediate the learning of enzymes through inquiry-based methods using, in particular, the Predict-Explain-Explore-Observe-Explain (PEEOE) approach. The approach entails learners making predictions and providing explanations for their predictions before they do their observations.

The study employed a qualitative case study approach underpinned by an interpretive paradigm. It was conducted at two schools in the Omusati Region in Namibia and three Life Science teachers (two from one school and one from a different school) participated in this study. A variety of data gathering techniques such as document analysis, workshop discussions, participatory observation, and journal reflections were used to gather data and for triangulation purposes. A thematic approach to data analysis was adopted and data analysis and interpretation were done inductively using Vygotsky's socio-cultural theory and Shulman's Pedagogical Content Knowledge (PCK) as lenses. Within PCK, the Topic Specific Pedagogical Content Knowledge (TSPCK) model was used as the analytical framework to identify and improve the quality of Life Science teachers' PCK in the topic of enzymes in particular.

Findings from this study revealed that some teachers had a narrow understanding of the concept of scientific inquiry, whereas some demonstrated a better understanding of the concept and how it is used in Life Science classrooms. The findings also revealed that the understanding of the teachers of an inquiry approach and how they understood science should be taught, further influenced their practice; this was in addition to resource constraints. Furthermore, it was also established that some teachers did not include the concept of enzymes in their teaching.

The workshop intervention equipped teachers with the knowledge on an inquiry approach and how to promote scientific inquiry skills in their classrooms. Likewise, the practical demonstration of making *oshikundu* also equipped the teachers with the knowledge of enzymes and together with the PEEOE approach, how to teach enzymes using an inquiry approach.

Teachers experienced challenges, as they had to use their creative, critical thinking and reasoning skills in order to identify the scientific concepts from the practical demonstration of *oshikundu*.

The study suggests that there is a need for professional development programmes focusing specifically on supporting in-service science teachers' understanding of inquiry and how to use the inquiry-based approach in their classrooms. Equally, the pre-service science teachers need such preparations during their training. Furthermore, the study also presents that there is a need to engage both pre-service and in-service teachers deeply with the new content of the Life Science syllabus.

Key words: Life Science, enzymes, scientific inquiry, indigenous knowledge, socio-cultural theory, Topic Specific PCK

Dedication

This thesis is dedicated to my late father Petrus Ndifikepo Ndiinhu ya Shinana, the man who named me Ndakondja Lineekela. These two names were my reservoir for the person I needed to be on this journey. Being Ndakondja, (which means I struggled), reminded me that I needed to be bold and fight the good fight through the struggles of this journey. Likewise, Lineekela (which means have faith) reminded me not to give up, but to keep my faith.

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List of Abbreviations and/or Acronyms

BEd:	Bachelor of Education
CO_2:	Carbon Dioxide
MKO:	More Knowledgeable Other
NCBE:	National Curriculum for Basic Education
PCK:	Pedagogical Content Knowledge
PEEOE:	Predict-Explain-Explore-Observe-Explain
SMK:	Subject Matter Knowledge
TSPCK:	Topic Specific Pedagogical Content Knowledge
ZPD:	Zone of Proximal Development

CHAPTER ONE: SITUATING THE STUDY

1.1 Introduction

The aim of this study was twofold. Firstly, it aimed at mobilising the indigenous practice of making *oshikundu*[1] to mediate the learning of enzymes. Secondly, it aimed at promoting the use of an inquiry approach in Grade 8 Life Science classrooms. The Namibian school curriculum guides teaching and learning in Namibian schools. These guidelines include the content which needs to be taught and the pedagogical approaches which need to be used in the mediation process. Particularly, the use of indigenous knowledge to teach content in a contextualised way and the use of an inquiry approach to enhance scientific inquiry and skills, are among the pedagogical approaches suggested in the curriculum.

However, by way of contrast, it has been observed that these pedagogical approaches are not well implemented in Namibian classrooms. For this reason, it seems content is taught in a decontextualised ways, practical investigations take a recipe approach and only a few are observed in science classrooms. Consequently, learners find it difficult to comprehend taught content which eventually leads to poor comprehension of science content. This background triggered this study which sought to support Grade 8 Life Science teachers in gaining knowledge on the concept of enzymes and on how to mediate the learning of enzymes using indigenous knowledge, coupled with an inquiry approach.

This chapter thus introduces the study. It provides the background of the study which draws on the National Curriculum for Basic Education (Namibia. Ministry of Education, Arts and Culture [MEAC], 2016) as well as the Grade 8 Life science syllabus (Namibia. MEAC, 2015).This is followed by my personal experiences, the statement of the problem, and the significance of the study. Afterwards, the goal and research questions are presented. Lastly, the theoretical framework, data gathering techniques, definitions of the key concepts used, and the

[1] *Oshikundu* is a non-alcoholic traditional beverage which is made from fermenting three flours, namely, *Ongundo*, *Uushutu* and *Mahangu*. It is a staple drink for many *Oshiwambo* speakers in Namibia and it is a rich source of carbohydrates, proteins, vitamins, as well as minerals. It also provides the body with water essentially to prevent dehydration.

thesis outline are highlighted. The chapter ends with some concluding remarks to pull the threads together.

1.2 Knowledge that the Namibian National Curriculum for Basic Education suggests for inclusion

The Namibian National Curriculum for Basic Education (Namibia. MEAC, 2016) is the official policy document that guides teaching and learning in Namibian schools. It provides guidelines in terms of how to plan, organise and implement teaching and learning in schools, as well as information about the knowledge that needs to be taught (Namibia. MEAC, 2016). The document advises the use of an inquiry approach and indigenous knowledge as pedagogical approaches. Similarly, the Grade 8 Life Science syllabus requires teaching of the concept enzyme. In this section I discuss the two pedagogical approaches and content which is required by the curriculum. In doing this, I hope to provide an in-depth information related to the background of the study. Eventually, this will set the stage for the purpose of the study and show why it was worth carrying out.

1.2.1 The place of scientific-inquiry and practical investigations in the Life Science syllabus

Namibia's vision 2030 strives for a knowledge-based society. Within this framework, the goal of basic education is to produce a society of learners who among others have creative, and practical skills, who can think scientifically to solve problems. To achieve this, in the Science discipline, Natural Science has been identified to potentially promote scientific inquiry and knowledge. Thus, the learning experiences in the Natural Science subjects are tailored towards promoting learners' knowledge and understanding of science inquiry skills and science as a human endeavour of the physical, biological and technological world of which they are part (Namibia. MEAC, 2015). The importance of teaching science through inquiry is made clear both in the broad curriculum of Namibia, in the National Curriculum for Basic Education (2016) and the Grade 8 Life Science syllabus (2015). Specifically, in the Grade 8 Life Science syllabus, this aim is embraced under point 3.3 (Namibia. MEAC, 2015, p. 2). The Life Science syllabus thus, carries the responsibility to produce learners who can use methods and skills to communicate their observations and conclusions using scientific and mathematical language, theories, laws and principles (Namibia. MEAC, 2016, p. 26). In addition, the syllabus is also expected to equip learners with the understanding of basic laboratory rules and knowledge on how to handle apparatus and follow laboratory safety procedures during scientific investigations.

To strengthen this requirement, Grade 8 Life Science syllabus has a topic on scientific process skills (Namibia. MEAC, 2015). Learning and development of these skills are done through scientific investigations. It is worth noting that scientific investigations take different forms. Some investigations involve practical activities in which learners have to manipulate materials hands-on, whereas others do not (Potvin, Hasni, & Sy, 2017). Additionally, assessment objective C of the Life Science Syllabus (Namibia. MEAC, 2015) requires science teachers to assess practical work which is aimed at developing learners who are able to: (i) use and organise techniques, apparatus and materials, (ii) observe measure and record, (iii) handle, processes and evaluate experimental tasks. Scientific-inquiry skills and knowledge discussed above are summarised in Table 1.2 below.

Table 1.1: A summary of the areas which promote scientific inquiry in the curriculum

Areas where scientific skills are promoted	Scientific skills which are promoted
Cognitive skills	To achieve this skill, learners should be able to: Explore, investigate, enquire, recognise, hypothesise, interpret, weigh up alternatives, analyse, synthesise, evaluate, think creatively, create knowledge. (Namibia. MEAC, 2016, p. 10).
Natural Sciences (End of phase competencies)	Learners use methods and skills to increase variables in the existing scientific models, communicate their observations and conclusions using scientific language. (Namibia. MEAC, 2016, p. 11).
Natural Sciences (realisation of knowledge-based society)	To empower learners with: Scientific knowledge, skills and attitudes to formulate hypotheses, to investigate, observe, make deductions and understand the physical world in a rational and scientific way. (Namibia. MEAC, 2016, p. 26).
Scientific skills	Develops a lively, questioning, appreciative and creative intellect to enable learners to discuss issues rationally, make careful observations, and analysis, think scientifically, solve problems and apply them to tasks. (Namibia. MEAC, 2015, p. 2).

Scientific process skills	Stating the aim of the investigation, explain the first step of scientific method; • Choosing the right question • Make a hypothesis • Planning how to collect information/ data • Describe how to make a test fair • Identify dependent and independent variables Estimating and measuring, observing classifying and drawing, Experimenting, investigating, recording and presenting results. (Namibia. MEAC, 2015, p. 9).
Assessment objective C: Practical (Experimental and investigative) skills	Learners should be able to: • Use and organise techniques, apparatus and materials • Observe measure and record • Handle, process and evaluate experimental observations and data • Plan investigations (Namibia. MEAC, 2015, p. 41).

It is evident from this table that the broader curriculum, as well as the Life Science Grade 8 syllabus, places emphasis on the use of inquiry approach in Life Science classrooms. These curriculum documents thus require that learners are introduced to inquiry by taking part in scientific investigations. The above section stated the expectations of the Life Science syllabus (Namibia. MEAC, 2015). Admittedly, these expectations pose issues to the teachers and learners alike. In other words, how these expectations should be achieved is not provided clearly by the syllabus. What is more, the facilities available at the schools do not accommodate some of these requirements. This is an important factor that in my view, the curriculum has overlooked. This study thus introduces the teachers to cost-effective resources which the teachers can use in their classrooms. This was done for the purpose of mobilising the use of easily, accessible, cost-effective resources, which in my view could mitigate resource constraints.

Scholars from various parts of the world have raised concerns on the implementation of an inquiry-based approach in science classrooms (Hodson, 1990; Kapenda, Kandjeo-Marenga, Kasanda, & Lubben, 2002; Ramnarain & Schuster, 2014; Simsek & Kabapinar, 2010).

In a Namibian study, Kapenda et al. (2002) established that the practical investigations they observed did not promote inquiry skills. These similar findings were also located in Kandjeo-Marenga (2008), when it was reported that some of the practical activities, she observed in Grade 11 Biology classrooms, were based on teacher demonstrations. She laments that consequently, learners were deprived of hands-on experiences which inhibited the use and development of inquiry skills. Recent studies done in Namibia also attest to these findings. Even though the issue of poor use of practical investigations has been pointed out by earlier studies, seemingly this issue is an ongoing one in Namibia. The current studies which reveal similar findings, resonate with this.

Asheela (2017), for example, observed that practical investigations are poorly implemented and at times they are just not conducted. Lending support, Abah, Denuga and Muyoyeta (2017) also confirm that in the absence of practical investigations, the teachers resort to teaching science through theory. That being the case, using such a pedagogical approach, it is warned that learners lack opportunities to use and develop cognitive skills such as creative thinking, which are normally enhanced through practical investigations (Namibia. MEAC, 2016). Following this claim, Ngishongwa (2017) puts it that, indeed, a lack of practical investigations has secondary effects on learners, such as learners failing to create science fair projects. While these findings were established in various studies, examiners' reports that the Namibian Ministry of Education makes available every year, also comment on learners' competencies in practical skills. There are many comments made by the examiners' reports from recent years on the learners' performance in practical related questions. It should be noted that the grade which is the focus of this study, does not take part in this national assessment. As a result, there is no report on the performance of Grade 8 learners in practical investigations on enzymes. Nevertheless, the examiner's reports this study relied on, are for Grade 10 and 12 levels where national assessments are done. Essentially, these reports serve as an eye-opener on how to prepare learners at the Grade 8 level, for complex content in those higher grades.

The examiners' reports for Biology (2012, 2015, 2016, 2017) (see Appendix G) highlight a lack of learner exposure to practical investigations. Particularly, the examiners' report of 2015 commented that; "in the event when the learners were asked to suggest other ways how to set up a control in an investigation, learners' answers revealed that, "they could not think of a different way in which a control test-tube could be set up" (Namibia. Ministry of Education, 2015, p. 8). The findings shared above, both in literature and the examiners' report, might explain the findings of Kambeyo (2018), whose recent study conducted in Namibia established that learners lack scientific inquiry skills and reasoning skills. In this regard, this finding might resonate with his claim that teaching and learning of science in Namibia, seems to concentrate more on content at the expense of the promotion of inquiry skills, which are minimal. Speaking about the observations made on the promotion and use of inquiry in Namibian classrooms, the concerns of poor promotion of inquiry in science classrooms are also observed in other countries.

For instance, Simsek and Kabapinar (2010) complain that in Turkey, the experiments they observed were in recipe form and as a result, they did not promote inquiry. To Hodson (1990), this could mean that learners were doing practical activities for observational reasons only and not necessarily for the promotion of learning both content and inquiry skills. In addition, two Lebanon teachers, Saad and BaJaoude (2012), confirmed that inquiry approaches are not used in their classrooms. In addition, studies carried out in South Africa also shared similar sentiments. For instance, in their studies, Dudu (2017), Nompula (2012) and Ramnarain and Hlatswayo (2018) found out that practical experiments are kept to a minimum in science classrooms. Shedding light on this matter, the authors explain that the condition is caused by lack of laboratory facilities, teaching materials, limited time to complete the syllabus, large classes, as well as lack of pedagogical content knowledge (PCK) and skills to conduct such lessons. The reasons given by these scholars are alike to the findings made in Namibia (Asheela, 2017). The literature discussed above suggests that when it comes to the topic of practical investigations, most of us will readily agree that it is not well implemented in science classrooms. Where this agreement usually ends, however, is the question of how to implement an inquiry-based approach through practical investigations in our classrooms to promote scientific inquiry. Essentially, the Predict-Explain-Explore-Observe-Explain (PEEOE) approach could be one of the approaches which might help to address this.

Thus, for the purpose of this study, an attempt was made to mediate the learning of enzymes through an inquiry-based approach using, in particular, the PEEOE approach.

The PEEOE approach is a teaching approach which is compatible with mediating scientific inquiry involving these stages: predict, explain, explore, observe, and explain. During the prediction stage, learners think about and suggest what will happen during an investigation. They write their thoughts down as they predict. As explained by Kibirige and Osodo (2014), the information presented during the prediction stage, is important as it helps the teacher to locate learners' prior knowledge. Pivotal to teaching and learning, learners' prior knowledge assists the teachers to teach in relation to what learners already know. In the explanation stage, the learners have to provide explanations for their predictions (Roschelle, 1995). Thereafter, learners explore by conducting hands-on activities, investigating, collecting data and evidence. During the observation stage, the learners observe what the outcome of the experiment is and write explanations thereof. They then discuss their observations, while concurrently they check their predictions against their observations. At this stage, the learners have two ideas, one they obtained from their observations, and one from existing scientific knowledge. Finally, the learners then have to provide explanations for their observations, using the scientific knowledge which is in existence to make sense of their observations (National Research Council, 2000). The activities involved in the PEEOE approach, fit in well with the essential features of inquiry, explained by the National Research Council (2000). It provides that, when learners are engaged in inquiry, they describe objects and events, ask questions, construct explanations, test those explanations against current scientific knowledge and communicate their ideas to others (National Research Council, 2000).

Taking into account that science classrooms face a lack of resources as a hindrance towards the promotion of inquiry (Asheela, 2017; Dudu, 2017; Nompula, 2012; Ramnarain & Hlatshwayo, 2018), an understanding of the use of cultural practices such as that of making *oshikundu*, which is the focus of this study, could be useful to mitigate constraints in resources. This study acknowledges the earlier studies in the literature that have shown a positive relationship between cultural practices and science concepts taught in science classrooms (Mutanho, 2016; Nikodemus, 2017; Paulus, 2017). These studies confirm that cultural practices indeed are useful in teaching science concepts, though many science teachers in Namibia do not make use of them in their classrooms (Nikodemus, 2017; Shetunyenga, 2019; Simasiku, 2017). Thus, I suggest that in the event that the use of an inquiry approach is hindered by lack of resources, teachers need to make use of indigenous knowledge as an alternative in their classrooms. It is against this background that this study sought to engage Grade 8 Life Science teachers in an intervention on how to integrate indigenous knowledge during their lessons, using an inquiry approach to mediate the concept of enzymes. Having learnt about the requirements of the curriculum concerning the concept of an inquiry approach and knowledge, let us look at what the Grade 8 Life Science syllabus says about teaching of enzymes as a concept, as the purpose of this study was to try exploring better ways of teaching it.

1.2.2 The requirements of the Grade 8 Life Science syllabus in terms of enzymes

To ensure that learners are well prepared to take up career paths in the biological sciences such as Biotechnology, Biochemistry, and Microbiology, the Grade 8 Life Science discipline introduces the topic of chemical digestion. Within this topic, learners are introduced to the concept of enzymes. The concept of enzymes is part of the Grade 8 Life Science syllabus. The syllabus requires the learners to be able to "distinguish between chemical and mechanical digestion" (Namibia. MEAC, 2015, p. 19). The topic of chemical digestion where enzymes is located forms an important core knowledge for Life Science Grade 8 learners. Understanding this concept is important since for learners to understand what chemical digestion is, they first need to know what an enzyme is and how it functions. Yet, while the learning of enzymes is important, in Grade 8 Life Science classrooms, the objective which requires teaching of enzymes is presented implicitly in the syllabus: "Distinguish between chemical and mechanical digestion" (Namibia. MEAC, 2016, p. 19).

The concept chemical digestion is a complex concept. Thus, one needs to have sufficient subject matter knowledge of chemical digestion and its associated concepts, to be able to know that enzymes are a component of chemical digestion. What is worrisome is that teachers with insufficient subject matter knowledge and less experience in teaching the concept of enzymes, might find it difficult to enact this objective (Aydin, Boz, Friedrichsen, & Hanuscin, 2012; Davidowitz & Rollnick, 2011). The problem presented above creates a gap. That is to say it suggests that there is a need for current Grade 8 Life Science teachers, notably those who do not have experience in teaching Biology Grade 11, to be deeply engaged with the current Grade 8 Life Science syllabus.

It must be remembered that the concept of enzymes was previously only taught in Biology Grade 11 and 12 syllabi; it was newly introduced to the Grade 8 Life Science syllabus in 2015 which was enacted for the first time in 2017. As a result, only those teachers who have experience in teaching Biology Grade 11 and 12, are experienced in teaching the concept of enzymes. In contrast, those who lack that experience might find it difficult to teach this concept. What make it more difficult is that the objective is implicitly presented which once again makes it complicated. To close this gap, the current study sought to engage the Grade 8 Life Science teachers with the relevant basic competency where the concept of enzymes is concerned.

As learners are taught this ability, literature reveals that they find it difficult to comprehend the concept. In addition, learners do not perform well in this concept. For instance, Nakale (2012) reported that learners grapple with the scientific terms used in the topic of enzymes, as well as the understanding of the topic itself. Furthermore, the Biology examiners' reports of 2015, 2016, 2017, and 2018 (see Appendix G) confirms that, indeed, the topic of enzymes needs attention. Some of the remarks made in the Biology examiners' report of 2018 (Namibia. Ministry of Education), as well as the importance to learners that they understand this topic, both warrant an intervention on how to teach this concept. One comment (p. 48) reads as follow:

> Learners could not define the concept enzyme correctly; they do not know the difference between enzyme and substrate; they fail to spell the term substrate and different names of enzymes correctly.

This extract reveals the learners' current understanding of the concept of enzymes at a senior secondary level. From this extract one would agree that learners struggle with the topic. Thus, this study saw it as imperative that this concept is well introduced to the learners in Grade 8 Life Science classrooms. In this regard, the focus of this study was to find ways to introduce the concept to the learners in such a way that they could comprehend it (Shulman, 1986). I used the cultural practice of making *oshikundu* as a vehicle to achieve this goal. Essentially, the cultural practice of making *oshikundu* was chosen on the grounds that the process of making *oshikundu* is seen as a suitable content representation, which has the potential in enabling mediation of learning of the concept of enzymes in Grade 8 Life Science classrooms (Mavhunga & Rollnick, 2013; Mavhunga, Ibrahim, Qhobela, & Rollnick, 2016). Admittedly, the knowledge of enzymes is needed for secondary and post-secondary science courses such as Biochemistry, Biotechnology and Molecular Biology. Beyond these benefits, learners might also acquire knowledge of the application of enzymes in their daily lives, as proposed by Novo, Casanoves, Garcia-Vallve, Pujadas, Mulero and Valla (2016).

The discussions above explored the relevant studies that help to provide an insight into the observations made on the concept of scientific inquiry and enzymes in science classrooms. These studies shed light on the topic, which enabled the current study to take its stand on how to mitigate the issues raised in these studies. Thus, with the discussions about scientific inquiry and enzymes above, let us now turn our focus to the knowledge which the Namibian education system suggests for inclusion.

1.2.3 The call for using indigenous knowledge in Namibian classrooms

The Namibian National Curriculum for Basic Education [NCBE], (2016) calls for knowledge which embraces indigenous or local knowledge and culture. This call is further emphasized by the Grade 8 and 9 Life Science syllabus (Namibia, MoE, 2015). The syllabus suggests teachers to have a holistic view of the learners, and to value the learners' life experiences. This is because, learners do not come to school like empty vessels to be filled with information, as they had many experiences including those from home and they are already learning NCBE, (2016, p. 39). Their life experiences forms part of the the knowledge which they have. In essence, some of this knowleledge is generated through the cultural practices in their homes. Essentially, the knowledge they obtain through these practices represents their cultural heritage (Cocks, Alexander, & Dold, 2012) which becomes part of their indigenous knowledge. Gay (2010) explains that the learners bring this knowledge to the school. As a result, the curricullum provide for this knowledge to be used in teaching and learning as it suggests that the starting point of teaching and learning should include this knowledge. Such an approach to teaching and learning resonate well with the constructivist theory which recognizes that knowledge is socially constructed and is gained continually from more knowledgeable other (MKOs) in their families or community, and through interaction with the environment (Vygotsky, 1978).

Central to the constructivist theory is the learner-centred education approach which is the overarching philosophy that informs teaching and learning in Namibian classrooms (Nambia. Ministry of Basic Education Sport and Culture [MBESC], 2003). This approach create a shift from the traditional way of teaching where the teacher is viewed as the autocratic knower and the learner as the unknowing, controlled subject, that study and memorize without understanding what the teacher knows (Nyambe, 2008). But rather, the teachers acknowledge their roles as facilitators in a learner-centered classroom where learners take ownership of their ideas (Awe & Kasanda, 2016; Nhase, 2019).

It is believed that using learners indigenous knowledge to teach scientific concepts have a positive contribution (Mutanho, 2016; Nikodemus, 2017; Paulus, 2017). For instance, Roschelle, (1995) explains that this helps the learners to add new knowledge to their existing knowledge (Roschelle, 1995). This benefits are also confirmed by Rennie, Goodrum and

Hacking (2011) who explained that drawing on learners' prior experiences helps the learners to make the most out of the science they receive at school. This is enhanced as learning becomes more authentic and relevant to the learners (Mavuru & Ramnarain, 2017). Furthermore, teaching that draws on learners' out of school experiences, such as practices that are done at home, assist the learners to realise that science is embedded in their daily activities (Oluruntegbe & Ikpe, 2011). What is more, the transition (border crossing) from home experiences to classroom science becomes smooth which make learning easier (Aikenhead & Jegede, 1999). These literature demonstrate that the use of cultural knowledge such as indigenous knowledge contributes positively towards teaching and learning in science classrooms. It is for this reason that Mhakure and Otulaja (2017) place emphasis on teaching that draws on the learners' cultural knowledge.

Given these benefits, the curriculum warns against the danger of ignoring this valuable knowledge, as it explains that teaching which does not build on learners' experiences might limit the learners' thinking, and the learners might not see the connection between the world outside school and what is taught and learnt at school (Oluruntegbe & Ikpe, 2011). In adition,

The curriculum thus warns the danger of ignoring this valuable knowledge as it explain that, teaching which does not build on those experiences, will limit the learners thinking, and the learners will not see the connection between the world outside school and what is taught and learnt in school. In consequence, learners will only learn through memorization, whereby some will remember what they have repeated many times, while most of them will forget it sooner or later and such knowledge is quite meaningless (NCBE,2016).

With the knowledge I shared here, I now discuss my personal experience as a teacher in relation to how I experience these concepts, indigenous knowledge and scientific inquiry in particular.

1.3 My Personal Experience as a Teacher

During my 11-year teaching career as a Life Science Grade 8-10 teacher and Biology Grade 11-12 teacher, I had a belief that the use of practical investigations in my lessons enhanced learners' understanding of the scientific concepts being investigated. Hence, I made an effort to teach my learners in this way and I was always happy with their participation, as well as the outcome of their class tests. Learners also seemed to enjoy my lessons, as they always pointed out that Life Science had a lot of content but were happy for the assistance, they were getting in learning the subject.

Notwithstanding, while this was the case, the end of year results for my Grade 10 learners, did not always correlate with the effort I put in mediating the learning of the subject matter knowledge (SMK). For instance, quality symbols of A and B were seen less often than C and D symbols. Statistically, the A-B symbols were only achieved by six learners out of a class of 41 learners. The remaining 35 learners were graded with either C or D symbols.

This was frustrating and it created an uphill battle which I had to fight, in an attempt to close such a gap in my learners' achievements. Moreover, even though the syllabus requires the learners to carry out investigations, reflecting on my own teaching, I always provided detailed, cookbook style practical work where the steps were clearly outlined and the questions were given at the end of the activity, something that has been critiqued by Hodson (1990). From my observations, the learners enjoyed the practical activities and they seemed to enjoy the process of doing hands-on activities. In hindsight, however, what I did not realise was that the amount of learning that these activities could deliver was limited. Furthermore, even though I attempted to conduct practical investigations in my lessons, it was not always possible to conduct all the practical work, due to the school's lack of materials.

It was not until I joined Rhodes University doing a Bachelor of Education (BEd Honours) Science elective course in 2015, that I was exposed to Asheela's (2017) study on the use of easily accessible resources to conduct hands-on practical activities. Such an experience made me realise that the lack of conventional materials should not limit one to conduct practical investigations. Essentially, the environment has materials which teachers can easily access and use in their classrooms (Asheela, 2017). In Asheela's (2017) study, for instance, I was exposed to doing experiments, such as how to test for carbon dioxide by placing a burning splint over a bottle of fermented *oshikundu,* how to produce hydrogen gas and many more. It is from this study that I learned the different scientific concepts associated with the process of making *oshikundu.* Relating the process of making *oshikundu* with my role as a Biology/Life Science teacher, this practical activity created curiosity within me to embark on a journey which would explore how the process of making *oshikundu* could be used to mediate learning of the concept of enzymes, which is one of the problematic topics raised in the Grade 12 Biology examiners' reports (see Section 1.2.1).

In addition, in 2016 whilst at Rhodes University, I was also introduced to the concept of indigenous knowledge. This was a mere introduction to the concept, and I did not have enough information on how to use this knowledge in my lessons. When I joined Rhodes University as a full-time student in 2018, once again during a lecture which was given on the use of indigenous knowledge to mediate electrostatics, I was exposed to the concept of indigenous knowledge. The lesson was as an eye-opener for me and provided some more insight on how to best make use of learners' home experiences to mediate learning in science lessons. The knowledge on the use of easily accessible resources was further strengthened in 2018 when I attended a workshop at the Chemistry Department of Rhodes University, where experiments on concepts such as the production of nitrous oxide, carbon dioxide, decomposition of permanganate and oxidation were conducted. Notably, all these practical activities made use of easily accessible resources.

Having discussed my experience, I now present the problem of the study. Merriam and Tisdell (2016) point out that it would be fruitless to embark on a research journey without first identifying a research problem. What follows is the problem which this study tried to address.

1.4 Statement of the Problem

Creswell (2014) indicates that a research problem is a problem or issue that leads to the need for a study. It can originate from many sources such as the personal experience of the researcher, extensive debates in literature, gaps in literature or alternative views that need to be studied. The Namibian curriculum encourages Life Science teachers to integrate indigenous knowledge in science classrooms. Additionally, it also encourages teachers to promote scientific inquiry in their classrooms. However, it does not provide clear guidelines how Life Science teachers should go about using local knowledge and how to promote inquiry-based approach. It is against this background I sought to mobilise the indigenous practice of making *oshikundu* to mediate learning of enzymes and to promote inquiry.

1.5 Significance of the Study

This research is a qualitative case study, the focus of which was on the promotion of scientific inquiry to mediate learning of the topic of enzymes. The cultural practice of making *oshikundu* was used as a vehicle in this regard.

This study could be of value in addressing the aspects of science teaching in the Namibian context – namely, the implementation of an inquiry-based approach. A further potential value of this study is that it might hopefully contribute to the field of science teaching in Namibia. That is, the participants might get some insights on how to mediate the learning of science concepts – enzymes in the context of this study – and draw on locally found materials, such as the process of making *oshikundu*. Together with the participants, we might also be afforded an opportunity to learn what is meant by an inquiry-based teaching and learning approach and how to best use it in our Namibian classrooms as a teaching method. Furthermore, both the participants and I could also have an opportunity to improve our pedagogical content knowledge (PCK) on the topic of enzymes and an inquiry-based approach, which might positively contribute to our personal pedagogical content knowledge (Carlson & Daehler, 2019).

1.6 Research Goal and Questions

This section presents the research goal, the main research question and the sub-questions.

1.6.1 Research goal

The main goal of this study was to mobilise the indigenous practice of making *oshikundu* to mediate learning of the concept of enzymes and to promote an inquiry-based approach in Grade 8 Life Science classrooms. To achieve this goal, the research was guided by the following main research question:

1.6.2 The main research question

How can the process of making *oshikundu* be mobilised to support Grade 8 Life Science teachers' understanding of the concept of enzymes and an inquiry-based approach?

To answer this question, the following sub-research questions were addressed:

1.6.3 Research questions

1. What lessons can Grade 8 Life Science teachers learn (or not) about enzymes and an inquiry-based approach through co-analysing the curriculum documents?
2. How does the practical demonstration of making *oshikundu* by an expert community member enable and/or constrain Grade 8 Life Science teachers' interactions, participation and understanding of the enzyme concept?

3. How does using the process of making *oshikundu* and the PEEOE model enable and/or constrain Grade 8 Life Science teachers' understanding of an inquiry-based approach?

1.7 Theoretical Framework

Biesta, Allan and Edwards (2011) suggest that the importance of theory is to make things which might not be, visible or realised. Due to this quality, a theoretical framework serves as the structure of support for the rationale of the study, the problem statement, the purpose, the significance and the research questions (Grant & Osanloo, 2014).

This study was informed by two theories. Vygotsky's (1978) sociocultural theory which acknowledges social primacy in all human developmental processes and Shulman's (1987) Pedagogical Content Knowledge (PCK), which is believed to be the knowledge that teachers develop over time and through experience, on how to teach content in a way in order to enhance learning.

1.8 Data Gathering Techniques

Four data gathering techniques were used to gather data for this study. These techniques were:

- Document analysis;
- Workshop discussions;
- Participatory observation; and
- Journal reflections.

1.9 Definition of Key Concepts

Enzyme: Biological catalyst that speeds up the rate of chemical reaction.

Indigenous knowledge: The inherited information and practices of the indigenous people which they have survived on for a long period of time (Mapara, 2009).

Pedagogical Content Knowledge (PCK): A concept which describes the knowledge which teachers have in terms of pedagogy and subject knowledge (Shulman, 1986).

Scientific inquiry: The different ways which scientists study the natural world and propose examinations based on evidence from their work (Namibia. MEAC, 1996).

Scientific process skills: The skills which are involved in doing science (Nhase, 2019).

Practical activities/investigations: Any science teaching and learning activity in which learners are working individually or in groups, handling and observing the objects or materials they are studying (Millar, 2010).

Sociocultural theory: A theory which emphasises that knowledge is acquired through social interaction (Vygotsky, 1978).

Social interaction: The process by which we act and react to those around us, as well as the environment (Vygotsky, 1978).

1.10 Thesis Outline

This thesis is comprised of seven chapters.

Chapter One: This chapter provided the background of the study and explained the reasons for carrying out the study. The statement of the problem was given which further provided an overview of why the phenomena under study was worth researching, which was further articulated in the significance of the study. In addition, this chapter provide the requirement of the curriculum regarding scientific -inquiry, teaching of enzymes in grade 8 Life Science classrooms, as well as indigenous knowledge. Furthermore, in this chapter, an outline of the research goals and the research questions that guided the study is provided. The theoretical frameworks and data gathering techniques were introduced and the key concepts of the study were defined as well.

Chapter Two: This chapter reviews the literature relevant to the study to illuminate what has been researched already. Literature around the concept of scientific inquiry and enzymes are discussed in this chapter. In addition, literature around professional development and hands-on activities are also discussed.

Chapter Three: The theoretical frameworks underpinning this study, Vygotsky's sociocultural theory and Shulman's PCK, are discussed in this chapter. The relevance of these theories to this study is explained.

Chapter Four: This methodology chapter describes the research design and methodology employed in this study. In addition, a description of my position in this study as the researcher is also provided. The goal and questions are also outlined. Furthermore, the research site and the participants in this study who were purposefully chosen to be part of the study are described. Similarly, data gathering techniques such as document analysis, workshop discussions, participatory observation and reflections are also discussed. The analysis of the data employed is described.

Chapter Five: Data presentation, analysis and the lessons that Grade 8 Life Science teachers learnt (or not) about enzymes and inquiry methods through analysis of curriculum documents are discussed in this chapter.

Chapter Six: Data presentation, analysis and discussions in relation to how the practical demonstration of making *oshikundu* and TSPCK components enabled and or constrained the teachers' interaction, participation and understanding of the concept of enzymes is discussed. In addition, I also present, analyse and discuss how the process of making *oshikundu* enabled or constrained the teachers' understanding of an inquiry-based approach.

Chapter Seven: This chapter summarises the main findings of the study. It also presents some recommendations and limitations from the study. Areas for further research are discussed in this chapter, and it also provides a summary of my reflections. This chapter ends with some conclusions.

1.11 Chapter Summary

This chapter set the stage for introducing the reader to the study. Literature from various studies, together with the curriculum, were discussed, which provided insight into the need and importance of carrying out this study. In addition, the theory and methodology data analysis were highlighted, to provide the design of the study. Most importantly, the thesis outline acts as a road map, giving the reader an overview of the thesis by introducing each chapter and what it entails. In the next chapter, I discuss literature relevant to this study.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

This study aimed at mobilising the indigenous practice of making *oshikundu* to mediate learning of enzymes and promoting the use of an inquiry-based approach in Grade 8 Life Science classrooms. In the previous chapter, I presented the context of this study and explained the reasons for carrying out the study which subsequently provided the importance of the study. The purpose of this chapter is to discuss and explore the various studies and the literature on the concept of enzymes and scientific inquiry. As indicated earlier, the focus of this study is on teachers learning about the use of an inquiry-based approach in their classrooms. However, there are less studies on teachers learning of inquiry methods and approaches, with the result being that, most literatures used in this study, are on how inquiry approaches help the learners in their learning. In exploring these literatures for my study, I also identified the gaps on the use of inquiry-based approaches and teaching of the concept of enzymes in Grade 8 Life Science classrooms. Besides that, I also explained how the current study sought to address those gaps. Regarding the concept of enzymes, there is limited research about teaching of this concept in the Namibian context. As a result, most literature is from and on, international studies. As this study focused on the concept of inquiry, the term scientific inquiry refers to the processes involved in inquiry – on the other hand, the concept inquiry-based approach is used as a pedagogical approach.

2.2 Teaching of enzymes

The concept of enzymes is defined in various ways by different authors. For example, Saperas and Fonfria-Subiros (2011) define enzymes as proteins that act as biochemical catalysts and that increase the rate of specific reactions by several orders of magnitude. On the other hand, Ramirez-Paz, Ortiz-Andrade, Griebenow, and Diaz-Vazques (2017) define an enzyme as a protein (and sometimes RNA) that catalyses biological reactions and as a result accelerates chemical reactions occurring in living systems. In the context of this study, an enzyme is considered as a catalyst which is used to speed up the rate of chemical reaction (fermentation of *oshikundu*), and that without its intervention the process of fermentation would proceed extremely slowly.

The concept of enzymes has been investigated before. Some of these studies were conducted at universities (House, Meades, & Linenberger, 2016; Novo et al., 2016) while others were conducted in secondary schools (Nakale, 2012; Putica & Trivic, 2017). All these studies revealed the kind of representations they used to help their students or learners to make sense of the concept of enzymes. At the university level, Tibell and Rundgren (2010) suggest that what makes the understanding of the concept of enzymes difficult, is the fact that the concept is unobservable which makes it appear abstract to the students. To assist the learners by visualising the phenomena (enzyme), studies revealed that the teachers made use of analogies. For instance, in Orgill, Bussey, and Bodner's (2015) study, the lecturers made use of an analogy to teach how substrates and enzymes interact with each other. In their study, the lecturers compared how a glove can accommodate people's fingers, to show how the enzyme accommodates a substrate. This was material known by the students and as such students could relate and understand the concept better.

Likewise, the use of analogies were also used in other studies. For instance, a study conducted with pre-nursing students in the United States by House, Meades and Linenberger (2016), revealed that one of the concepts around enzymes which students grapple to understand is enzyme substrate interaction and inhibition. Their study thus made use of a guided inquiry activity, which involved using coins of different sizes as an analogy to help develop the students' conceptual understanding, of factors impacting enzyme kinetics and various types of enzyme inhibition.

At secondary school level, Putica and Trivic (2017) who conducted their study in Serbia, the teachers made use of learners' prior knowledge which they acquired from different subjects to mediate learning of the concept of enzymes. A teacher, for example, made reference to the use of alcohol and food intolerance to elaborate why certain foods have a particular taste or why other foods are easier to digest than others. The study reported that the approach used contributed to the learners conceptual understanding of the concept of enzymes.

Looking at the literature written on teaching of enzymes, there are only a few examples of research on teaching of enzymes in Namibian classrooms, with only Nakale's (2012) study so far being recorded. In his study conducted in Namibia, Nakale (2012) found that the teachers made use of two approaches when teaching the concept of enzymes. Firstly, some teachers made use of learners' prior knowledge to teach the role of enzymes in seed germination. In particular, one teacher made reference to, for example, how seeds are sown at home and what happens to them to eventually germinate. This is a practice which the learners would have been familiar with at their own homes. As a result, learners were given the opportunity to study a concept in relation to their home experiences. This way of teaching as espoused by Mavuru and Ramnarain (2017) creates an opportunity to make learning experiences more authentic, and relevant to the learners. They further explain that learners' interest in the subject is stimulated and their understanding of the concept under study is also enhanced. Secondly, some made use of storytelling as an analogy to introduce the properties of enzymes. Besides that, Nakale also found that some of the teachers he observed carried misconceptions which were revealed in the work that they presented to the learners. In addition, he also observed that some teachers had poor subject matter knowledge (SMK) which influenced the content knowledge which they presented to the learners.

The findings from this study revealed information that suggested the gap in those studies. To illustrate, Tibell and Rundgren's (2010) findings suggested that the concept of enzymes was indeed problematic to learn. It further suggested that there was a need to use various approaches to teach the concept of enzymes. One could also assume that the teachers might have insufficient SMK of enzymes which made it difficult to teach the subject (Aydin et al., 2012; Davidowitz & Rollnick, 2011). Thus, for those reasons, the current study made use of an authentic example, the process of making *oshikundu* to help mediate the concept of enzymes.

Furthermore, the pedagogical approaches used in these studies in the above paragraphs, involved the use of analogies and learners' prior knowledge to assist conceptual understanding of the concept of enzymes. However, they did not involve the learners in practical investigations, but instead the teachers used the traditional method (teacher talk) to illustrate the concept of enzymes to the learners. This too created a gap that my current study sought to close. To illustrate, this current study made use of practical investigations, providing the teachers with the opportunity to compare abstract enzyme concepts with an experience where the teachers could manipulate materials.

Additionally, in my study, the focus was on teachers being supported to learn about inquiry approaches. Essentially, this study drew on the seminal work of Maselwa and Ngcoza (2003) and used the predict-explain-explore-observe-explain (PEEOE) approach to provide an insight into inquiry approaches (see Section 1.1.2). Essentially, the PEEOE approach is a teaching approach which is compatible with mediating scientific inquiry involving the stages of predict, explain, explore, observe, and explain. During the prediction stage, learners think about and suggest what might happen during an investigation. To achieve this, the process of making *oshikundu* was used as a vehicle. The process of making *oshikundu* is an indigenous practice known both by the teachers and learners in the schools where the study was conducted. It is recognised, however, that they might not be aware of the science concepts embedded in this cultural practice. It is prudent therefore for science teachers to understand how local or indigenous knowledge could be integrated in science lessons.

2.3 Local or Indigenous Knowledge

A large body of literature calls for the inclusion of local or indigenous knowledge (IK) in school curricula, in particular within science (e.g., Aikenhead & Jegede 1999; Baquete, Grayson, & Mutimucuio 2016; Ogunniyi & Ogawa, 2008). These scholars suggest that including IK in curricular could be beneficial in many ways. For instance, Aikenhead and Jegede (1999) suggest that IK can be used to enable border crossing between home and school science. Concurring, Govender (2014) suggests that integrating IK in science classrooms can lead to learners becoming motivated to learn science. Furthermore, it increases learners' participation in classrooms (Naidoo, 2010; Sedlacek & Sedova, 2017). Likewise, Kibirige and van Rooyen (2006) agree that science teaching is enriched when IK is used as indigenous prior knowledge in the classroom and can thus be used as a starting point to explore concepts associated with Westernised Science (WS).

Westernised Science is described by Jegede (1997) as Eurocentric science or modern science which originated in Europe and then spread to the rest of the western world and other non-western countries. He argues that *western culture* sees modern science as the only path of knowledge acquisition and thus separates non-western thoughts and ideas from the body of science, even though they also contribute to teaching and learning of science concepts. The recognition of IK in science classrooms led to scholars embarking on studies that made use of IK to mediate learning of science content knowledge. This is observed in findings from various studies conducted in Namibia. For example, Nikodemus (2017) made use of *Oshikundu* to teach rates of reactions; Nanghonga (2012) made use of cultural beliefs around lightning to mediate learning of static electricity; Uushona (2013) made use of *Ombike to* mediate learning of fermentation and distillation; and Asino (2012) made use of *Oshimumu* to mediate caring of teeth and prevention of tooth decay. In South Africa, Kuhlane (2011) used learners' home experiences to mediate the concept of acids and bases. These studies confirmed that learners were able to make links between their experiences which subsequently increased their level of engagement. Learners asked more questions and eventually understood the concepts better. However, all these studies focused on learners. Yet, using IK in science classrooms could be challenging to science teachers and the views that the teachers hold towards the inclusion of IK can also pose challenges relating to its inclusion.

In their study Mukwambo, Ngcoza and Chikunda (2014) revealed that there are some challenges in integrating IK in the science curriculum. This is due to IK being implicit in nature and usually accompanied by some ‘myths’ that are not scientific. It is for this reason that scholars argue and warn for the proper use of IK in science classrooms. In this regard, Southerland (2000) points out that forcing all forms of knowledge about nature and naturally occurring events into the construct of science, sets no boundaries for the limits of the science discipline. Taking the argument further, some scholars such as Cobern and Loving (2001), Hodson (2009), Horsthemke and Schafer (2007) and Webb (2013), warn against the assumption that anything using the label ‘indigenous’ should automatically be accepted and embraced as science. Nikodemus (2017) also believes that not all cultural beliefs and practices are scientific. When the beliefs and cultural practices contain non-scientific elements, Kibirige and van Rooyen (2006) suggest that learners should be allowed to debate such cultural beliefs to minimise misconceptions and confusions in the classroom. Misconceptions are defined as individuals’ ideas about the world around them that do not agree with scientifically accepted understandings (Darling-Hammond & Bransford, 2008). Southerland (2012) refers to such ideas as pre-conceived ideas that learners have about a phenomena which they have developed through their interaction with the environment.

In cases when learners’ cultural beliefs are non-scientific, Webb (2013) suggests that teachers should show that they value such cultural beliefs by discussing them. Of a similar sentiment, Mukwambo et al. (2014) advise teachers to engage with those non-scientific ideas in their classrooms, while Cyr and Potvin (2017) discourage teachers from labelling them as wrong ideas. Cyr and Potvin (2017) indicate that this is because, while those beliefs could be considered non-scientific in some context or topics under discussion, they could be accepted in other contexts. Given the nature of this study, which will relate to the cultural practices and beliefs teachers have around *oshikundu,* it is likely that teachers’ beliefs could have non-scientific understandings. Thus, to account for that, it is vital for this study to engage teachers in a workshop to prepare them on how to deal with such issues in their classrooms. This was done by engaging the teachers with the content specific components of learners’ prior knowledge (Mavhunga & Rollnick, 2013). In addition, the practical experiment which was conducted may also provide evidence against those pre-conceived ideas that are at odds with the scientific explanations being promoted in the curriculum. Pre-conceived ideas are of value as they provide opportunities for learning and they encourage discussions that involve arguments, questions, and a critical analysis of views which do not only contribute to understanding of science, but also to the enhancement of higher order thinking skills (Greasser, Person, & Hu, 2002; Vygotsky, 1978).

While the curriculum formulation has been pointed out as contributing to the poor implementation of IK in science classrooms, it is believed that teachers' views towards the inclusion of IK also play a significant role (Cronje, de Beer, & Ankiewicz, 2015; Govender, 2014; Ogunniyi & Hewson, 2008). Thus, it is suggested that for the successful implementation of IK in science classrooms, it is important to help teachers to understand the nature of science (NOS) and the nature of indigenous knowledge systems (IKS) (Ogunniyi, 2007). This could be done by engaging science teachers in long-term mentoring and dialogue to show them how to translate knowledge of the two systems into classroom practice (Ogunniyi, 2007). The workshop discussions planned for this study were therefore intended to afford us an opportunity to get an understanding of what IK is and how best we can include it in our classrooms. The indigenous practice of making *oshikundu* was used as a vehicle to achieve this.

2.4 The Indigenous Practice of Making *Oshikundu*

Namibia is a multicultural country with diverse cultures. These cultural groups practice a variety of cultural and traditional practices. For instance, one of the common traditional practices of the Aawambo people is the making of a traditional non-alcoholic beverage called *oshikundu* also known as *ontaku.* The traditional art of making *oshikundu* has been passed on orally from generation to generation (Embashu, Cheikhyoussef, Kahaka, & Lendelvo, 2013; Kasanda & Kapenda, 2015; Kibirige & Van Rooyen, 2006). It is hoped that the current learners in our classes are familiar with this cultural practice. Kasanda and Kapenda (2015) however, bemoan that this knowledge is not documented and so there is a danger that it could be lost or distorted. Thus, bringing it into the classroom as a teaching aid, might just be one of the ways of ensuring that this knowledge remains in our society. Moreover, using this knowledge to mediate science concepts, might also help to bring about the realisation of the importance of our cultural heritage as espoused by Cocks et al. (2012). Thus, in my view, and in line with culturally responsive pedagogies (Mhakure & Otulaja, 2017), the science embedded in the cultural practice of making *oshikundu* could be optimally used by teachers in their science classrooms to contextualise science lessons.

There is a body of literature on *oshikundu* (Asheela, 2017; Embashu, 2014; Hepute, Embashu, Cheikhyoussef, & Nantanga, 2016 ; Nikodemus, 2017). For instance, Embashu's (2014) study focused on the nutrient content and microbial composition of *oshikundu.* He describes o*shikundu* as a traditional cereal based fermented, non-alcoholic beverage (alcohol content insignificant), made with water, *mahangu* flour, *uushutu* and malted sorghum flour (*ongundo*). In the absence of malted sorghum flour, malted *mahangu* flour is used (Hepute et al., 2016). As explained in Lyumugabe, Gros, Nzungize, Bajyana and Thonart (2012), malting is the germination of cereal grain in moist air under controlled conditions. The aim of malting is to promote the development of hydrolytic enzymes which are not present in ungerminated grain. The malting process involves steeping, germinating and limiting cereal seedling growth, once the enzymes have been produced for the degradation of starch and proteins in cereal grain (Lumugabe et al., 2012). The enzyme amylase which is produced during germination leads to the hydrolysis of starch and proteins which then releases sugar and amino acids (Adhikari & Acharya, 2015).

The first procedure of making *oshikundu* involves the production of the initial mixture by adding boiled water to the mixture of *mahangu* (called *uushutu*) which is then left to cool to room temperature (Asheela, 2017; Embashu, 2014; Nikodemus, 2017). Malted sorghum flour is then added to this cooled mixture. Dewar and Taylor (2000) explain that the purpose of adding malted sorghum flour to the cooled mixture is to prevent the inactivation of enzymes that are involved in the fermentation process, which are the yeast and lactic acid bacteria. After all, Nangia and Anderson (2012) explain that temperature controls metabolism through its effect on the rates of enzymatic reactions. Moreover, they explain that temperature does not only affect instrinsic reaction rates but also rates of diffusion of reactants, intermediates and products (Nangia & Anderson, 2012).

In addition, Nikodemus (2017) explains that *oshikundu* is diluted while cool, because if it is diluted while warm, then the enzyme activities are activated faster by the favourable temperature of the dilute. As a result, fermentation will be faster, making *oshikundu* sour at a faster rate. Dewar and Taylor (2000) further explain that when malting the sorghum, enzyme amylase is activated to break down starch in the grains into simple sugar. The sugar is then utilised by the lactic acid bacteria and produces lactic acid. This explain why fermentation is likely to take place when malted sorghum or malted *mahangu* flour is added to *oshikundu*, during the process of making *oshikundu*. Sugar is then utilised and produces alcohol (ethanol) (CH_3CH_2OH) and carbon dioxide (CO_2); thus, it should be noted that the practice of making *oshikundu* highlights the importance of the intersection of traditional practices and science and technology (Hepute et al., 2016). The focus of this study thus sought to explore how *oshikundu* could be used to mediate the Life Science/Biology concept of enzymes and to promote scientific inquiry.

These studies provided literature on the concept of *oshikundu.* The information they shared is relevant to this study as they provide the scientific view around the concept of *oshikundu*. This information played an important role in this study, as it helped to find the scientific reasons behind the practices which are involved in the process of making *oshikundu*.

2.5 Scientific Inquiry

Scientific inquiry broadly involves several approaches that scientists use to study and get a better understanding of the natural world. In this section, I review the existing literature on the concept of scientific inquiry, what literature says about its role in science classrooms, and the shortcomings when using this approach and suggestions thereof. It is thus hoped, that this will help to provide a foundation for the current study.

2.5.1 Nature of science

Science is both a body of knowledge that reflects the current understanding of the world, and a set of practices used to establish, extend and refine that knowledge (National Research Council, 2012). To Settlage and Southerland (2012), the phrase 'nature of science' refers to the unspoken assumptions that guide the actions of the scientists as individuals and as part of a large cultural group which takes part in shaping knowledge that science produces. The definition provided by the NRC (2012) indicates that science is a body of knowledge. This knowledge is established through the use of various practices and procedures. To Bosman (2016) and Nhase (2019), these involve the use of scientific process skills. Essentially, it is when the learners in our classrooms make use of those skills that they practice how to develop scientific knowledge as little scientists (Nhase, 2019).

Additionally, the Next Generation Science Standards (National Research Council, 2013, p. 1) defines science as "a human endeavour which tries to address questions about the natural and material world". To Harlen and Qualter (2018), this could mean that science is a form of learning which is question driven which normally develops from curiosity. In these paragraphs I discussed what science is. In this section I have also discussed the nature of science. From these discussions it is clear that_science is an activity done by humans with the aim of finding answers to questions. Drawing on the above literature, they also inform this study by agreeing that the knowledge of science is developed through the use of skills. In the context of my study, this means those skills that are observed in the school curriculum as scientific skills processes (Kandjo-Marenga, 2008; Nhase, 2019).

2.5.2 The nature of scientific inquiry

In this section, I will describe and discuss the concept scientific inquiry. As I examine this concept, I will point out the relevancy of it in science classrooms, highlighting its benefits. Next, I address the characteristics that make up an inquiry classroom. Finally, I highlight the challenges, as pointed out in literature, when using this approach.

The concept inquiry and nature of science are interrelated (Flick, 2006). As a result, it is a challenge to distinguish concepts related to the nature of science and scientific inquiry (Settlage & Southerland, 2012). In the book 'Scientific inquiry and Nature of science', Flick (2006, p. x) provides the intersection between inquiry and nature of science:

> Scientific inquiry refers to a variety of processes and ways of thinking that support the development of new knowledge in science. In addition to the *doing*, inquiry also refers to the knowledge *about* the process's scientists use to develop knowledge. This in itself is the nature of science.

In this study, a deeper understanding of the nature of science and how science should be taught using inquiry is imperative, as it is this understanding that shapes how science teachers teach science to their learners (Settlage & Southerland, 2012). This understanding ultimately also benefits the learners, as the learners are taught science in ways that they understand. I now return to the subject of an inquiry approach which this study considers as a pedagogical approach used to promote scientific inquiry.

An inquiry approach originated from a constructivist view of learning. Authors such as Deboer (2006) and Wells (2011) explain that an inquiry approach has been part of the educational landscape since the middle of the nineteenth century. The approach focuses on learners discovering information for themselves. The value in making learners discover things for themselves, is that in this form of learning, learners take an active role in creating knowledge and do not passively receive information from the teacher (Mkimbili, Tiplic, & Odegaard, 2017; Vygotsky, 1978). Due to such recognition, this pedagogical approach is still practiced in today's science classrooms. This was established in a more recent study which was conducted in South African classrooms. Nhase (2019) puts it that teachers still consider this approach important and she observed that they make use of it in their teaching. In her study, one teacher explained her motives in using the discovery approach as she indicated:

> Learners will be discovering things for themselves and that makes learning more meaningful, deepens understanding, and encourages a culture of asking questions. Furthermore, it broadens thinking and problem-solving skills. (Nhase, 2019, p. 207)

It is when the learners make use of problem-solving skills that they use the general skills used in scientific inquiry. To Deboer (2006), scientific inquiry is the general process of investigation that scientists use as they attempt to answer questions about the natural world. Scientific inquiry however involves more than processes which scientists employ. To Flick (2006), scientific inquiry refers to three things: the variety of processes and ways of thinking that support the development of new knowledge in science; a learner outcome that requires the learner to have the ability to use scientific processes, and the knowledge about these processes; and finally, a teaching approach that can be used to teach learners the subject matter of science. In view of these definitions of scientific inquiry, it is thus important to realise that, scientific inquiry is both a set of skills to be learned by learners which are combined when performing a scientific investigation and a teaching approach which is used to communicate scientific knowledge to learners (Lederman, Antik, & Bartos, 2014).

Thus, drawing on the seminal work of Deboer (2006), Flick (2006) and Lederman et al. (2014), in this study 'scientific inquiry' is used to refer to the general processes of investigation that scientists use as they attempt to answer questions about the natural world. In this case, the processes involved in the predict-explain-explore-observe-explain approach (Maselwa & Ngcoza, 2003) were used in this study (see Section 1.2). Likewise, the term 'inquiry approach' is used to refer to pedagogical approaches which allow the use and development of scientific inquiry. As a process, another characteristic of scientific inquiry is that it is a question driven learning process.

For instance, Harlen and Qualter (2014, 2018) explain that it is indeed questions which emege from curiousity that are the driving force for seeking explanations or information and also for making sense of the new information obtained through inquiry. Curiousity is viewed as a key character in learning science. To Contant, Tweed, Bass and Carin (2018), it is when learners stay curious when they start wondering about the phenomena they are studying, as they will be asking the 'why' questions. Sharing similar thoughts, Bosman (2016) and Nhase (2019) stress that it is important to stimulate learners' curiousity at earlier schooling years, as learners at this stage are active and curious in nature. Above all, humans are naturally inquisitive (Deboer, 2006) and thus, Contant et al. (2018) and Nhase (2019) opine that allowing learners to stay curious plays a major role, as it leads to both creative and critical thinking abilities, which are foundational learners' skills leading to the learning and loving of science.

In addition, questions also play other vital roles in inquiry classrooms. For instance, Meier (2016) explains that questions help to ascertain the status of the learners' knowledge. This might be of benefit to the teacher using inquiry approaches in their classrooms. Essentially, in the context of this study, the teachers' questions would be used to assess the knowledge which they acquired during the intervention workshop (Meier, 2016). Given this, it is thus advisable that the teachers in this study were made aware of the importance of arousing learners' curiosity through inquiry which can be done by using approaches such as story telling, during the introductory phase of the lesson (Nhase, 2019). However, while questions seem to have a positive contribution towards teaching and learning, it should be noted that using questions alone should not equate to inquiry (Llewellyn, 2014).

Thus, posing questions to the learners and guiding them towards answering, cannot be equated with inquiry (Lee & Shea, 2016). Instead, for effective use of questions, it is advisable that teachers need to ask open-ended questions that lead learners to develop their own questions and design investigations that can answer their own questions (Killen, 2015). Still on the subject of questions in inquiry, it is also suggested that teachers' questioning skills can have fundamental problems in inquiry classrooms.

For instance, Harlen and Qualter (2018) argue that the structure of the question determines how the learners answer the question. To clarify, it was established that tricky questions are often misleading, and subsequently they discourage and inhibit learners from participating in the classrooms. Yet, I believe participation is key in inquiry-based classrooms, as learning is learner driven which makes it dependable on learner input (Mkimbili et al., 2017; Sedlacek & Sedova, 2017). Likewise, just as Meier (2016) puts it, ambiguous questions can also be unclear to the learners which could lead to further confusion. In my opinion, owing to the nature of inquiry-based classrooms which place the teacher in the facilitator role, the teacher in this regard might inevitably be forced to provide unnecessary explanations which could take away much of the learners' autonomy (Ramnarain & Hlatswayo, 2018). In addition, the answers which the learners provide might not be a true reflection of their understanding, which could further mislead the teacher (Meier, 2016).

What this literature means for a study which is aimed at promoting inquiry, is that the use of questions in inquiry classrooms can be challenging if not well considered. These authors however seem to be pointing to a need to create awareness within teachers and to support them on how to use questions in inquiry lessons in such a way, that they lead to learners developing their own investigative questions. An investigative question is one of the essential features of inquiry. The features of inquiry are discussed in the following section.

2.5.3 Characteristics of inquiry classrooms

For a classroom which is grounded in inquiry, there are several features that act as indicators to supporting inquiry. In the context of this study, the essential features from the NRC (2000) are key features that inform classroom inquiry. Essentially, these features are discussed one by one to provide teachers with the essence of what an inquiry-based classroom involves. These features are (National Research Centre, 2000):

a) Learner engages in a scientifically oriented question;
b) Learner designs and conducts scientific investigation;
c) Learner collects evidence and provides explanations for their evidence;
d) Learner links their findings and explanations to scientific knowledge; and
e) Learner communicates and provides reasons, arguments and justifications.

Sharing similar sentiments, Harlen and Qualter (2014) are also of the opinion that during practical investigations learners need to raise questions, predict and plan for the investigations, collect evidence through observations which needs to be analysed and interpreted, after which explanations need to be provided. Likewise, Bosman (2016) also suggests that in inquiry classrooms, learners use inquiry skills such as observing, asking questions, describing their observations, predicting, providing explanations, using tools, planning investigations, recording what happens during the observations, interpreting their findings, and communicating and sharing their ideas. In my view, all these aspects are encapsulated in the predict-explore-explain-observe-explain (PEEOE) approach discussed earlier on in Section 1.1.2. Granted, the nature of an inquiry-based approach in science classrooms, suggests that for effective implementation of this approach, teachers are required to have a high level of Pedagogical Content Knowledge (PCK), including a broad understanding of the nature of science (Flick & Lederman, 2004; Shulman, 1986).

2.5.4 The benefits of using a scientific inquiry-based approach

Teaching science through inquiry has proven to be beneficial to both learners and teachers alike (Bosman, 2016; Killen, 2015; Lamm, 2017; Nhase, 2019;).

Inquiry-based learning is very much aligned with a social constructivist view of learning (Harlen, 2015; Ramnarain & Hlatswayo, 2018) and a learner-centred approach, which is the overarching philosophy informing the Namibian education policy. This policy seeks to place the learner at the centre of learning while the teacher facilitates the learning process (Namibia. MEAC, 2016). That is to say, with this approach, learners have the opportunity to raise questions to suggest ways of answering them, to make predictions, to propose explanations, to collect evidence and to interpret it in relation to the question being investigated (Harlen & Qualter, 2014; Maselwa & Ngcoza, 2003).

In addition, through inquiry, learners learn science concepts in an authentic manner. This suggest that the learners are given the opportunity to explore the materials and the resources that they are learning (Deboer, 2006; Kuhlane, 2019). In doing that, Nhase (2019) and Lamm (2017) accentuate that with this approach, learning involves learners investigating and discovering knowledge. To put it another way, this shows that as learners discover knowledge, they construct new knowledge as independent thinkers (Lamm, 2017). Most importantly is the fact that this knowledge is not learnt through memorisation and therefore is not easily forgotten (Lamm, 2017) but rather retained (Blanchard et al., 2010; Easterly & Myers, 2011). In agreement, Schmid and Bogner (2015) reported that they found out that after a period of 12 weeks, the learners involved in their study proved that they had retained content knowledge which they obtained through inquiry education.

Moreover, learning through inquiry focuses on the why and how and less on the what, which gives learners the opportunity to gain a better perception of what science is and how it is practiced (Rooney, 2012). In my view, as espoused by Maselwa and Ngcoza (2003), as the teachers predict and provide explanations for their predictions, they will be addressing the how and why notion. It is also during their explanation stage when the learners test their findings against the existing knowledge of the scientists (Dixon, 2015). Furthermore, science is known for a poor return of learners or less amount of students who choose to further their studies in science disciplines. It is thus advised that allowing learners to learn science through inquiry, motivates them to learn science (Korganci, Miron, Dafinei, & Antohe, 2015; Osborne et al., 2010; Wells, 2011). Beyond this, learning through inquiry fosters learners' curiosity (Suarez, Specht, Prinsen, Kalz, & Tenier, 2018); contributes to the development of conceptual understanding in science concepts (Easterly & Myers, 2011; Lamm, 2017); and promotes learning of scientific inquiry skills (Killen, 2015; Nhase, 2019; Namibia. MEAC, 1996). Learning of these skills contributes positively to the learner both in their academic life, as well as other parts of their life were these skills will be required.

For instance, the approach may lead to the development of higher-order thinking skills such as analysis, synthesis, critical thinking and evaluation (Conklin, 2012). Indeed, these skills are important, as Bosman (2016) explains that with these skills, learners develop the ability to work in complex and unpredictable environments, making them more critical thinkers who are able to think at a higher cognitive level. In the same vein, the NRC (Namibia. MEAC, 1996) acknowledges that these skills benefit the learners as they need them in their daily life and will need them later as adults in jobs in industry. To this end, Ramnarain and Hlatswayo (2018) also agree that inquiry-based learning is key in preparing a workforce that is adaptable in its thinking and able to operate with greater autonomy. With much written on the positive contribution of inquiry approaches in learning science, it is recognised however, that there are challenges to teaching science using inquiry approaches.

2.5.5 Challenges associated with using a scientific inquiry-based approach

Depending on the context, literature reveals that science teachers carry different opinions regarding the challenges associated with the use of scientific inquiry. As Harmon (2011) puts it, some teachers are overwhelmed by the number of learners in the classroom, as they see the approach unsuitable for overcrowded classrooms. Not only is an overcrowded classroom a burden in terms of using an inquiry approach, but it also makes it difficult for teachers to share limited resources in an overcrowded classroom (Asheela, 2017; Dudu, 2017). To return to the subject of time, BouJaoude (2012) opines that the belief about the importance of preparation for examinations and the importance of covering the syllabus in time, has a powerful influence on the implementation of inquiry. That is to say, when teachers believe in teaching for exam preparation and feel urgency in covering the curriculum in time, they might be reluctant to make use of an inquiry approach. Beyond these, literature also reveals that teachers see the learners' cognitive abilities as a factor that determines whether or not to use inquiry in their classrooms. In Lee and Shea's (2016) study, teachers shared that they found it difficult to teach inquiry science in classrooms were there were mixed ability learners. For instance, they were of the opinion that learners with low cognitive abilities might not learn well with this approach, as opposed to those with high cognitive abilities (Lee & Shea, 2016).

The challenges shared in the above literature, share similar situations which science teaching in Namibia also face. For instance, in Namibia, the classrooms are overcrowded, schools lack resources to conduct practical investigations, and often our classrooms are made up of a mixture of learners who have low and high cognitive levels. These literatures left me with the assumption that these challenges also contribute to the poor use of inquiry in Namibian classrooms. While the classroom setup seems to be a challenge towards implementation of inquiry, the design of the syllabus is also considered a hindrance.

To Harmon (2011), teachers reported that the syllabus is already overcrowded with content, and on the other hand, inquiry requires much time. As a result, using an inquiry approach, could lead to teachers using the time which is needed for teaching other science content. While it is true that the curriculum consists of much content, the view and understanding that the teacher has towards inquiry, could also be a contributing factor. The reason being, that the teacher could lack understanding of inquiry-based approaches, including its many pedagogical and curricular issues (Flick & Lederman, 2004). As explained by Quigley, Marshall, Deaton, Cook and Padilla (2011), this could mean that when teachers see content and inquiry as constructs that are not mutually inclusive, but rather as aspects of different goals, then these teachers might find using inquiry methods challenging. However, while that is their finding, other scholars established contrasting findings. For instance, in a study in Lebanon, Lee and Shea's (2016) findings revealed that the teachers had a general understanding of inquiry teaching. This involved the understanding that inquiry was not just about doing experiments, that there was no step-by-step method of doing science through inquiry, as well as acknowledging the importance of inquiry in primary schools. To get back to the point of challenges with the implementation of inquiry, Killen (2015) also suggests that some of the challenges are a result of factors such as:

a) Learners might lack the skills to gather or interpret information;
b) As a consequence, learners may learn little;
c) Teachers may see the exercise as time wasting;
d) To the teacher, much time would be required to assist learners to interpret the data rather then doing it themselves; and
e) Learners that lack the neccesary skills might also get frustrated and not enjoy learning through inquiry.

However, shedding a light of hope, Lamm (2017) opines that at first, using an inquiry-based approach may be considered a challenge, as some teachers and learners might not be familiar with the approach; however, once the skills are acquired, then the teachers together with the learners, will no longer see it as a challenge.

Other challenges mentioned in literature, also stem from the design of the learner textbooks. For instance, Kim and Tan (2011) indicated that teachers in their study reported that learner textbooks contained answers to experiments which learners needed to conduct. They explained that what was problematic, was the fact that learners felt demotivated to carry out the practical investigations, as they knew the answers before conducting the experiment. In addition, the curiousity of the leaners was also reduced and thus learners might learn facts without any understanding. Besides this, the learners were also deprived of using high cognitive skills such as high order thinking skills (Conklin, 2012). What seemed to be more of a worry, was the idea that even the teachers themselves feared the embarassment of losing face when their experiments produced different results than those in the learner textbooks (Kim & Tan, 2011). The danger herein, as ascertained from their findings, is that teachers might create some form of restrictions as they would be inclined to teach a particular result without giving reasons, or allowing learners to argue, debate or even discuss (Kim & Tan, 2011).

Another challenge discovered, was that teachers reported that they feared losing control of the class during inquiry (Quigley et al., 2011). However, while that was their fear, Quigley et al. (2011) explain that, during inquiry lessons, teachers carry the responsibility to control the classroom. This means guiding the classroom interactions in order to ensure creation of a caring and respectful learning environment. This entails taking the responsibility to manage classroom interactions, as learners during inquiry might argue; as a result, the teacher needs to ensure that the learners listen to one another, hear each other out and find appropriate ways to argue

(Quigley et al., 2011). While these challenges point to classroom management, it is also established that helping learners during inquiry, poses challenge to the teachers.

Yoon, Joung and Kim (2012) explain that the challenge is in helping learners in the design of the investigation. Peeters and Meijer (2014) clarify that notably, teachers in primary school find it difficult to guide learners through the process of inquiry in formulation of research questions. As a result, Yoon et al. (2012) posit that this leads them to taking much longer to complete their tasks. However, Deboer (2006) argues, that learners are naturally inquisitive and thus can design their own questions through conversations with their teachers, peers or from investigations with the natural world. Thus, he suggests that to support learners in inquiry, specifically to develop their own investigative questions, an open and supportive learning environment where learners receive constant support in generating questions that are interesting and important for investigating is required (Deboer, 2006). In other words, such questions are those that are aimed at seeking clarity, open questions, questions that encourage exploration, as well as those that motivate debate (Meier, 2016). The use of debate in inquiry has received credit due to its positive contribution towards learning. Nhase (2019) terms such debate as scientific debate that has the potential to promote scientific discussions that subsequently lead to the construction of scientific knowledge. Nevertheless, the bottom line is, the teachers have to be given a chance to gain an understanding of what inquiry is and how it should be implemented in science classrooms. This can be done in professional development workshops, as was done in this study.

2.6 Professional Development

Professional development is viewed as an occupational instruction which is aimed at equipping teachers with tools and resources necessary to produce quality instruction (Buczynski & Hansen, 2010). The goal is for teachers to implement knowledge from these professional developments and to provide the learners with enduring and applicable understanding of scientific concepts. Tekkumru-Kisa and Stein (2017) point out that the transformation that needs to occur for improving instructional quality in science and mathematics classrooms, demands a sustained focus on professional development of science and mathematics teachers. For this reason, Eun (2008) suggests that professional development is one of the most effective ways to improve the teaching and learning process. He further explains that workshops are essential in professional development, as they create opportunities for teachers to interact with others. In the same way, Guskey and Yoon (2009) allude to the idea of workshops as they emphasise that they are seen contributing more positively to professional development. Thus, Eun (2008) elaborates that what makes workshops a good place for learning, is that workshop interactions afford teachers an opportunity to share their experiences, knowledge, skills, and problems, difficulties and possible solutions. Subsequently, these could then lead to teachers learning new knowledge which can assist them to improve their teaching practice.

However, for teachers to improve their practice they need to get particular assistance. Eun (2008) explains that teachers should first be provided with materials resources, for example, textbooks and classroom materials to enhance changes in their teaching environment. Vygotsky (1978) terms these tools as mediatory tools which aid the learning process. In the context of this study, the process of making *oshikundu* was used as both a representation (Mavhunga & Rollnick, 2013) and a mediatory tool used to support the teachers learning the concept of enzymes and scientific inquiry. Equally, the journal reflections used in this study allowed the teachers to internalise the learnt materials. In addition, the reflections were also vital sources for me, as the researcher, to find out how the teachers progressed throughout the workshops, which also acted as an assessment mechanism.

2.6.1 The benefits of professional development workshops

Professional development workshops create an opportunity for both restructuring of pre-existing thoughts and behaviour (Eun, 2008). The benefits of conducting an observation during a workshop, are that the observed teacher receives feedback to improve their teaching practice and it also creates an opportunity to critically assess their practice through the eyes of an outsider. The observing teacher on the other hand, has the opportunity to closely monitor aspects of teaching that are not readily recognisable when immersed in their own teaching (Eun, 2008).

Guskey and Yoon (2009) reported that the workshops in their study proved to have positive impacts on teachers' professional development. Teachers were involved in a workshop which involved active learning experiences and provided them the opportunity to adapt the practices to their unique classroom situations. It was noted that this had positive effects on learners learning. Thus, they concluded that the most effective way to bring improvement was to have teachers meet to explore common problems and seek solutions based on experiences and collective wisdom (Guskey & Yoon, 2009).

Also, acknowledging the positive contribution of professional development, Buczynski and Hansen (2010) explained that from their study they found out that professional development in specific science content and pedagogical strategies, led teachers to not only improve their science content knowledge and practice, but also contributed to learner achievement in national examinations. These findings were also observed in Sinclair, Nazair and Ledbetter (2011) who contended that a professional development science programme led to science teachers improving their content knowledge.

In addition to improving PCK, Asheela (2017) reported that the teachers' perspectives and attitudes towards the use of practical activities improved due to the professional development intervention they were involved in. Whilst on this point, I have to confess that I am cognisant that teachers have filters (Gess-Newsome & Carlson, 2013). In other words, the filters thus influence their decisions in accepting new knowledge given to them. For instance, when teachers are introduced to new knowledge, say a new teaching pedagogy, the teacher has the opportunity to either embrace or reject it depending on how he or she finds it suitable to her or his classroom (Gess-Newsome & Carlson, 2013). For instance, it has been observed that teachers believe that science is a subject where information is given to the learners and having learners inquire into new information, seems to be a waste of time (Dudu, 2017). In such an event, the teacher's belief might be the filter to accepting teaching using inquiry. After this discussion that focused on the benefits of professional development, I will now discuss the possible challenges of professional development training.

2.6.2 Challenges of professional development workshops

Ngcoza and Southwood (2015) argue that professional development training given to teachers when curriculum innovations are made, are often inadequate and not aligned to the teachers' needs. The introduction of the new syllabus for Life Science Grade 8, brought along new topics which in the previous curriculum were presented in the Grade 11 and 12 syllabi. As a result, some teachers might not have the PCK to teach this new syllabus. Literature suggests that there is a need to engage teachers in professional development to create awareness and empower them with the necessary PCK to deal with the new Grade 8 Life Science syllabus.

To achieve that, Garet, Porter, Desimone, Birman and Yoon (2001) suggest that this requires professional development such as a workshop, with activities planned which are purposefully directed and focused on content, pedagogy or both; it should not be just to inform the teachers about the changes, but rather, thorough interrogation is required. While these literatures provide good advice on professional development, literature also revealed that traditional models of professional development tend to treat teachers as passive recipients of knowledge (Jacobs, 2015).

This could mean that facilitators attend workshops with completed outlined plans for the activities which teachers need to cover (Ngcoza & Southwood, 2015). However, these authors argue that in this way the teachers are given limited opportunities for their input. Thus, they call for a transformative continuous professional development approach that is emancipatory in nature, which seeks to address the teachers' needs. With so much said on professional development, Guskey and Yoon (2009) suggest that it is important to critically assess and evaluate the effectiveness of what is done in the professional development. This in my view can be monitored using journal entries and workshop reflections. Secondly, they also suggest that when new strategies such as a new teaching approach is introduced, it is better to start off on a smaller scale to test its effectiveness in that context, before moving to a larger scale. In the context of this study an inquiry-based – predict-explain-explore-observe-explain (PEEOE) – approach, together with the essential features of inquiry, were introduced to the teachers in this study. While this approach might be new to the teachers, working with them in such a small group would provide me with insights into the effectiveness of the approach.

2.7 Hands-on Practical Activities

Millar (2010) defines practical work as any science teaching and learning activity in which the learners work individually or in small groups and handle or observe the objects or materials they are studying. Deboer (2006) explains that hands-on experiences also carry the benefits of providing learners with a deeper understanding of the way the world works and a way to personally verify the principles of science. In essence, Kibirige and Tsamago (2013) agree that these kinds of activities generally also support learning of science content and inquiry skills in science classrooms. As a matter of fact, Bosman (2016) explains that through direct interaction with the materials and during the collection of data which the learners use to support their explanations, knowledge and understanding of the phenomena under study are achieved. There is also literature which reveals the usefulness of practical investigations in science classrooms.

For example, da Silva, Hunter, Smallhorn and Young (2015), whose study involved first year Biology university students, found out that practical investigations enabled the students involved in their study to understand the concepts of the molecular basis of life. What is more, the students in their study also indicated that the hands-on activities enhanced understanding of the science concepts and enabled them to use their hands, visualise, and apply knowledge which helped them to understand the concepts better than reading words in books.

Likewise, Kibirige and Tsamago (2013) also found out that practical investigations improved learners' understanding of the subject, reinforced critical thinking, logical reasoning and reduced reading time. Furthermore, in a Namibian study, Nikodemus (2017) found out that practical investigations made the lessons interesting to the learners, promoted active participation, understanding of the science concepts, motivated the learners to value their culture and ways of doing things and enabled retention of information. While these studies reported on the usefulness of practical activities in terms of the learners, in Asheela's (2017) study, it was also confirmed that teachers had good experiences with the practical activities which they were engaged in.

According to Asheela (2017), teachers shared positive views on practical activities. They further indicated that practical activities captured their interest, stimulated questioning, thinking, and enhanced active participation (Asheela, 2017). Furthermore, the teachers also expressed that, during the practical activities, they made observations which enabled them to come up with scientific concepts which in turn enhanced learning with understanding (Asheela, 2017; Lamm, 2017).

With the promises that practical activities hold, some scholars question its effectiveness in science classrooms and learning. Hodson (1990) for instance, contends that practical work is misunderstood, confused and does not produce the desired outcomes in learners. His findings resonate with King, Stephanie and Shumow (2001), who indicate that practical activities which they observed were done as fun activities, in which the learners worked on the activities without engaging their mind and skills. In addition, learners were following a sequence of procedures on a work sheet, which further limited their thinking. These findings echo Simsek and Kabapinar (2010), who also found that practical investigations in Turkish science classrooms were generally written in recipe form, in which the procedure needed to be followed. These findings indicate that teachers who follow the recipe approach, concentrate on teaching the content and not the process, which can further inhibit the learners making use of scientific skills and developing their process skills (Kim & Tan, 2011). In addition to the poor use of practical activities observed, conducting of practical activities is also a challenge to science teachers.

In Namibia, for example, it was confirmed that some teachers do not carry out practical activities in their classrooms (Asheela, 2017). This might be in part, due to the unavailability of resources and laboratories, as highlighted in Asheela's (2017) study. Responding to scholars such as Hodson (1990) who raises concerns on the ineffective use of practical activities, Maselwa and Ngcoza (2003) caution that the practical activities should not be conducted for fun, where learners only use their hands to manipulate the materials, but instead they also need to use their minds and words to write down their experiences. It is for these reasons that these scholars advocate for the predict-explain-explore-observe-explain (PEEOE) approach to be employed both to promote learning of content during practical activities, as well as inquiry skills.

Essentially, the PEEOE approach is an inquiry-based teaching approach which is compatible for mediating scientific inquiry involving the stages of predict, explain, explore, observe, and explain. During the prediction stage, learners think and suggest what will happen during an investigation. They write down their thoughts as they predict. This information is important as it helps the teacher to find out learners' prior knowledge (Kibirige & Osodo, 2014). In the explanation stage, the learners provide explanations for their predictions. The learners then explore by conducting hands-on tasks, investigating, collecting data and evidence. During the observation stage, the learners observe what the outcome of the experiment is and write explanations thereof. They then discuss their observations, while concurrently they check their predictions against their observations. The learners then have to provide explanations for their observations. In doing this the learners will be making sense of their observations, which will help them understand the phenomena being investigated.

In addition to the five components (PEEOE), in this study another component was added. That is, the teachers had to draw their predictions and their observations. Use of drawings, sketches and illustrations are some of the process skills that aid in development of scientific inquiry. Therefore, sketches carry more significance than just a presentation of a simple illustration or a diagram. This is because drawings have the potential to promote learning, identify relevant information, create deeper engagement with the learning materials and generations of inference (Scheiter, Schleinschok, & Ainsworth, 2017). Learners drawings can also reveal significant details about the quality and complexity of their understanding (Cooper, Williams, & Underwood, 2015). Lastly, drawings also help to reveal misunderstandings of science phenomena (Kelly, Barrera, & Mohamed, 2010).

In addition, Maselwa and Ngcoza (2003) suggest that the learners also record the scientific concepts which they can then use to develop a mind-map and further develop a concept map from the mind-map. A concept map is defined as a graphic tool in which concepts are linked by lines and words indicating the relationships between concepts (Kaseke & Nyamupangedengu, 2019). According to Tripto, Assaraf, Snapir and Amit (2016), a concept map is useful as it helps learners to organise their own learning and also provides the assesor a yardstick to measure the extent to which the learners have understood the concept taught. Sharing similar sentiments, Yaman and Ayas (2015) explain that concept maps give the students an opportunity to organise their knowledge systematically and reflect on their understanding of a topic, including their experiences, beliefs and perceptions. Thus, one could argue that concept maps could be a powerful tool in learning and teaching science, as it provides oportunity for learners to organise and present their knowledge (Loughran & Mulhall, 2006). Furthermore, Loughran and Mulhall (2006) reiterate that a concept map creates opportunities to reveal the level of concept attainment, misunderstandings and difficulties. On the other hand, this could also act as a form of feedback to the teacher on the teaching and learning experience (Loughran & Mulhall, 2006). In the context of this study, concept maps were used to show and present teachers learning and to give a picture of their understanding about the concept of enzymes, which further contributed to their content knowledge of this concept.

However, effective use of concept maps depends on its structure (Safdar, Hussain, Shah, & Rifat, 2012). That is, when the concepts are written in a hierachical approach, learners tend to remember them more easily than when written in text format. Thus, Safdar et al. (2012) stress that when concepts are in a semantic order, this helps learners and teachers to organise their thoughts and ideas in an orderly way. With the discussions of indigenous knowledge and scientific inquiry above, it is evident that integrating both in science lessons, has positive impacts on teaching and learning. Yet, such positive benefits heavily depend on the effective integration of these two pedagogical approaches. The effectiveness of implementing these approaches in teachers' practices are influenced by various factors such as perceptions, dispositions, and attitudes which the teachers hold.

2.8 Chapter Summary

In this chapter, I discussed literature relevant to this study. I discussed the requirements for the curriculum in terms of scientific inquiry and enzymes. Discussions around scientific inquiry also revealed that the approach has both benefits and challenges in science classrooms. In addition to the challenges that could hinder the effective implementation of scientific inquiry, consideration of teachers' conceptions, perceptions and attitudes are regarded as factors that could also influence the teachers' practices. The chapter thus ended with a discussion on professional development, an activity which is believed to have the potential for allowing teachers to learn examples of how to promote inquiry in their Life Science classrooms. In the next chapter I discuss the two theories which informed this study.

CHAPTER THREE: THEORETICAL AND ANALYTICAL FRAMEWORK

3.1 Introduction

The main purpose of this study was to mobilise the indigenous practice of making *oshikundu* in order to mediate learning of enzymes and promote the use of an inquiry-based approach in Grade 8 Life Science classrooms. In the previous chapter, I presented literature relevant to this study. In this chapter, I present the theoretical and analytical frameworks that informed this study. Biesta et al. (2011) suggest that the importance of theory is that it enables things which might not have been seen or realised to become visible, to generate explanations and to provide quality to explanations. Cohen, Manion and Morrison (2018) explain that without theory, we can only observe correlations, and we need theory to infer or make sense of outcomes. Thus, in a hermeneutic world, we need theory to understand and interpret experiences, social behaviours, texts and discourses. They further add that theory gathers together all isolated pieces of empirical data into a coherent conceptual framework of wider applicability.

Maxwell (2012) explains that theory is a lens which one uses to make sense of the world. The theory used influences how the study is designed and how empirical data are collected and analysed (Bertram & Christiansen, 2015). This follows from Creswell (2014), who explains that a theoretical lens becomes a transformative perspective that shapes the types of questions asked, informs how data are generated and analysed and provides a call for action or change. I now discuss my conceptual, theoretical and analytical frameworks that informed this study.

3.2 Conceptual Framework

Grant and Osanloo (2014) posit that a conceptual framework offers a logical structure of connected concepts that help to provide a picture or visual display of how ideas in a study relate to one another within the theoretical framework. I now discuss my conceptual framework for this study.

3.2.1 Conceptions and attitudes

Vhurumuku and Mokeleche (2009) define conceptions in relation to scientific inquiry as an individual's ideas, beliefs, understandings and assumptions about the scientific process, what scientists do, and how scientific knowledge is developed and validated. To Attalah, Bryant and

Dada (2010), conceptions are the views that learners hold on a subject, and what they believe is required in learning and doing the subject. It is warned that negative beliefs could lead to the development of negative attitudes towards learning a topic, which could consequently affect the learners' performance (Said, Adam, & Abu-Hannieh, 2018).

The views and the beliefs that teachers hold have an influence on their teaching practice. For example, in her study conducted in Namibia, Asheela (2017) found out that the beliefs that the teachers held about hands-on practical activities, influenced how they conducted them. She explained that some teachers in her study believed that hands-on practical activities can only be done in laboratories, while some held the view that they can only be carried out using conventional materials. As a result, in the absence of conventional chemicals, science teachers seemed not to conduct hands-on practical activities. Hence, Dudu (2014) suggests that with in-service training leading to teachers' better understanding of scientific inquiry, their orientations might shift positively.

3.3 Theoretical and Analytical Framework

This study is informed by two theories, Vygotsky's (1978) sociocultural theory, as well as Shulman's (1986, 1987) theory of Pedagogical Content Knowledge (PCK). The socio-cultural theory acknowledges social primacy in all human developmental processes. On the other hand, PCK is a theory that describes teachers' knowledge as a mixture of content and pedagogical knowledge which teachers draw on to teach learners. Within PCK and drawing on the seminal work of Mavhunga and Rollnick (2013), I focused on the five-topic specific pedagogical content knowledge (TSPCK) components as my analytical framework. I now discuss each of these theories below.

3.3.1 Theoretical framework: Vygotsky's sociocultural theory

Vygotsky's (1978) sociocultural theory is a learning theory that realises the link between social interactions and human development. Vygotsky maintains that mental processes begin as actual social relationships among people on the interpsychological level, and later the new information will be processed further on the intrapsychological level. In McRobbie and Tobin's (1997) view, at the social level, meaning is constructed by individuals as new information interacts with their existing knowledge. That is, meaning coming from the new information is achieved through integration of that new information with existing knowledge. The idea is that learners (teachers in the context of this study) learn best when working together with others during collaboration (Goos, 2004). It is through such collaborative endeavours with more skilled persons that learners learn and internalise new concepts, psychological tools, and skills. In Vygotsky's socio-cultural theory, I focused on two concepts, namely, mediation of learning and the zone of proximal development.

3.3.1.1 Mediation of learning

Vygotsky (1978) explains mediation as a tool used in cognitive change. Kozulin (2003) classifies these mediatory tools into three categories: a) human mediator (the more knowledgeable other; b) psychological or symbolic mediator (the system and skills modeled by the more knowledgeable other in the process of social interaction with the less competent); and c) the external mediator (the technical tools that are involved in the process of social interaction).

In the context of this study, the workshop intervention created leaning opportunities for teachers. For instance, during the analysis of the curriculum documents, opportunities for learning science pedagogy and content were created. In addition, it was during the practical demonstration of making *oshikundu* where mediation of learning took place. In this regard, the demonstrator (a local expert) is the more knowledgeable other (MKO) Vygotsky (1978), demonstrated and explained how *oshikundu* was made to the less competent (the teachers and I). This provided us with an opportunity to relate the knowledge from the demonstration to science concepts. Furthermore, the use of psychological tools such as *Oshiwambo* (an indigenous language), increased the level of participation (Naidoo, 2010; Sedlacek & Sedova, 2017).

The use of reflections and journals which we used to record our reflections on the intervention process, also served as a mediatory tool. It was hoped that this form of reflection and journal entry, might reflect our learning progression through the intervention. I believed and hoped that what was learned, might have an influence on our zone of proximal development in this study.

3.3.1.2 Zone of Proximal Development

Vygotsky (1978) defines the zone of proximal development (ZPD) as the space between the actual development and the potential development of a person. Drawing on Vygotsky's seminal work, Blanton, Carter and Westbrook (2001) further define the teacher's ZPD as a learning space between their present level of teaching knowledge, consisting of content (theoretical) and pedagogical knowledge and skills, and their next (potential) level of knowledge to be attained with the support of others. Vygotsky indicates that learning is mediated within the ZPD and can lead to cognitive development. In addition, Miller (2011) stresses that this leads to acquisition of a higher-level of psychological functions. Zohar and Dori (2003) view higher order thinking skills as skills such as the ability to analyse, to evaluate, reason and synthesise information or situations. In addition, Barak and Dori (2009) view them as those skills that enable people to pose complex questions, present solid opinions, reason, introduce consistent arguments, and demonstrate critical thinking.

The practical demonstration of making *oshikundu* could thus be a good example to use to explore the higher order thinking skills which the participants and I could acquire. In addition, it was hoped that the acquisition of these skills might strengthen our pedagogical content knowledge (PCK) (Shulman, 1987), as well as our scientific process skills (Kuhlane, 2019). Our general subject matter knowledge on the topic of enzymes and its associated concepts might be strengthened as well. The model (Figure 3.1) below, is adapted from Shabani, Khatib and Ebadi (2010, p. 242) to show how the ZPD is affected by influential factors.

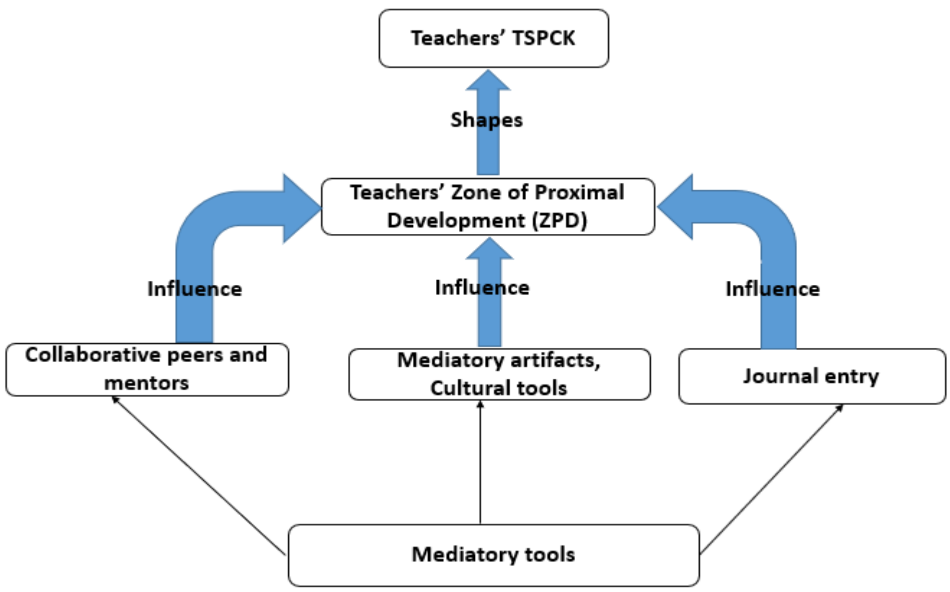

Figure 3.1: Influential factors on teachers' ZPD (Adapted from Shabani et al., 2010, p. 242)

From this model, the concepts of mediation of learning and ZPD were used to analyse how the mediatory tools used in this study enhanced the mediation of skills and knowledge in the following: a) How to integrate indigenous knowledge to teach concepts of the science curriculum; b) How the tools enhanced mediation of scientific process skills; c) How the tools promoted the acquisition of higher order thinking; and d) How the acquisition of these skills further influenced the teachers' PCK.

While Vygotsky's theory focuses on how children learn, the nature of this study, which was intended to promote teacher learning through interaction with each other and the MKO (the local expert woman), makes Vygotsky's theory compatible with it. Singh and Richards' (2006) study revealed that English teachers who were involved in their study learnt collaboratively from the activities and interactions which were mediated using cultural artefacts. This was also established by Barak and Dori (2009), who also confirmed that engaging teachers in professional development enhances their development of critical thinking and argumentation skills. Likewise, Shabani et al. (2010) also contend that the use of mediatory tools – such as mentors, artefacts and diary writing – influence teachers' ZPD positively.

Furthermore, Eun (2008; 2011) and Shabani (2016) explain that the models which are used in teacher professional development are aligned with Vygotsky's theory. For example, the concept of 'mentoring' is aligned to Vygotsky's idea of the MKO. In addition, most professional development initiatives are conducted through 'training' which engages teachers in interactions with others. This creates an opportunity to learn and build on their knowledge. The enhancement of learning results in extension of the teachers' ZPD (Shabani et al., 2010). It was hoped that the influence of the mediatory tools, would help the teachers in this study to learn and acquire new information and knowledge on how to integrate indigenous knowledge and promote scientific inquiry in their lessons. Acquisition of such knowledge was hoped to contribute to the teachers' PCK.

3.3.2 Analytical Framework: Pedagogical Content Knowledge

Pedagogical Content Knowledge (PCK) is an academic construct that was introduced by Shulman (1986). PCK represents an idea rooted in the belief that teaching is more than just delivering subject content knowledge to learners with the expectation that learners will just absorb information for later reproduction. Instead, PCK is believed to be the knowledge that teachers develop over time and through experience, about how to teach particular content in particular ways in order to enhance learners' understanding (Shulman, 1987).

Shulman (1987) views PCK as consisting of distinctive bodies of knowledge for teaching. He indicates that PCK, represents "the blending of content and pedagogy into an understanding of how particular topics, problems, or issues are organised, represented and adapted to the diverse interests and abilities of the learners and presented for instruction" (Shulman, 1987, p. 8). To Loughran and Mulhall (2006), teachers' PCK is related to their experience and it entails transforming knowledge so that it makes sense to the learners. Concurring, Kind (2009) describes PCK as a concept that represents the knowledge that teachers use in the process of teaching. These definitions thus indicate that PCK is knowledge which is developed with experience, and that teachers use this knowledge in their planning of lessons and teaching of learners. However, PCK is not the same for all teachers of a given subject area, as it is influenced amongst other things by the teaching context, content and experience (Loughran & Mulhall, 2006).

Shulman (1986, 1987) states that teachers possess Subject Matter Knowledge (SMK). Preparing this knowledge for teaching requires a teacher to engage in transforming the content in a way that is going to be comprehensible to the learners (Shulman, 1987). This entails that the knowledge has to be transformed to fit the level of the learners, as well as their learning abilities. This resonates with Vygotsky's concept of the ZPD, which emphasises that learning should be mediated within the ZPD. If a learner is not able to do a task on their own, Vygotsky suggests the learner does the task under the guidance of a more capable person. Thus, together with the teachers' pedagogical knowledge, the teacher needs to have rich conceptual subject content that they teach (Loughran & Mulhall, 2006). The nature of PCK explained above represents PCK as a teaching theory.

Some scholars critique Shulmans' theory, saying it lacks a theoretical background (Bromme, 1995; Kind, 2009). For instance, Bromme's critique is that in defining PCK as an instructional strategy, it gives the impression that the influences of other factors on teaching and learning are not acknowledged. She found that, within PCK, mediating factors such as presentation of content should be considered. In addition, she laments that PCK is regarded as being difficult to measure because it is tacit in nature and not easy to document (Kind, 2009). The above explanations of PCK represent it as a teaching theory.

Shulman's work on PCK led to scholars embarking on studies on the components, sources of PCK and how it is developed. It was concluded from these studies that there are a number of views regarding PCK, yet a common view was needed for a common understanding of PCK. Therefore, to come to the common understanding of PCK, a group of researchers met in 2012 in Colorado Springs and created an agreed model, referred to as the Teacher Professional Knowledge (Consensus PCK Model) (Gess-Newsome, 2015, p. 31). This is shown in Figure 3.2 below.

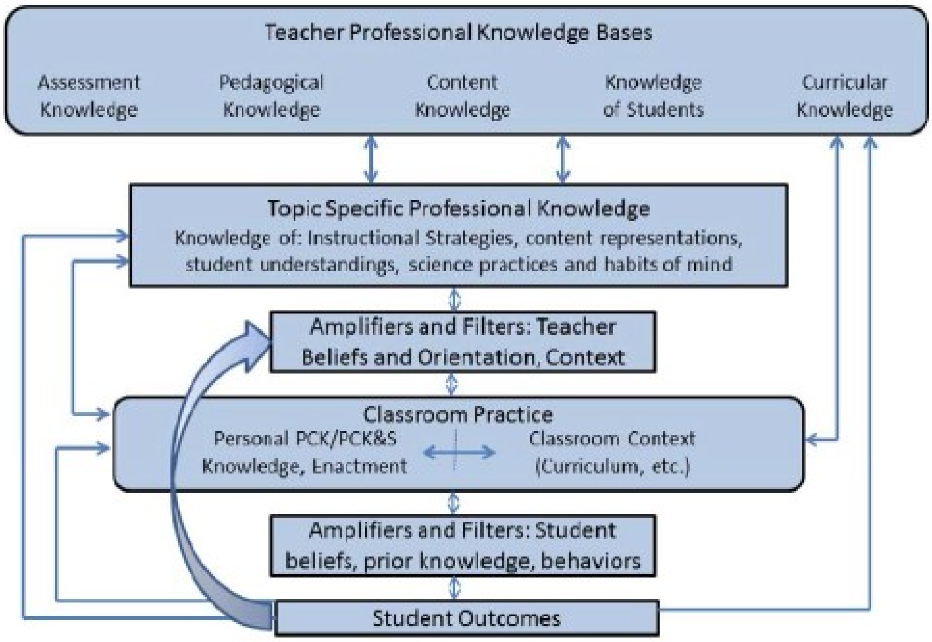

Figure 3.2: Consensus model of PCK from PCK Summit 2012 (Gess-Newsome, 2015, p. 31)

In this model, PCK is defined as both a knowledge base used in planning for and the delivery of a topic in a specific classroom context and as a skill used when involved in the act of teaching (Gess-Newsome, 2015). The use of this model has limitations as it has minimal details about PCK. Some of the limitations pertain to the place for knowledge about instructional strategies, which is not accommodated in the model. Consequently, the model has been further refined to reflect the multi-dimensional nature of PCK (Carlson & Daehler, 2019). The new Refined Consensus Model of PCK introduces the three realms of PCK, namely, collective PCK, personal PCK and enacted PCK shown in Figure 3.3 below (Carlson & Daehler, 2019).

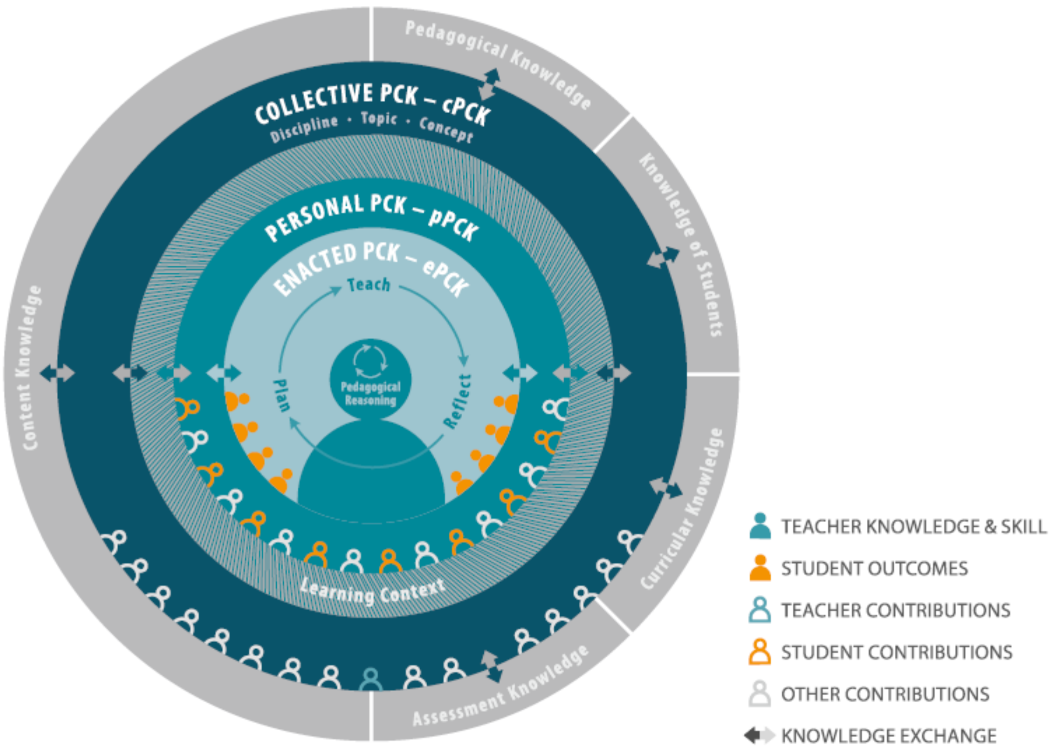

Figure 3.3: Refined Consensus Model of PCK (Carlson & Daehler, 2019, p. 83)

To Carlson and Daehler (2019), the collective PCK is the specialised knowledge held by multiple educators in a field. It is collective because it is published information about PCK that is shared by the broader community of science education. The teacher has learned this knowledge in a course, for example, at a teachers' college. Therefore, the knowledge is possessed by more than one person; it is not private knowledge but rather knowledge that is public and held collectively. The teachers then take this collective PCK in, they think and reason on it, to find a way to show their PCK. As a result, the teachers show their PCK in a unique personal way which then makes up their personal PCK. Thus, the personal PCK is the cumulative and dynamic pedagogical content knowledge and skills of individual teachers that reflect these teachers own teaching and learning experiences, along with the contribution of others.

Lastly, there is the enactment PCK which is the unique subset of knowledge that a teacher draws on to engage in pedagogical reasoning during the planning of, teaching of, and reflecting on a lesson. According to Carlson and Daehler (2019), a teacher's personal PCK is developed, shaped and refined over time through formal education, teaching experiences, and professional sharing. In this study, it was hoped that the participants would be afforded an opportunity to improve their personal PCK through the social interactions (Vygotsky, 1978) that took place during the intervention workshops. During the intervention workshops, the teachers drew on their personal PCK to explain their enacted PCK in the topic of enzymes, in that way making their PCK explicit (Carlson & Daehler, 2019). It should be noted that in this study, the teachers showed their enacted PCK by explaining their PCK on the topic of enzymes.

The nature of this study looked both at the teachers' knowledge in terms of Topic Specific Pedagogical Content Knowledge (PCK-TSPCK) and the impact of the intervention workshops towards their learning. To counteract the criticisms by Bromme (1995) and Kind (2009), in this study I used Vygotsky's sociocultural theory as the learning theory which would then help me to analyse learning, which was promoted through professional development activities. Equally, this should allay the concerns of those who share Bromme's critique of PCK.

Since PCK differs from topic to topic, I adapted the model for Topic Specific Pedagogical Content Knowledge (TSPCK) used in Mavhunga and Rollnick (2013, p. 115) as an analytical framework (see Figure 3.4 below). The model adapted the five content specific components used by Geddis and Wood (1997, p. 613). Mavhunga and Rollnick (2013) subsequently termed these components as 'content specific components' found on the right side of Figure 3.4 below.

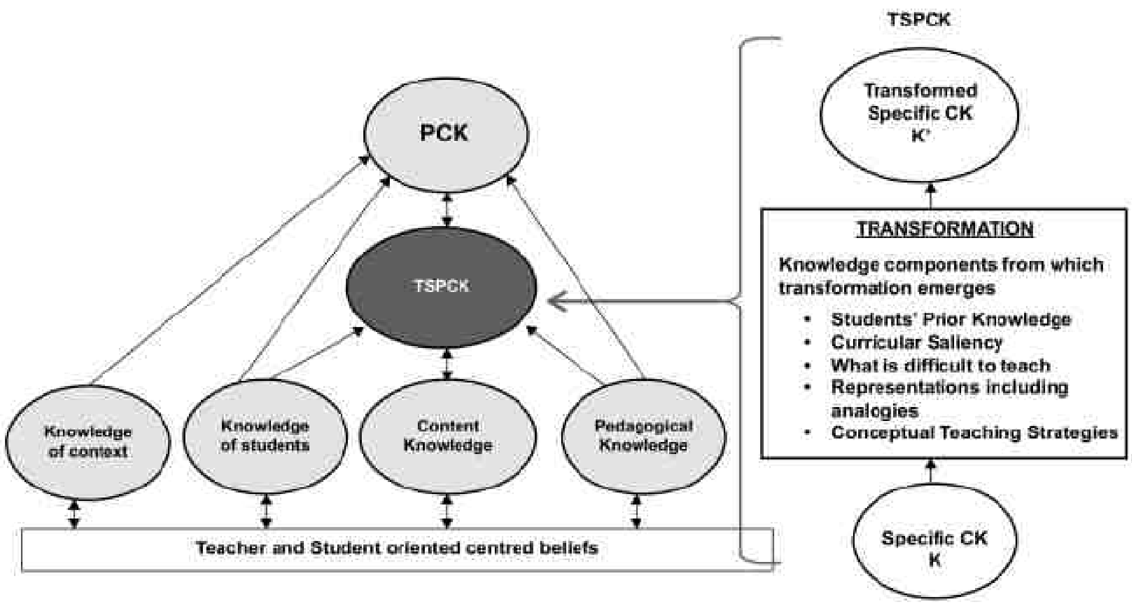

Figure 3.4: A model of Topic-Specific PCK (Mavhunga & Rollnick, 2013, p. 115)

The topic specific nature of PCK, as described by Mavhunga and Rollnick (2013) and Mavhunga (2019), is relevant to this study when exploring transformation of the subject of enzymes. It was observed, however, that the teachers' SMK or content knowledge had an influence on their teaching practice. This study refers to content knowledge as the teachers' knowledge about the subject matter to be learned or taught (Koehler & Mishra, 2009). In this study I acknowledge that each teacher's personal PCK is unique to that teacher (Carlson & Daehler, 2019). This is explained by Abell (2008), who indicates that teachers' PCK develops over time as a result of different experiences, such as teacher preparation programmes and teachers' own teaching and learning experience. As a result, different PCK's are observed among teachers. Adding to the debate, Carlson and Daehler (2019) reiterate that even teachers with similar experiences might have different attitudes and beliefs that could result in varied personal PCK.

Aydin et al. (2012) suggest that limitations in teachers' SMK create obstacles for the teachers in determining learning goals, how to teach, identifying key concepts and selecting activities to use. These claims were also echoed by Rollnick, Bennett, Rhemtula, Dharsey and Ndlovu (2008), who observed that the teachers in their study had shallow understandings of the topic (mole), and as a result this made it difficult for them to relate to conceptual and algorithmic parts of the mole topic. Concuring, Mizzi (2013) maintains that teachers' lack of knowledge about the structure and the nature of a topic makes it difficult for them to transform and present the topic. In consequence, poor pass rates in science subjects are observed (Pitjeng, 2014).

The observation made by Mizzi (2013), might be a result of the teachers' inadequate SMK, which often results in a low PCK (Mavhunga & Rollnick, 2014). While this is Mavhunga and Rollnick's (2014) assumption, Boone, Park, Juttner and Neuhaus (2013) argue that there is not always a relatioship between SMK and PCK. This view was then confimed by Mavhunga and Rollnick (2014) and Davidowitz and Vokwana (2014), who observed that in their studies some teachers with adequate SMK presented poor PCK knowledge.

3.3.2.1 Learners' prior knowledge (LP)

This component entails elicitation of learners' prior knowledge and paying attention to their misconceptions. It also requires the teacher to have the skill of being able to handle the preconceptions or misconceptions learners might have. It also includes understanding of knowledge that learners might have as a result of prior teaching, before teaching the new concepts.

3.3.2.2 Curriculum saliency (CS)

This component demands that teachers identify the major concepts around the topic. In addition, teachers also need to identify the prerequisite concepts learners need to know before the topic is presented and also take into consideration the interrelatedness of concepts. Teachers are also expected to allow the development of big ideas (Mavhunga & Rollnick, 2013; Mavhunga et al., 2016). Furthermore, teachers should also be able to sequence these big ideas in a way to allow comprehension and understanding. When sequencing, an understanding of what should be taught now and what needs to be taught later, is pivotal.

To Mavhunga and Rollnick (2013), knowledge of concepts that make up a topic and the relationship between them, is fundamental to a teacher if correct content is to be chosen and to be taught to the learners. Sharing the same sentiment, Sibida (2018) also agrees that when teaching the concept of chemical bonding the correct sequencing of concepts is key for learners' understanding of the topic. However, in my view, consideration of the teachers SMK is also vital in this component, as it makes up the knowledge which the teacher has with regard to that topic, which is knowledge that they will depend on in practice.

3.3.2.3 What is difficult to understand (WD)

This component describes teachers' awareness of the gatekeeping concepts within a topic that make it difficult for the learners to understand or grasp a new concept.

3.3.2.4 Representations, including analogies (RP)

This refers to how learning content is presented in such a way that it carries meaning to the learners. This can be achieved through the use of aids that teachers consider having potential in supporting the teaching of a particular content. These representations could be illustrations, metaphors, demonstrations, experiments, analogies, models or simulations. In other studies, it was established that analogies are useful, as they help learners to visualise abstract concepts (Tibell & Rundgren, 2010) and communicate scientific concepts that are abstract and complex (Orgill et al., 2015).

3.3.2.5 Conceptual teaching strategies (CTS)

Lastly, the category of conceptual teaching strategy looks at teaching strategies that can be used. The choice of the teaching strategy should consider the misconceptions if there are any, educational purpose, as well as the learners. In this study I used the five content specific components to guide teachers on how to transform Subject Matter Knowledge (SMK) or content knowledge of enzymes, in a way that was comprehensible to the learners.

The five content specific components were used. This provided the teachers with the opportunity to expand their content knowledge on enzymes and their pedagogical knowledge (PK) in planning for mediation of enzymes.

3.4 Chapter Summary

In this chapter, I discussed the conceptual, theoretical and analytical frameworks that informed this study. I started with a discussion on conceptions and attitude. These two concepts were worth discussing as they play a major role in the decisions that teachers take in their teaching. Vygotsky's sociocultural theory with the focus on mediation of learning and the Zone of Proximal Development were also discussed. As his study is a learning theory, Shulman's Pedagogical Content Knowledge was also used in this study as a theory looking at teaching or pedagogy.

In the next chapter, I discuss the research design and methodology underpinning this study.

CHAPTER FOUR: RESEARCH DESIGN AND METHODOLOGY

4.1 Introduction

The aim of this study was twofold, which was to mobilise the indigenous practice of making *oshikundu* to mediate learning of enzymes. Secondly, the study was aimed at promoting the use of an inquiry-based approach in Grade 8 Life Science classrooms. To achieve this, I needed to establish a research design with an appropriate methodology. In the previous chapter, I presented the conceptual, theoretical and analytical frameworks underpinning this study. In this chapter, I thus present the research design and methodology used in this study. The chapter ends with the discussion of ethics, validity and concluding remarks.

4.2 Research Design and Orientation

Merriam and Tisdell (2016) describe a research as a systematic inquiry. They further elaborate that engaging in a systematic inquiry involves choosing a study design that corresponds with your research questions, your worldview, personality and skills. Concurring, Cohen et al. (2018) explain that a research design is a plan or strategy that is drawn up for organising the research, and making it practicable, so that the research questions can be answered based on evidence. The research determines the design of the research, which in turn informs the methodology (Cohen et al., 2011).

This study was informed by an interpretive paradigm which I deemed to be suitable for this study as I sought to understand the experiences, perspectives, pedagogical insight and views of the participants prior to the intervention (Cohen, et al., 2011; Cohen et al., 2018). To ensure that the study was feasible, the study was divided into two phases.

In the first workshop, three Life Science teachers were involved in the analysis of documents. That is, the examiners' reports were analysed to give an overview of the performance of the learners in the topic of enzymes and their inquiry skills. In addition, the Life Science Grade 8 syllabus and National Curriculum for Basic Education (Namibia. MEAC, 2016), were also examined to find out the requirements for teaching the topic enzymes, and promotion of scientific skills. This information further informed the second workshop. This was also intended to augment and triangulate the data generated. Data from the first workshop, provided an insight on how teachers mediate learning of the concept of enzymes. Knowing this information was vital, as it guided my planning and design of the workshops which were aimed at providing support to the teachers.

Additionally, journal reflections were written after every workshop. These reflections acted both as learning tools, as well as tools which we used to express our experiences of the workshops (Göker, 2016). Owing to the view that the social world is not straightforwardly perceivable and instead is different for each of us as we attach different meanings to every event (Thomas, 2013), this study was thus informed by an interpretive paradigm.

4.2.1 Interpretive paradigm

Cohen et al. (2018) are of the view that individual behaviours can only be understood by the researcher who understands the individuals own interpretations of the world around them. This is because they develop subjective meanings of their experiences which are many and at times they also vary (Merriam & Tisdell, 2016). Extending the interest of an interpretivist, they also seek to understand the world in which those they are interested in live and work (Creswell, 2014).

Thomas (2013) elaborates that the key in interpretivism is to make sense of the understanding people we are talking to, have about the world, and how we can in turn comprehend this. This could be achieved by talking to people and listening to every word they say. Based on this perspective, the discussions that took place in the workshops were essential to help me understand three things. Firstly, through these discussions I found out the kind of lessons which the teachers had either learnt or not about enzymes and inquiry methods, as we co-analysed the curriculum documents. Secondly, the practical demonstration of making *oshikundu* which was done by a local expert woman, and the use of topic specific pedagogical content knowledge (TSPCK) components, also helped me to gain insight into the teachers' interactions, participation and understanding of the concept of enzymes. The rich discussions during this activity, allowed me to talk to the participants in-depth and listen to their words on what they thought and understood about the concept of enzymes (Thomas, 2013). In this way, the social interactions as reiterated by Vygotsky (1978), allowed me to explore how the knowledge of enzymes was acquired. Thirdly, I also had an opportunity to find out how the process of making *oshikundu* enabled or constrained the teachers understanding of an inquiry-based approach. In addition, as we were discussing, I also used follow-up questions for the teachers to elaborate on their ideas (Cohen et al., 2018).

Within the interpretive paradigm, a qualitative case study was adopted which is discussed in the following section.

4.2.2 Qualitative case study research

Merriam and Tisdell (2016) explain that a qualitative research is characterised by focusing on the search for meaning and understanding. That is, the interest of a qualitative research lies in understanding how people interpret their experiences, how they construct their worlds and what meaning they attach to their experiences. By conducting this study, I was interested in finding out the influence of the practical demonstration of making *oshikundu* on the teachers' understanding of the concept of enzymes and an inquiry-based approach. Creswell (2015) accentuates that a qualitative researcher collects data by observing participants, and directly asks them open-ended questions. During the workshop discussions I observed how the participants were interacting and I also had an opportunity to ask questions as a co-learner in the study.

One advantage of qualitative study is that the researcher can expand his or her understanding through non-verbal, as well as verbal communication (Merriam & Tisdell, 2016). In this regard, I accessed information from the observations that I made, and the reflections that the teachers provided (Eisner, 2017). This too further gave me an opportunity to find out more.

Eisner (2017) expounds that qualitative researchers are interested in matters of motive and in the quality of experiences undergone by those in the situation studied. This study was also interested in how the workshops assisted the teachers to gain an understanding of the concept of enzymes and an inquiry-based approach. In addition, together with the participants, I was also interested in finding out how the process of making *oshikundu* could be used to mediate learning of the concept of enzymes. The study used a case study approach to explore the research questions guiding this study.

A case study is an in-depth description and analysis of a bounded system (Merriam, 2009; Merriam & Tisdell, 2016). A case study is also defined as an empirical inquiry that investigates a contemporary phenomenon (the case) within its real-life context (Yin, 2014). Lending support, Creswell (2014) defines a case study research as a qualitative approach in which the investigator explores a bounded system (case) or multiple bounded systems (cases) over time, through detailed, in-depth data collection using multiple sources of information. To Thomas (2013), a case study involves an in-depth research into a case or small set of cases. The aim of a case study is to get a rich detailed understanding by examining aspects of the case in detail.

The case in this study was the three Grade 8 Life Science teachers. The unit of analysis in this case was how the practical demonstration of *oshikundu* influenced (or not) the teachers' understanding of the concept of enzymes and an inquiry-based approach. To achieve this, three sources of data gathering were used, namely, document analysis, the workshop discussions and the reflections.

4.3 Research Goal and Questions

The goal of a study outlines what the study is aiming to achieve. To operationalise that goal, one has to have questions that are directed at achieving the goal of the study. Below I present the goal of this study and the research questions which I planned as an aid in achieving this goal.

4.3.1 Research goal

The main goal of this study was to mobilise the indigenous practice of making *oshikundu* to mediate learning of the concept of enzymes and to promote an inquiry-based approach.

To achieve this goal, the research was guided by the following main research question:

4.3.2 The main research question

How can the process of making *oshikundu* be used to support Grade 8 Life Science teachers to understand the concept of enzymes and an inquiry-based approach?

To answer this question, the following sub-research questions were addressed:

4.3.3 Sub-research questions

1. What lessons can Grade 8 Life Science teachers learn or not about enzymes and an inquiry-based approach through co-analysing the curriculum documents?
2. How does the practical demonstration of making *oshikundu* by an expert community member and topic specific pedagogical content knowledge components

enable and/or constrain Grade 8 Life Science teachers' interaction, participation and understanding of the enzyme concept?

3. How does using the process of making *oshikundu* enable and/or constrain Grade 8 Life Science teachers' understanding of an inquiry-based approach?

4.4 Research Site

The study was conducted in two government schools in the Omusati region. The Omusati region is found on the northern part of Namibia, near the Angola border (see Figure 4.1). The schools are in one of the Omusati region's districts, Oshikuku. The learners who attend school in those two schools, come from both Oshikuku and the nearby villages. Furthermore, learners from both schools speak *Oshiwambo*.

In terms of facilities, school 1 had two laboratories but was not well equipped to conduct practical investigations. School 2, on the other hand, had no laboratory and science teachers conducted hands-on practical activities in their classrooms. Further than that, school 1 had an enrolment of 799 learners, 345 of those learners were males, while 450 belonged to the female gender. This school was made up of a staff of 33 teachers. The school had one principal who was male. In addition, the school had three head of departments. The departments represented in this regard were the mathematics and science department, languages and commerce. Furthermore, school 1 had a hostel (dormitory); however due to space, a few learners were accommodated outside the school. On the other hand, school 2 had an enrolment of 835 learners, 359 of those learners were males, while 476 belonged to the female gender. This school was made up of a staff of 20 teachers. The school had one school principal who was male. The school also had two head of departments, one for the languages and another one for mathematics and science. These schools had a good academic record in terms of performance. For the past five years both these schools had been obtaining position 1 and 2 respectively in their learners' academic performance in the Junior Secondary Certificate.

Both school 1 and school 2 were poorly resourced schools though their needs varied. The concept of under-resourced schools in this study is defined as "schools where features like teaching and learning materials, teaching space and laboratories are missing or are partially present" (Kibirige & Hodi, 2013, p. 426). The situations of these two schools motivated my choice to conduct my study there, as they provided a good opportunity for me and the participants to explore alternative means to conduct an inquiry-based practical activity through the process of making *oshikundu* to mediate the concept of enzymes. With a research site alone, it would be practically impossible to collect data to address the research questions. In this regard, I present details of my participants drawing on sampling techniques I used to select them.

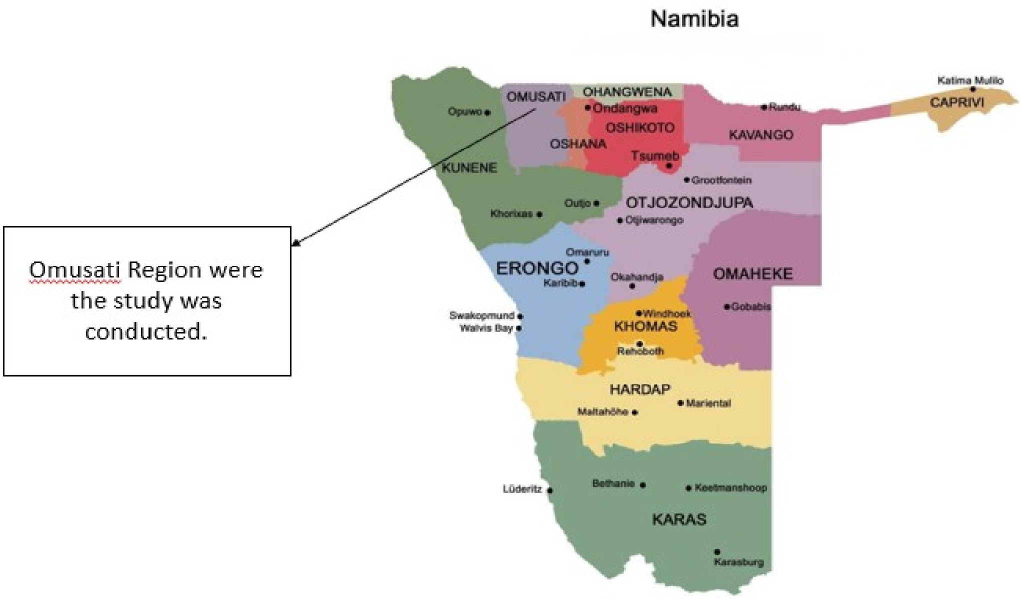

Figure 4.1: Shows a Namibian map with different regions

4.4.1 Sampling and participants

This study involved three Grade 8 Life Science teachers from two different schools in Omusati Region. These teachers were purposively selected as they were suitable to best help me to understand the central phenomenon that I was exploring (Aurini, Heath, & Howells, 2016; Creswell, 2015). Due to the changes to the Life Science syllabus, it was indispensable to select teachers who were familiar with the new syllabus in terms of content and pedagogy. That is, the teachers should have taught the new syllabus in 2017, when the new Grade 8 Life Science syllabus was first taught. To the benefit of this study, one of the teachers were experienced in teaching Biology at Grade 12 level. Though this was not the criteria, his participation was of benefit to the study as the concept of enzymes currently taught in Grade 8 (the focus of the study), was previously only taught in Grade 11 and 12 Biology. This placed him in a more knowledgeable position of the concept of enzymes, as opposed to the other teacher who was experiencing the concept of enzymes for the first time in their teaching. As a result, his content knowledge of enzymes enriched the discussions during the workshops. The participants were all familiar with the Life Science content, as well as the different teaching approaches in Life

Science, including the use of hands-on practical activities. This suggested that the introduction of the Predict-Explain-Explore-Observe-Explain approach would help them to improve their current ways of conducting practical work. Secondly, the participants were all Oshikwambi. Thus, I assumed that they were also familiar with most of the common indigenous practices of the Oshikwambi people, including the making of *oshikundu.* It was recognised, however, that they might not be aware about the science embedded in this cultural practice.

The sample size in this study was relatively small because the aim of this study was not to generalise the findings to a larger population, but to understand the Life Science teachers' experiences, perspectives and pedagogical insight on the use of an inquiry method in the Life Science classrooms (Merriam & Tisdell, 2016).

4.4.2 Teachers' biographical information

The teachers who participated in this study were all from the same Omusati region. All three teachers participated in the workshop. Each teacher is given a code, as T1, T2, and T3. Table 4.1 below provides a summary of the teachers' biographical information.

Table 4.1: The biographical information of the teachers

Biographical information	Category	Participants' codes
Age	30-35	T1, T2, T3
Gender	Two Female	T2, T3
	One Male	T1
Home language	Oshiwambo	T1, T2, T3
Qualifications	BETD	T1, T2
	ACE	T2
	MASTEP	T1
	BEd (Honours)	T3
Teaching experience	5 years	T3
	7 years	T2
	10 years	T1

From Table 4.1 above, all three teachers who provided this information, were *Oshiwambo* speakers. These teachers were almost of the same age range. Two of these teachers were females and the other one was male. Pertaining to their qualifications, two of the teachers held a Basic Teaching Diploma, an Advance Diploma in Education, as well as a Further Diploma in Education. One of the teachers had an Honours degrees in education. Furthermore, the table indicates that they had teaching experience in Life Science which ranged between five to 10 years.

4.4.3 My positionality

Thomas (2013) is of the view that an interpretive researcher has an undeniable position in the research process and this position affects the nature of the observations and the interpretations that they make. He thus suggests that the researcher must be explicit in their interest, personal circumstances, uncertainties and allegiances in the study undertaken.

I am conducting this study as a Life Science and Biology teacher who has 11 years of experience in teaching these subjects. In doing this study, I was interested in developing my academic understanding of how best to integrate indigenous knowledge in my classrooms. In addition, I wanted this study to broaden my understanding of the examples of indigenous knowledge in my society, which are aligned to the Life Science syllabus in particular. Furthermore, I wanted the study to improve my understanding on how to use an inquiry-based approach in my classrooms, something which seems to be a challenge to most Life Science teachers. Equally, I hoped that the study would enrich my content knowledge of human digestion, specifically on the topic of enzymes.

Therefore, I approached this study from an interpretive perspective. That is, "the social world in which we are interested in as social scientists is not straightforwardly perceivable because it is constructed by each of us in a different way" (Thomas, 2013, p. 108). I thus assumed that reality is socially constructed; that is there is no single, observable reality. Rather there are multiple realities and interpretations of a single, observable reality (Merriam & Tisdell, 2016).

I was, however, cognisant of the fact that being born and raised in an urban area put me in a less knowledgeable position about the wealth of indigenous knowledge in the society where I lived and taught. Given that, the study relied on the participants' knowledge of indigenous knowledge in the community and that put me in a position of learner-facilitator during the research process, as an active learner but not an academic expert. Reflecting on my personal experience, the concept scientific inquiry which this study focused on, was a new concept to me. When I heard of it at Rhodes University, I had little understanding about it. I thus decided to conduct this study hoping to learn *with* the participants about this concept and how best to use it in our classrooms. However, being a Master's student at Rhodes University placed me in a challenging position, as my participants could have viewed me as the more knowledgeable other (Vygotsky, 1978), while in reality we were all participating in a learning process.

4.5 Data Gathering Techniques

This study used four data gathering techniques which helped to answer my research questions. That is, I used document analysis, workshop discussions, participatory observation and journal reflections. Mills (2011) points out that using different data generation techniques ensures triangulation of data. This strategy "reduced the risk that my conclusions did not only reflect the systematic biases or limitations of a specific source or method, but it allowed me to gain a broader and more secure understanding of the issues I was investigating" (Maxwell, 2012, p. 106). The data for this study were generated during the workshop discussions. For the descriptive data gathering plan please see Appendix F. In the following section I now discuss each data gathering technique in detail and provide an insight of what transpired during that process.

4.5.1 Workshops

As mentioned before, workshops were conducted in this study. Four workshops were conducted in this regard and all were done after teaching hours. With the permission of the participants, these workshops were videotaped by a critical friend. The aim of the workshops was to create learning experiences for both the participants and I, to learn about the concept of enzymes and an inquiry-based approach. In doing this, we hoped to improve our pedagogical content knowledge (PCK). Eun (2008) suggests that the best way to improve teaching and learning is through engaging teachers in professional development by conducting training such as workshops. The workshop discussions seemed most appropriate as they set an environment for social interaction and collaborative learning (Vygotsky, 1978). Sedlacek and Sedova (2017) also view participation in social interactions as a mechanism to enhance learning. What follows are descriptions of the activities of the workshops.

4.5.2 Workshop one (phase one): Orientation workshop

This workshop was unpacked in various activities as seen in Appendix H. This was the first time when all three participants were together with me and meeting as a group. The workshop commenced with the introduction of the participants. As this was a professional development practice, I grounded my work in Eun (2008) who alludes to the idea that involving teachers in the planning stage of professional development would be an effective means to achieve the purpose, as their needs and goals will then be reflected in their activities. Given this, I then handed over the mandate to the participants to discuss their workshop expectations and every aspect they felt needed to be addressed during the workshops. This is because I believe that adult learners are self-directed and therefore prefer to participate in planning, implementing, and evaluating their own learning (Merriam, 2009). Having welcomed my request, teachers shared their workshop expectations, decided on the rules of the workshop, meeting times, and how activities such as reflections should be done. The workshop went well, as all the participants managed to attend. The teachers were happy to meet each other, and they shared jokes here and there. One of the weaknesses I observed from this workshop was time management. One of the teachers came to the workshop an hour and a few minutes late. This delayed the activity of the workshop. In addition, the other participants also felt delayed and as a result we ended up leaving some work which we were to cover on that particular day. Nevertheless, we discussed it the next day.

This activity led us to the second phase of workshop one. This is the phase where document analysis was done. This is discussed in the following section.

4.5.3 Workshop one (phase two): Document analysis

Bowen (2009) points out that document analysis is a systematic procedure used for reviewing or evaluating documents, both printed and electronic material. In the context of qualitative research, document analysis requires that data be examined and interpreted to elicit meaning, gain understanding, and develop empirical knowledge (Cobin & Strauss, 2008). The documents that we co-analysed were the examiners' reports, the broader curriculum of education (Namibia. MEAC, 2016), Grade 8 Life Science syllabus (2015), and textbooks. The examiners' report is a document which provides comments based on common mistakes and errors detected from the learners' answer scripts countrywide. These reports describe the learners' performance by commenting on every examination question paper and for each school subject that the learners sat for (Nsingo, 2015). As Nsingo puts it, the examiners' reports play a vital role as a means from which teachers can learn how learners performed in past examinations, what mistakes they made, and examples of how specific questions should be answered. The Namibian National Curriculum for Education (NCBE) on the other hand, is the official policy document that guides teaching and learning in the Namibian schools. Thus, the subject syllabus for instance of Life Science, is developed to achieve the aims and goals of education stipulated in the NCBE. Likewise, the text books are designed in relation to the content which is provided by the subject syllabus. To offer a comprehensive view of reviewing these documents, the purpose for analysing each document is displayed in Figure 4.2 which I designed myself.

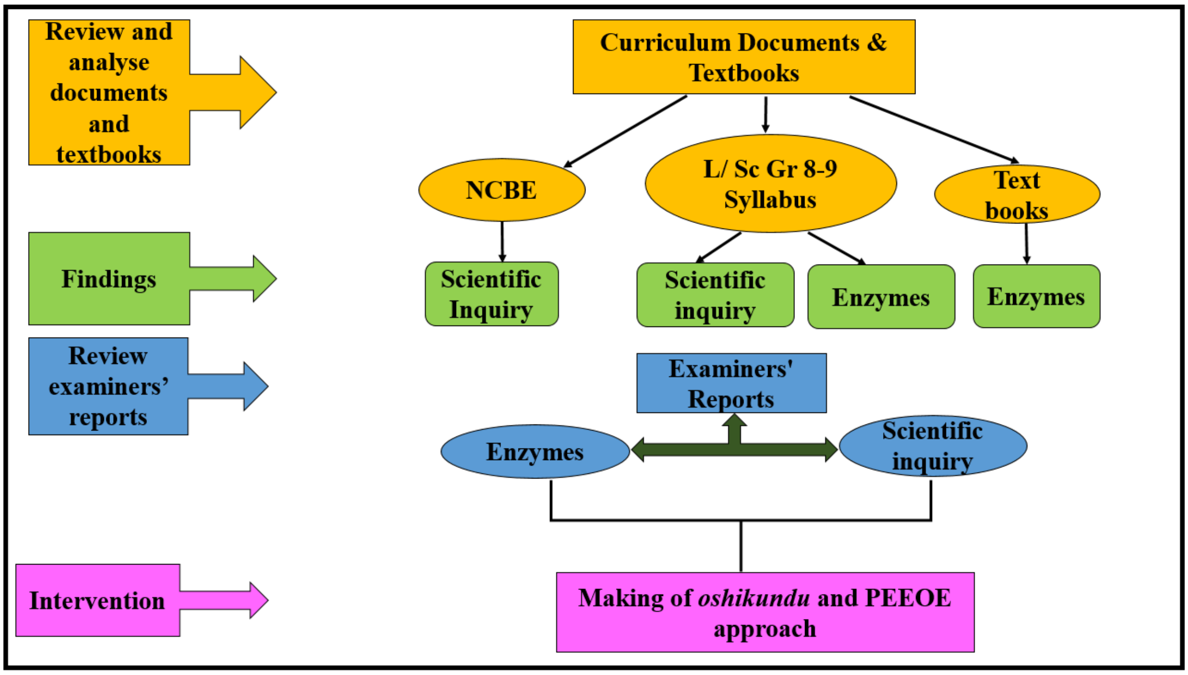

Figure 4.2: The different phases of document analysis

Central to this study was promotion of the use of the indigenous practice of making *oshikundu* to mediate learning of the concept of enzymes and an inquiry-based approach. The review of documents was done in two stages; in the first stage I reviewed the documents alone, as I was establishing the context of my study. I found it essential that my participants also got the opportunity to have the experience that I did. This was motivated by the idea that we were all working collaboratively through the study, to address the situation at hand – the poor performance of learners in the topic of enzymes and the poor implementation of inquiry-based teaching approaches. Thus, allowing them to understand the essence of the situation by analysing these documents, would help them to work collaboratively with me in finding solutions.

At the second stage during the orientation workshop (see Section 4.5.1), we analysed the extracts from the examiners' reports, and this was to gain insight from the reports given about the performance of the learners in this specific topic. The performance in this regard focused on enzymes and their level of understanding of scientific skills. We further analysed both the

Namibian National Curriculum for Basic Education (Namibia. MEAC, 2016), and Life Science Grade 8 syllabus (Namibia. MEAC, 2015), as well as the three-recommended textbooks. It was imperative to analyse the National Curriculum for Basic Education and the Life Science Grade 8 syllabus in terms of its requirement regarding the use of an inquiry-based approach in the Life Science classroom. The Life Science syllabus was further analysed to find out how the topic of enzymes is presented. This similar purpose was also taken to analyse the Life Science Grade 8 recommended textbooks. These analyses played a role as it provided the context of the problems to the participants and I in our classrooms, which we were trying to address in this intervention study. Moreover, this helped the teachers to gain an understanding of the nature of the activity they were involved in (Pollen, 2009).

During this workshop, the teachers who were not aware that the concept of enzymes was part of the Grade 8 Life Science curriculum, got the opportunity to learn that enzymes are indeed part of the Life Science curricullum. We also had the opportunity to share knowledge and learn from each other on how to use inquiry in our classrooms.

4.5.4 Workshop two: Practical demonstration on the process of making *oshikundu*

As is indicated in Section 4.5 of this thesis, I carried out an intervention in the form of workshops which took place over a period of four days. Three Grade 8 Life Science teachers (T1, T2 and T3) participated in the workshops. In addition to the three teachers, a local woman who was an expert in making *oshikundu* (see Section 4.5.2) was invited to demonstrate the process involved in making *oshikundu*. This suggests that bringing a community expert to do a practical demonstration does not only involve parents in the education of their children but contributes a sense of value to indigenous science so that learners may respect their culture (Cocks et al., 2012).

Situating the workshop activities within the sociocultural learning theory as espoused by Vygotsky (1978), during the practical demonstration the local woman communicated in *Oshiwambo*. *Oshiwambo* is the indigenous language of the Aawambo people (the teachers in this study). According to the sociocultural theory, the use of cultural tools such as language, is essential to the learning process. In line with this perspective, the language was used to encourage the teachers to verbalise their ideas and to comment on the ideas of the others, which subsequently contributed to their learning (Simsek & Kabapinar, 2010). During this process, I was a participatory observer. While the woman demonstrated how to make *oshikundu*, we identified the scientific concepts that emerged from the process of making *oshikundu* which were used to develop a mind map. Additionally, a worksheet was provided (Appendix H) for the practical demonstration. The aim of the worksheet was to unpack how the teachers could use the predict-explain-explore-observe-explain (PEEOE) approach to enhance planning and conducting practical investigations which were inquiry-based.

When the woman finished preparing *oshikundu*, the participants bottled *oshikundu* in six bottles. Three of the bottles had *oshikundu* with *oshipithitho*[2], while the other three contained *oshikundu* without *oshipithitho*. The bottles were placed in three different environments. For each place there was two bottles, one with *oshipithitho* and another without *oshipithitho*: two bottles in the classroom (room temperature); two bottles in the cool environment (cool box with ice cubes); and two bottles outside the classroom (in direct sunlight). The teachers made predictions of the set experiment, illustrated their predictions and provided explanations for their predictions on the worksheet provided (Appendix H). Observations of the set experiments were then done in workshop three.

All in all, the workshop went well. This was demonstrated by the level of teacher participation. The teachers were interested in being part of the practical demonstration. What motivated their interest and level of participation, was the vernacular language that was used during the workshop discussions. The development of the mind-maps and the concept maps were also evidence that the teachers had gained knowledge from the workshop.

4.5.5 Workshop three: Observations

The teachers then made observations to find out what occurred as a result of the set experiment. The teachers completed their observations on a worksheet (see Appendix H) and illustrated their observations. Concepts that emerged from the discussions were identified and added to the mind-map, which was constructed during workshop two. The observations provided opportunities to discuss concepts around the topic of enzymes and scientific inquiry. The one

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[2] *Oshikundu* which has already fermented, which acts as a catalyst when added to *oshikundu* which did not ferment.

teacher who had experience in teaching enzymes at Grade 12 level, took the lead in these discussions on enzymes. Furthermore, he presented a lesson in the form of peer teaching to the rest of the group, drawing on the concept of enzymes and associated concepts which emerged from the process of making *oshikundu*. The teachers showed excitement as they were conducting their observations. They were questioning, suggesting possible answers, and arguing over solutions.

4.5.6 Workshop four: Making of concept maps

The teachers and I used the concepts from the mind-maps and developed two concept maps. The first concept was the links made between all the different concepts. The second concept map was specifically for the concept of enzymes.

4.5.7 Participatory observation during the workshops

Observation can be classified either as non-participant or participant observations, depending on the role played by the observer. Maxwell (2012) points out that an observation provides a direct and powerful way of learning about people's behaviour and the context in which this occurs. Ivankova (2015) defines observation as the process of observing and recording events, situations, behaviours, and interactions of people in natural settings to explore individuals' experiences with the studied issue. Thus, Thomas (2013) suggests that to have better insight and understanding, the interpretivist researcher should be a participant in their research situation and understand it as an insider. This provides the advantage to the researcher to collect data directly from the real-life lived experiences (Cohen et al., 2018). During the workshop of the practical demonstration of making *oshikundu*, I was a participant observer. That is, I took the role of an insider during the activities that were taking place. In that case, I was both observing and at the same time, taking part in the activities of the workshop.

My experience of doing the observation and participating in the activities of the workshops were a bit demanding for me. I needed to divide my time well, so that I could both concentrate on observing and gathering rich data from the discussions. Likewise, I also needed to give directions for the workshop activities.

4.5.8 Journal reflections

Killen (2015) explains that the use of journal reflections is an effective way of helping to consolidate one's learning and to identify gaps in developing understanding with others. To

Göker (2016), journal reflections are considered important tools in teacher development as they create self-awareness, evaluation of teaching methods used, problems encountered in teaching and change of teaching practice when necessary. To Eun (2008), writing of reflections in teacher development leads to self-analysis and personal reflection. He stresses that this process is essential for internalisation of learned knowledge to occur (Eun, 2008). In this study the teachers took their reflection tasks seriously and they were committed in doing them, even though they were done after the workshop activities. The aim was to provide an insight into the teachers' learning, and they also acted as a reflection of my workshop activities whether they were helpful or not.

4.6 Data Analysis

The data sets in this study were generated from document analysis, workshop discussions, participatory observations and journal reflections. Merriam and Tisdell (2016) describe data analysis as the process of making sense out of data. This involves interpreting what people have said and what the researcher has seen and read. To find out the meaning in data, Cohen et al. (2011) explain that this is a process that involves organising, accounting and explaining data. In this thesis, data are presented and analysed in both Chapter Five and Six. These chapters are organised according to the research questions. Data in this study were analysed using an inductive approach adapted from Creswell (2014).

In Chapter Five and Six, I begin the process of data analysis which was done by means of a narrative which was then written out as a story. From the narratives, I identified episodes. I then started to colour code the data. Coding data means organising data so that you can easily retrieve specific pieces of the data (Merriam & Tisdell, 2016). The aim in coding data was to identify episodes. Within these episodes, I identified the emergent themes and categories (Appendix J). The themes which emerged where then grouped together as sub-themes (Appendix J). These sub themes which were similar, were further grouped together.

These themes will be discussed in relation to the literature, as well as the two theories, namely, PCK and socio-cultural theory. Notably, when it came to the PCK theory, during the analysis of the episodes I looked at those episodes where the topic specific pedagogical content knowledge components (TSPCK) as proposed by Mavhunga and Rollnick (2013), featured. A TSPCK moment is a moment where two or more TSPCK components are demonstrated in a specific teacher task segment (Mavhunga, 2015).

Drawing on the seminal work of Mavhunga (2018), the components of TSPCK found in the teachers' narratives, were presented in a TSPCK MAP (Park & Chen, 2012). A TSPCK MAP is defined as a visual pictorial diagram which is a representation of the interactions of the TSPCK components in a TSPCK episode (Park & Chen, 2012). Vygotsky's theory was also used to analyse how the social interactions contributed to learning and teachers' PCK. To validate data, the following process was used.

4.7 Validity and Trustworthiness

Validity has to do with how accurate and credible findings are (Creswell, 2014). In light of this, Merriam and Tisdell (2016) suggest that validity can be ensured through careful attention to a study's conceptualisation and the way in which the data are collected, analysed, interpreted, and the way in which findings are presented. Validity in this study was ensured through various ways. The data were gathered from four different sources. Firstly, data were gathered through document analysis. What makes data from document analysis valid, is that all participants, including myself, were involved in co-analysing the curriculum documents. That is, this data was generated through the discussions which involved more than one person.

Secondly, data were also gathered through various interactions and discussions that took place during the workshops and the observations which I made during the workshops. This was firsthand data. Thirdly, combining data from the document analysis, workshop discussions, and participatory observation and journal reflections was also another way of validation, termed as triangulation (Aurini et al., 2016; Cohen et al., 2018).

During the intervention workshop, three different worksheets were given to participants which were completed during the discussions. This created an opportunity for the teachers to write down their thoughts and ideas. This suggests that I did not just rely on observed data which I might have misinterpreted, but instead I also relied on the written information from the teachers' worksheets. This strategy was useful in strengthening validity and trustworthiness in this study.

4.8 Ethical Consideration

In carrying out this study, I was cognisant of ethical principles that I needed to adhere to. Thus, in this section, I highlight how ethical principles were addressed in this study.

4.8.1 Negotiating access and getting informed consent

Before I conducted my study, I asked for permission from the Ministry of Basic Education and Culture and the Omusati Regional Directorate to get an informed signed consent to carry out a study in the schools in the region. I further asked for permission from the school principals to conduct my study in their schools, as well as permission from the local expert woman who verbally consented to be a participant in this study. This negotiation was then followed by a formal letter. This letter was written in the *Oshiwambo* language that was accessible to her.

I further asked the principals to grant me permission to work with the teachers from their schools.

Before I gave the consent letters to my participants and the local expert, I engaged with them in discussions about my study. These discussions included:

- The nature and the purpose of the study;
- The programme of the study;
- How many workshops there would be;
- I also informed the participants including the local expert woman about the workshop presentations; and
- The benefits which the participants would obtain from the study.

These discussions were vital because they provided the picture of what the study entailed, as well as what the study demanded from the participants – for example, the time that they needed to spend at the workshops. It was after these discussions that I asked the participants if they were interested in the study. Their positive responses then led to the issuing and signing of the consent letters.

4.8.2 Respect and dignity

The rights, welfare, anonymity and privacy of the participants was respected and protected. During signing of the informed consent letters, I explained to the participants and local expert woman that their participation in the study was voluntary and thus they had the right to withdraw from the study anytime they wished to do so. I was also mindful of and respected the schedule of the participants and the local expert woman and hence ensured that research activities were done in convenient places and times. It was recognised, however, that since I would be doing research *with* these teachers rather than on them (Ngcoza & Southwood, 2015), anonymity might be a challenge and so I gave them an option to use their real names if they wanted to. In response to this request, the participants asked for their identities to be hidden. Thus, I used codes. As this thesis would be in the public domain, I also considered what data I would present to ensure that anything that I wrote in the thesis would not compromise the dignity of the participants.

4.8.3 Transparency and honesty

While planning for this study, I also considered the benefits and the risks that the study might have for the participants. The potential risk that this study carried, lay in the time that may be compromised by the teachers, that was needed to be involved in this study. However, beyond that risk, I had also considered the benefits which the participants might gain from this study, that is, the knowledge that they would gain from the entire study.

4.8.4 Accountability and responsibility

When I conducted this study, I made sure not to misuse my position as a researcher but rather conducted my study in agreement with research principles, as well as the education department regulations of Namibia on conducting research in schools. That is, I ensured that the participants' work was not compromised by the study. To clarify, the workshops were conducted after school hours. In addition, I was also in constant communication with my supervisors' guidelines and contributions during the time I conducted the study. This ensured that ethical issues which were raised during my data collection phase or write up of the thesis, such as one participant withdrawing from the study, was communicated to my supervisors. My supervisors thus provided suggestions thereof.

4.8.5 Integrity, academic professionalism and researcher positionality

I conducted a study that was free from political, racial, gender, and cultural bias. Likewise, the methodology of my study was academically comprehensive. I also developed a research journal where I recorded the relevant research processes. Data gathered for my study was kept safe in soft copies, so that they could not be accessed by other people. In addition, for the sake of this study, I also kept my participants' transcripts, journal reflections, notes and video items in hard, as well as soft copies, in a safe place.

4.9 Chapter Summary

In this chapter, I described the paradigm that informed this study which was the interpretive paradigm. Within the interpretive paradigm, a qualitative case study approach was employed. In addition, the research goals and questions were outlined. Furthermore, the research site and the participants in this study who were purposefully chosen and expressed their willingness to be part of the study, are described. Similarly, data gathering techniques such as document analysis, workshop discussions, participatory observation and reflections were also discussed. The analysis of data employed was described.

In the next chapter, I present, analyse and discuss data from phase one of workshop one, and this was aimed at answering my research question one.

CHAPTER FIVE: DATA PRESENTATION, ANALYSIS AND DISCUSSION (WORKSHOP INTERVENTION ONE)

5.1 Introduction

The aim of this study was twofold, which was to mobilise the indigenous practice of making *oshikundu,* to mediate learning of enzymes. Secondly, the study was aimed at promoting the use of an inquiry approach in Grade 8 Life Science classrooms. In the previous chapter, I presented the research design and methodology used in this study. In this chapter, I thus present, analyse and discuss data generated from phase one and phase two of workshop one.

Data from the intervention workshops and reflections aimed at answering my sub-research question 1:

> What lessons can Grade 8 Life Science teachers learn or not about enzymes and an inquiry-based approach through co-analysing the curriculum documents?

Firstly, I present, analyse and discuss data from the workshop discussions generated from phase one of workshop one which was the orientation workshop (see Section 4.5.2). I then present data from phase two of workshop one, which was based on document analysis (see Section 4.5.3). However, during the co-analysis of documents, we engaged in discussions. From those discussions, information emerged which I considered important in this study, as it was pivotal to the activities of the second intervention workshop. This data is presented and discussed after document analysis as additional findings. All the data from both phase one and two of workshops one was presented and analysed as explained in Section 4.7.

5.2 Intervention Workshops

The main aim of the intervention workshops was to support teachers to get an understanding of the concept of enzymes and an inquiry-based approach. Before rendering support to the teachers, it was imperative that we first analysed the curriculum documents as explained in Section 4.5.3. But before we did that, we had to orient ourselves. The intervention workshops thus started with the orientation workshop.

5.2.1 Orientation workshop

This was the introduction phase of the intervention workshops. The main aim of the orientation workshop was to orientate the participants about the study and for the participants to get to know each other.

The introduction phase started with greetings of the participants. This was followed by a welcoming remark which was concluded with thanksgiving. Essentially, I used the opportunity to thank the teachers for their willingness to participate in the study and for sacrificing their time, to attend and participate in the workshops. The teachers also introduced themselves. I then explained the study in order to give the teachers an overview of what the study was all about, as well as the activities which would be involved. This was followed by a discussion of ethical issues such as voluntary participation, autonomy and confidentiality (see Section 4.9). The orientation workshop was useful in creating a learning environment and sense of ownership.

According to Merriam (2009), teachers as adult learners prefer to participate in planning, implementing, and evaluating their own learning. It is when participants in a particular activity fully participate and are given the right to plan for their activities, that the participants in those activities understand the nature of the activity they are involved in (Pollen, 2009).

Grounding my workshop in both Merriam's and Pollen's seminal work, I allowed the teachers to suggest how they would like the workshops to operate. For example, the time to conduct the workshops, and how they would conduct their group activities. This was also motivated by my belief that the teachers involved in this study are not passive recipients of knowledge but rather I regarded and acknowledged their wealth of knowledge which they brought to the study (Jacobs, 2015). In this regard they discussed the workshop rules to govern the workshop activities.

For instance, the teachers suggested that all phones should be on silent during the workshop sessions. They also agreed to keep jokes to a minimum. They also placed more emphasis on the issue of respect and notably on respecting each other's views. In addition, they also used the opportunity to suggest meeting times. While on that discussion, T3 stressed the aspect of punctuality.

The above contributions by these teachers showed that they placed emphasis on factors that would ensure a pleasant learning environment for all the participants, while paying some attention to their needs. Literature revealed that quite often professional development training given to teachers is often inadequate and not aligned to the teachers' needs (Ngcoza & Southwood, 2015). Being cognisant of this, the teachers were asked to share their expectations. This was to allow the teachers to further share their needs.

The following extracts captured during group discussions, revealed the teachers' expectations from the workshops. For example, T1 and T2 pointed out that:

> *I assumed that maybe the way we currently* ***conduct practical activities is wrong*** (T2).
>
> *As for me, I am looking forward to see if* ***the inquiry approach*** *is suitable for my learners* (T1).
>
> *You know my class is a* ***mixture of slow and fast learners.*** *I am wondering whether my slow learners will catch up if I use the inquiry method* (T1).
>
> *My class is also having* ***many learners****; this can challenge me to use the method* (T1)

These excerpts revealed that the teachers entered the intervention workshops with hopes to find answers they had regarding the use of inquiry-based teaching method in their classrooms. For instance, T1 was concerned whether the method would be suitable for his large class consisting of a mixture of slow and fast learners. From this expectation, it could be deduced that T1's belief is that an inquiry approach might not be suitable in overcrowded classrooms or classrooms with a mixture of slow and fast learners. Such a belief might have a negative influence on the teachers' practices as postulated by Saad and Boujaoude (2012), that teachers carry beliefs that at times hinder effective implementation of inquiry practices. Moreover, T1's belief confirms the findings of Lee and Shea (2016) who also discovered from their study that teachers were of the opinion that the inquiry method is not suitable in classes with mixed ability learners.

In light of such beliefs, it was hoped that the intervention workshops would create opportunities for the teachers to realise that the inquiry method might be applicable in all kinds of classrooms, regardless. Such change was confirmed in Asheela's (2017) study in which she reported that through her professional development activities, she observed a change in the perspectives and attitudes of her participants towards the use of practical investigations. However, one cannot overlook the views shared by Harris and Rooks (2010) who opine that it appears easy to change teachers' beliefs about inquiry-based approaches such as practical investigations through training, but it remains difficult to change their practice.

To Gess-Newsome (2015), teachers have filters as seen in the consensus model (see Section 3.3.2, Figure 3.3.2.1). They postulate that when teachers gain new knowledge, say a new teaching pedagogy, the teacher has the opportunity to either embrace or reject it as a result of those filters.

5.3 Document Analysis

Using Cobin and Strauss's (2008) opinions on document analysis, in this study I examined documents together with my participants in order to find meaning, gain understanding, and develop empirical knowledge about the concept of enzymes, and inquiry approaches. The documents that we co-analysed were the examiners reports, the broader curriculum of education (Namibia. MEAC, 2016), Grade 8 Life Science syllabus (2015), and textbooks. Each document was analysed for a particular purpose as explained (see Section 4.5.3). I now present the findings from those documents.

5.3.1 Curriculum documents

As alluded to earlier, two curriculum documents were analysed, the National Curriculum for Basic Education (Namibia. MEAC, 2016) and the Life Science Grade 8 syllabus (Namibia. MEAC, 2015). Specifically, the National Curriculum for Basic Education was analysed to find out its requirements regarding teaching of scientific inquiry in Namibian classrooms. The Life Science syllabus on the other hand, was explored to give insight on the requirements for both scientific inquiry and teaching of enzymes. I now present the findings from co-analysing of both the NCBE and the Life Science syllabus. In this section I discuss the lessons which the teachers learnt in relation to inquiry approaches and the concept of enzymes.

As we analysed the curriculum documents, the teachers came to learn about the term's scientific inquiry and scientific knowledge. In this regard, the teachers leant that the NCBE requires that learners acquire different cognitive skills which are promoted through the use of scientific skills. For instance, the NCBE puts it that learners should be able to analyse, synthesise, think creatively, and create knowledge. The teachers further gained knowledge that the Life Science syllabus requires learners to learn and develop basic scientific process skills, such as estimating, measuring, observations, classifying and drawing. Beyond this, they also acquired knowledge that the syllabus requires learners to develop and use those scientific skills which are cognitively demanding such as problem solving, analyzing and application of scientific knowledge to task.

In addition to the above skills, the teachers also learnt that learners are required to be taught practical skills through practical investigations. On the topic of investigations, the teachers got the opportunity to learn the different steps that are involved in scientific investigations. For instance, they gained knowledge that learners are supposed to develop their own investigative questions, and plan how they are going to go about finding answers for those questions. To get back to the point of practical investigations, the teachers also gained knowledge on how to assess practical skills using the guidelines stipulated by the assessment objective C of the Life Science syllabus. However, it has also been recognised, that conducting of practical investigations are kept to a minimum due to inadequate or no resources in our schools. The syllabus shed light on this matter, as the teachers learnt that in cases where resources are not available for practical investigations, the Life Science syllabus suggests that the teachers use resources from the environment as alternatives.

While the above learnt knowledge referred to knowledge that was promoted by both the curriculum and the syllabus, we also had the opportunity to clarify phrases within the syllabus which could lead to misconceptions. One of these phrases is the mentioning of the word laboratory in the syllabus. It was then made clear that indeed, the learners have to learn laboratory rules, yet it does not restrict teachers from carrying out practical investigations in areas other than laboratories.

Furthermore, as we co-analysed these curriculum documents, the teachers had the opportunity to reflect on the way they promoted scientific inquiry and made use of inquiry approach in their classrooms. In consequence, the teachers realised that the way they conducted investigations in their classrooms was not aligned to the curriculum expectations. The teacher also realised that when they did not have resources to use in their teaching, they could explore their immediate environment to look for alternative resources. With this knowledge, the teachers then realised that the environment could be used to facilitate learning. Above all, the teachers noted the importance of giving the learners the autonomy to come up with their investigative questions and plan for their own investigation. After the analysis of the curriculum documents on the concepts of scientific inquiry we also analysed the Grade 8 Life Science syllabus on mediation of the concept of enzymes.

5.3.2 The Life Science syllabus, learners' textbooks and the concept of enzymes

Analysis of the syllabus led to the discovery that the concept of enzymes is implicitly outlined in the syllabus and the extract from the syllabus confirms this: "Distinguish between chemical and mechanical digestion" (Namibia. MEAC, 2015, p. 19).

The concept of enzymes is located in the concept of chemical digestion. What is important, is that the understanding of the concept of enzymes is a pre-requisite for the understanding of chemical digestion – it is the understanding of what enzymes are and their functions that will allow learners to understand what chemical digestion is. This could then lead to the ability to distinguish between the two types of digestion as espoused by the syllabus – chemical and mechanical. Further analysis of the concept of enzymes was done within the three recommended Life Science textbooks.

Table 5.1: How the concept of enzymes is presented in different textbooks

Textbook title	How enzyme is presented
Platinum Life Science Grade 8 learners' book	• Introduce the concepts mechanical and chemical digestion. • Name the enzymes in the different parts of the human digestive system and the food (substrate) they digest. E.g. • Mouth (enzyme amylase). • Amylase to starch to glucose. • Enzyme found in the stomach E.g. ❖ Protease ⟶ proteins ⟶ amino acids. • All pancreatic enzymes E.g. ❖ Lipase-break ⟶ lipids ⟶ fatty-acids & glycerol. • Enzymes present in the Ileum E.g. ❖ Maltase ⟶ maltose ⟶ glucose
Solid foundations Life Science learner's book Grade 8	• Two kinds of digestive processes ❖ Mechanical ❖ Chemical • Defines chemical digestion. • Define enzyme. • Enzyme in the saliva start chemical digestion in the mouth. • Pancreatic juice contains enzymes.
Living Life Science learner's book	• Describe mechanical digestion. • Describe chemical digestion. • Indicate that different enzymes act on different food types. • One example given: amylase digest starch to sugar.

Three textbooks are recommended in this subject: Living Life Science, Platinum and Solid Foundation. We found out that none of the three recommended textbooks made a provision to provide details on the properties of enzymes. Essentially, it is the understanding of the properties of enzymes that allows learners to get the essence of what enzymes are. Instead, the textbook (Solid Foundation) attempted to provide the definition of an enzyme, as “a protein that aids a metabolic reaction”. On the other hand, the Platinum textbook provided detailed information about enzymes which include different enzymes, their substrates and their products. Even so, the starting point for learning enzymes should be its properties which paves the way to its definition and then to how the enzymes work. In the Platinum textbook, most of the enzymes found in different parts of the human alimentary canal are presented and the substrates which they digest, as well as the end products are also noted. After analysing these textbooks, I still maintain that the textbooks failed to sequence the knowledge of enzymes in such a way that what should be taught now and what needs to be taught later, is clearly spelt out.

The manner in which the textbooks present the concept of enzymes is worrisome; notably, Solid Foundation and Living Life Science. Considering that a textbook should also act as a guide for teaching, the teachers who use these two textbooks who have less subject matter knowledge (SMK) about chemical digestion, might not have any idea that enzymes actually form part of the syllabus. This could then result in inadequate SMK being taught.

Having learnt that the concept of enzymes and inquiry are components of the Grade 8 Life Science syllabus, we also saw the need to examine the examiners’ reports to find out how learners have performed in these two concepts.

5.3.3 The examiners’ reports

Owing to the purpose of the examiners’ reports, the purpose for analyzing them was to find out how the learners have performed with regards to the concept of enzymes and scientific inquiry skills. First, I present the findings on how learners performed regarding scientific inquiry and then later I will discuss the reports on how learners performed in the topic of enzymes.

Examiners’ reports from the past four years were examined: 2015, 2016, 2017 and 2018 (see Appendix G). During the analysis of the examiners’ reports, it was evident that the learners lacked scientific skills. We identified three of those skills that learners lacked. For instance, in

2015, the examiner's report revealed the following: learners did not know how to make a fair test; learners lacked understating on how to set up a control in the experiment; and learners lacked skills on application of knowledge in different contexts.

With these findings, the teachers involved in this study realised that practical activities were not being implemented in some classrooms. This finding confirms those of Asheela (2017), whose study found that Namibian science teachers generally did not conduct practical investigations. The findings further confirmed that if the teachers did conduct them, then possibly those practical activities did not necessarily promote scientific inquiry skills (Kandjo-Marenga, 2008; Kapenda et al., 2002). While these are the findings from the literature, teachers also had several comments to make.

T3 for instance, argued that learners are taught the importance of repeating a test even though not practically, "*to make the test fair"*. The teachers did not welcome the remark made by the examiner's report on repeating a test to show what is meant by a fair test. They all lamented that it is quite impossible to repeat a practical investigation to demonstrate what is meant by a fair test. Making her argument clear, T3 explained "*even if I wanted to do that, where will I find the resources, we are already struggling to find resources to do a practical activity … it is a waste".* Lending support, T1 added, "*it is going to be costly".*

This finding shown above is in agreement with Ramnarain and Schuster (2014) who postulate that availability of resources influences the methods adapted by the teachers towards an inquiry approach. In this case, the teachers resorted to not demonstrating to the learners how a fair test is ensured, due to a lack of resources. An analysis of the teachers' comments revealed the teachers' frustrations in response to the examiners' report. Essentially, it might not be fair to blame teachers for poor implementation of the syllabus, if the schools are not supported to enhance that. However, with the availability of other resources to mitigate the issue of resource constraints, it is imperative that teachers are made aware of such alternatives.

Also, making reference to the examiner's remarks on learners not knowing how to set up a control in the experiment, T2 also indicated, "*for every practical activity done, there is always a control … learners are taught these things …. the problem is only that our learners do not want to think".* She explained that possibly, the learners get confused when the examination asks for that knowledge in a different context from the one they had done. T2 thus concluded that "*as a result they failed to provide correct answers … but to say we do not teach them, aaye* (no) *we do teach them"*.

From the arguments made in the extract above, in my view, sometimes learners learn without understanding. As a result, they might not see the meaning in that new knowledge. The NCBE (2016) discourages such a form of learning, as it warns that what is learned through memorisation is learned without any understanding and is easily forgotten. In this context, the knowledge was not forgotten, but rather the learners were not able to apply that knowledge. The preceding discussions revealed the performance of the learners in scientific skills. The next discussion is on reports of learners' performance in the concept of enzymes. A summary of the examiner's report on learners' performance of enzyme is given below:

> Majority of learners could not define enzymes correctly; most learners could not spell the names of the enzymes correctly; the term "catalyst" was written as catalistic/most learners cannot spell substrate correctly; they made reference to substance; the majority of learners made reference to "enzyme activity stops" instead of "reaction stops".

It is evident from the examiners' report that learners performed poorly in this topic. The examiners' reports suggested that seemingly the learners did not know what enzymes were. We also learnt that the learners also grappled with spelling the biological terms 'enzymes' and 'substrate' correctly. This finding concurs with that of Nakale (2012) who also established that the learners in his study were challenged with spelling the terms associated with the concept of enzymes correctly. While these concerns are shared by the biology examiners' reports of 2015 and 2016, T2 indicated that one of the topics she herself finds challenging to teach is enzymes. In contrast, T1 did not agree with T2 as he remarked, "*personally I believe that enzyme is an easy topic, but … learners generally find it difficult … they just have that belief that the subject is difficult"*.

The discussions by T1 and T2 provide insight into what is difficult to teach (Mavhunga & Rollnick, 2013). Following T1's opinion, one could deduce that learners' beliefs can also be a hindrance towards understanding the topic. Literature warns that negative beliefs can lead to the development of negative attitudes towards learning a topic, which could consequently affect learner performance (Abu-Hannieh et al., 2018).

T1 agreed with T2's claim that learners find the topic difficult because they learn it without relating it to situations which they are familiar with. This could further imply that the learners find the concept abstract. These teachers' arguments thus resonate well with those of Asheela

(2017), Mavuru and Ramnarian (2017) and Nicodemus (2017), who conclude that learning which is not relevant to the learners might produce undesirable results. As we were analysing the curriculum documents and examiners' reports, the teachers also had the opportunity to reflect on their classroom practice – data from those reflections are presented in sections that follow. First, I present the reflections on the teachers practice regarding conduct of practical investigations and promotion of inquiry. Thereafter I discuss their reflections on how they taught the concept of enzymes.

5.3.4 Teachers' PCK in conducting practical investigations and promotion of scientific inquiry

Practical activities are believed to have positive contributions towards learners (Miller, 2010). Nonetheless, T3 indicated that she finds it difficult to conduct practical investigations with her learners. She explained this was due to the following three factors. Firstly, the school does not have the required resources to conduct practical investigations; secondly, it is quite unsafe for the learners to conduct practical activities in an overpopulated classroom; thirdly, some practical investigations involved flammable materials, thus doing it close to learners could be unsafe as they could burn. Specifically, she stressed that Grade 8 learners are playful, and if practicals are done in an overpopulated classroom with less space, the safety of the learners could be jeopardised.

In analysing T3's views on conducting practical investigations, one could deduce or hypothesise that she believes practical investigations should be conducted in laboratories and not in classrooms. Her understanding in this regard is that doing practical investigations in the laboratories, promotes learner safety. Furthermore, it seems she believes that it is inappropriate to conduct practical activities in an overcrowded classroom. This finding concurs with Asheela (2017) and Harmon (2011) where teachers shared their concerns of overcrowding classrooms as an inhibitor towards effective implementation of inquiry. Likewise, this finding also corroborates with studies done in South Africa where lack of resources was identified as one of the inhibitors of practical investigations (Dudu, 2017; Nompula, 2012; Ramnarain & Hlatswayo, 2018). However, the beliefs on practical activity shared by T3, could be changed if the teacher can be equipped with knowledge and help on possible ways of conducting practical activities (Quigley et al., 2011). This might mean engaging teachers in a form of professional development to provide them with knowledge which could hopefully help change their beliefs and perspectives as espoused by Asheela (2017), Eun (2008) and Ngcoza and Southwood (2015).

Also, reflecting on how she promoted inquiry in her classroom, T3 expressed that at times her learners plan their investigations, but they tend to take a longer period of time. Her concern resonates with Peeters and Meijer (2014) who note that in inquiry-based lessons, learners grapple with the formulation of research questions and with the design of the investigation. Thus confirming her argument, Yoon, Joung and Kim (2012) posit that this could lead them to taking much longer to complete their tasks. This notion thus points back to Flick and Lederman (2004) who suggest the importance of knowing the skills in conducting inquiry-based lessons. From the discussions in this paragraph, one could agree that the teacher had some knowledge on how to promote inquiry through investigations.

For example, her mentioning that she allows learners to plan for their investigations and also allows them to come up with their own questions, is an indication that the teacher is aware of the principles that guide inquiry (NRC, 2000). She further demonstrated that she is aware that the learners have to come up with investigative questions. This equally revealed that the teacher makes use of the constructivist approach when she gives autonomy to the learners, a construct of the learner-centred approach (Vygotsky, 1978).

Furthermore, data from this study, also revealed the teachers' pedagogical knowledge level (PK) in conducting practical activities. Firstly, T1 reported that he provides all the instructions of the practical activities to the learners (both secondary and senior secondary learners) and the learners do the practical activity following those instructions. Such an approach to conduct practical investigation is discouraged as seen in literature, as it deprives the learners the use of their curiosity, their inquiry skills, and hinders the development of their process skills (Kim & Tan, 2011). Secondly the teachers also demonstrated that they believe in getting the anticipated correct answer when doing the experiments. This is explained in the next paragraph.

In a constructive argument, T1 pointed out that one has to do a pre-test to ensure the experiment gives the expected outcome. This sentiment was also shared by T3 who explained that results must be like those in the learners' textbook. Thus, she suggested doing a pre-test that would allow for that. This finding confirms the argument made by the teachers in Kim and Tan's (2011) study that getting the right answer is key to practical investigations. Just like those teachers of Kim and Tan (2011), in this study the teachers also showed they feel restricted to getting the exact answer as it appears in the learner's textbooks. One could then agree with the teachers in this study, that there is a fear of losing face if the results are opposite to those in the textbooks (Kim & Tan, 2011). Thus, these findings could suggest that perhaps, textbooks do not have to include the answers to the practical activities, to reduce this burden that leads to epistemological constraints such as learning of process skills – for example, the process of prediction. Similarly, I also agree with Suarez et al. (2018) who argue against such a way of conducting practical activities. The authors believe that this does not foster the learners' curiosity and motivation to learn science; in fact, getting the wrong answer should be an opportunity to promote learning.

5.3.5 Unexpected answers create learning opportunities

In this section, I used the teachers' views which they had about getting a particular answer for an experiment. The discussion was aimed at helping them realise why we as science teachers, should never think if the results we get from experiments are not as expected, then we have failed. Earlier on the teachers used the following phrases, "*what if the chemicals have expired, you cannot just come to the class and say let us do this experiment*?" (T3), to explain why it is important to make a pre-test or to ensure the learners get the right answer in the practical activity.

Following from her argument, I used this scenario as a representation to allow for a discussion that would help us understand that such answers considered as wrong answers, create opportunities for learning. I used the following scenario:

> *I put a drop of Iodine*[3] *solution on a piece of apple, the iodine solution turned red instead of blue black, what could be the reason?*

Teachers engaged with the scenario and provided possible suggestions as to what could be the reason behind this. For example, T2 indicated that maybe the apple was *rotten*. While T1, suggested that maybe there were other underlying factors for the color change. Following on his suggestion, I then asked, "*which factors*?" T1 responded "*maybe the chemical has expired"*. T3 and T2 also concurred with T1's suggestion. This discussion shows how beliefs and views

[3] Iodine is a brown coloured solution which is used to test for the presence of starch in food. In the presence of starch, Iodine turns blue-black.

that teachers have can shift positively using different scenarios, as these teachers did. This finding confirmed what Asheela (2017) found in her study about the change in the views of the teachers towards conducting practical activities after they were shown how to conduct practical activities using easily accessible resources. The change in view is also an indication that the scenario used acted as a mediatory tool which contributed to the teachers' collective PCK (Carlson & Daehler, 2019) in this social setting (Vygotsky, 1978).

Likewise, the scenario used, acted as an analogy (Mavhunga & Rollnick, 2019) which helped the teachers to visualise what was being discussed and gave them a better view (Korganci et al., 2015). The result further implied that this shift in thinking reflected in the improvement of the teachers' PCK which could also hopefully help to inform their PCK when conducting practical activities in the future (Carlson & Daehler, 2019). Despite the challenges and the poor conduct of practical activities observed, the teachers still believed that using practical activities carried some benefits.

5.3.6 Practical activities contribute positively in science lessons

T1 is of the view that practical activities promote learning. This view concurs with those of Maselwa and Ngcoza (2003) who explain that what promotes learning during practical activities is the Predict-Explain-Explore-Observe-Explain (PEEOE) approach which allows learners to use their hands to manipulate materials, use their minds and words to write down their experiences. In addition, they also reiterate that the development of mind-maps and concept maps further promotes learning during practical activities. To Harlen and Qualter (2014), learning during practical activities is enhanced as learners are afforded an opportunity to raise questions to suggest ways of answering them, to make predictions, to propose explanations, to collect evidence and to interpret it in relation to the question being investigated. T1's findings also resonate with Kibirige and Tsamago's (2013) findings who postulate that practical activities increase understanding of content because it reinforces critical thinking and logical reasoning. Above all, knowledge which is gained through activities in which learners are involved such as practical investigations, promote learning with understanding (Asheela, 2017; Lamm, 2017) and contribute to retention of knowledge (Blanchard et al., 2010; Easterly & Myers, 2011; Nikodemus, 2017; Schmid & Bogner, 2015).

T1 also noted that "*learners get the opportunity to discover things on their own*". This view resonates with Bosman (2016) who explains that direct interaction with the materials during the collection of data leads to discovery of knowledge. After learners gain information that they discover during practical investigations, they further get the opportunity to test their findings against those of the scientists (Dixon, 2015; NRC, 2000). The activities that lead to discovery, also gives learners the opportunity to use their inquiry skills. Thus, learners are able to construct new knowledge as independent thinkers (Lamm, 2017).

In a similar vein, T2 also believes practical activities are good for learners. Her belief of practical activities is that it promotes learners' interest which she puts as, "*The more the learners do practical activities, the more they want to know and observe to see what is really happening*".

Her view concurs with Suarez et al. (2018) who indicate that inquiry such as practical investigations, fosters learners' curiosity and motivation to learn science. As a result, T2 concluded that because of motivation, learners would be eager to come to your class. Beyond the promotion of interest, Wells (2011) indicates that an inquiry approach motivates learners which leads them to engage with concepts and strategies, which in turn can be used as tools for achieving true understanding (Da Silva et al., 2015).

Also acknowledging the importance of practical activities, T3 shared that knowledge obtained from one practical activity can also be used in another topic. She referred to the practical activity of the potato which is used to demonstrate osmosis. Having a good knowledge of the syllabus, she explained that in using this practical activity, with the knowledge from this activity about osmosis, one can also use it to teach water uptake in plant roots. Unfortunately, while that is her view, T3 observed that our learners lack the skill of application of knowledge. As a result, they tend to separate this knowledge from the topic of water uptake in plant roots from osmosis. This finding could reveal that the learners learn science as facts without any understanding (Kim, & Tan, 2011). In addition, T2 also had interesting views on the importance of practical activities.

Being a strong believer of practical activities, T2's school lacks resources to conduct practical activities. Thus, she conversely stated, sometimes "*I use diagrams and reading from the textbook ... I do not think it is enough*". She condemned the approach of just using diagrams and reading from books which she experiences in her classrooms as a bad teaching approach. It could be surmised that T2's views concur with those of Da Silva et al. (2015) where learners expressed that the practical investigation enabled them to use their hands, visualise, and apply knowledge which helped them to understand the concept better than reading words in books. Given that the lack of resources observed in our classrooms contribute to poor implementation or lack of practical activities, teachers shared knowledge on how to improvise for resources. This is discussed in the next section.

5.3.7 Teachers shared knowledge on how to improvise materials for practical activities

In the absence of resources to conduct practical activities, the teachers involved in this study pointed out that they look for alternative ways to conduct practical activities. For instance, all the teachers explained that they improvise with other resources to conduct practical activities when opportunities arise. While it is possible to improvise, T1 stressed that this is not the case in all practical activities, as some require conventional materials which one need to buy. He motivated his argument when he stated: *"Let me say a practical that requires Carbon Dioxide gas, it will be difficult to improvise this gas – how do you do it?"*

The issue of lack of resources to conduct practical activities is a non-contested fact, as it not only affects Namibia, but other countries such as South Africa as well (Asheela, 2017; Kibirige & Tsamago, 2013; Nompula, 2012). While it is possible to improvise, not all materials are suitable for use in the school environment, for example, those that contain alcohol. T1 suggested that the scientific process skill of observation (taste) cannot be used when doing some practical investigations as the learners cannot taste the alcoholic drink used in teaching, which limits the use of this skill.

Concurring with this, T3 suggested that in some practices that produce alcohol, like the making of *ombike* (used in teaching distillation), the teacher could prevent the alcohol content from being produced. T3 pointed out that this could be ensured by allowing the berries "*eembe*" to steep in water for a shorter period than the required days. In that way the teacher could still use the same practice and procedure, but the vapour produced "*ombike*" would not contain alcohol. This was new knowledge to us as none of us had ever thought of such an innovation. T3 shared this information with us giving us an opportunity to learn and to find a solution to the problem of not only resource constraints, but how to make use of these fermented beverages without the fear of learners being in contact with alcohol. The learning of this new innovation from T3 is proof that workshops are essential in professional development, as they create opportunities for the teachers to interact with themselves which in turn creates opportunities for the teachers to share their experiences, knowledge, skills, and problems, difficulties and possible solutions (Eun, 2008). This further also attests to the notion of social learning, as espoused by Vygotsky (1978). While it is evident that the lack of resources affects the practice of practical activities, data from this study also revealed that the beliefs that the teachers hold about practical activities also influence their practice. Having discussed the PCK of the teachers in practical investigations, in this next section I discuss the teachers' PCK in teaching the concept of enzymes.

5.3.8 Teachers' TSPCK in the topic of enzymes

As the teachers were reflecting on their teaching, in their explanations I captured those moments in which the topic specific pedagogical content knowledge (TSPCK) components were exhibited (Mavhunga & Rollnick, 2013). Drawing on the seminal work of Mavhunga (2018), those TSPCK components were then summed up and presented as a TSPCK map (see Section 4.7). All three teachers presented their PCK on how they use it to mediate the concept of enzymes. However, only T1's narrative is presented in a TSPCK map while for T3 and T2 only their narrative is presented. This stemmed from what I explained earlier, that both T3 and T2 seemed not to mediate learning of the concept of enzymes (see Section 5.3.2). As a result, their narratives did not have much to say on their teaching of the concept of enzymes.

Firstly, I present T1's narrative. From his narratives, I extracted segments which represented the TSPCK components. I then developed his TSPCK map extracted from his narrative. In this regard I adapted the approach from Mavhunga (2018) on mapping the TSPCK components identified from the teachers' narrative as shown in Figure 5.3. The information on the map is presented as follows: The TSPCK components are identified from the narrative, and as components of TSPCK have been abbreviated as follows: learners' prior knowledge (LPK), curricular saliency (CS), what is difficult to understand (WD), representations (RP) and conceptual teaching strategies (CTS).

These components are then further presented to indicate how they represented the teacher's conceptual teaching strategy in teaching the topic of enzymes. That is, the components are presented in circles with solid circular lines. In addition, where the components were found to be inseparable and interlinked, they are presented as overlapping circles (Mavhunga, 2018). Likewise, where components were in a linear sequence, they are presented with a solid linear arrow to point out the sequence in which the components emerged (Mavhunga, 2018).

This is how T1 narrated his teaching of the concept of enzymes.

> *I first explain chemical digestion to the learners. I do this by providing an explanation that chemical digestion is the digestion where new substances are formed. I then provide an explanation how the new substances are formed. That is, I tell them that the insoluble substance will be converted to soluble substance. For example, i.e. starch is converted to maltose. I also describe rates of reaction and enzyme activities by referring to real life situations. The following examples were highlighted:*
>
> - *Enzymes control the activities in our bodies, in the morning, the temperature is lower, and this makes us less active too;*
> - *In the morning, a wasp will not sting, but as the temperature start to increase through the day, the wasp become more active and if tempered with it will be able to stink; and*
> - *Similarly, a bee is often less active in the morning and hardly stink in the morning. However, when the temperature rises, it could stink a person when provoked.*

It is clear from T1's narrative that he teaches the concept of enzymes. His teaching starts with the explanation of chemical digestion. He does that by first explaining what chemical digestion is. This is a reflection of curricular saliency (CS). This is evident from his identification of the big idea 'chemical digestion'. The mention of the words insoluble and soluble is an indication that T1 is knowledgeable about the concepts that make up the topic. This too is a manifestation of CS. T1 also seemed to be mindful of what is difficult for the learners to understand (WD). This is evident in the efforts he made to provide examples of what is meant by converting insoluble substances to soluble ones. In this case, he used the example of starch (insoluble substance) being converted to maltose (soluble substance).

The component of LP is also evident in T1's narrative. This is evident from his teaching that draws on real life examples (wasp, bee, and human body); this could be the knowledge that the learners already know (Roschelle, 1995). It could be surmised that the use of real-life examples is an illustration that the teacher is aware of what learners find difficult to understand (WD). Likewise, it is also a representation (RP) that he uses to make learning relevant which enhances understanding. This is also a reflection of the teacher being thoughtful of the gatekeeping concepts that prevent learners from understanding enzyme activity (WD). Drawing on LP is pivotal in teaching, as Rennie et al. (2011) stress that this allows learners to make the most from the science they receive at school, as they are able to make links with what they experience outside the school doors. Beyond this experience, learners might also find learning relevant and meaningful. In addition, the teacher also manifested a conceptual teaching strategy (CTS) that took into consideration LP, what they find difficult to understand and the kind of representation the teacher uses to address that.

To Mavhunga and Rollnick (2013) and Mavhunga et al. (2016), representations play an important role in teaching and learning as they aid teaching of a concept, so that what is taught can be meaningful. Furthermore, it is evident that T1 seems to sequence his teaching in such a way to maximise learners' understanding. He first explained what chemical digestion is: "*new substances are formed*". Then he provided an explanation of how new substances are formed. He explained that insoluble substances will be converted to soluble substances. This explanation is followed by an example aimed at making clarity of the insoluble substance that is 'starch' and the soluble substance being 'maltose'.

Even though T1 tried to sequence his teaching in the manner explained above, he did not start his teaching by giving the properties of enzymes. In my view, the problem associated with teaching the concept of enzymes without starting with its properties and then its definition, is what makes the concept abstract to the learners. It is for that reason that this study emphasises on teaching the concept in a contextualised manner – in this case, the practical demonstration of *oshikundu* which is used to introduce the concept of enzymes. Pertaining to the subject of TSPCK, the TSPCK components identified from T1's narrative, are now presented in the TSPCK map in Figure 5.3 below.

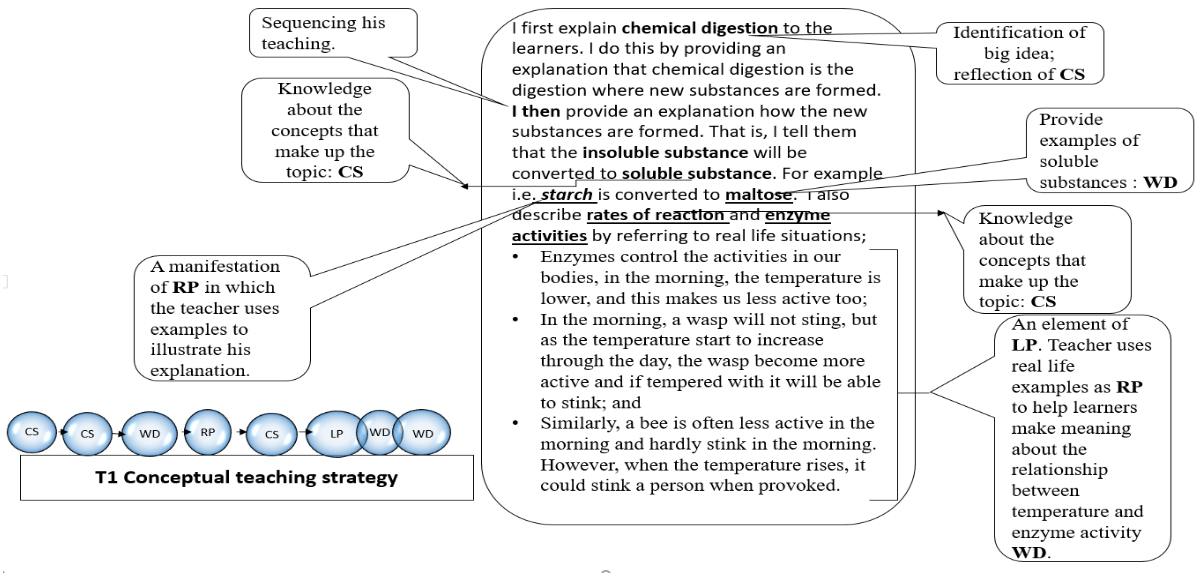

Figure 5.1: Shows the TSPCK MAP of T1 (adapted from Mavhunga, 2018)

In this episode, T1 demonstrated a TSPCK episode with four different TSPCK components, some repeating. Curriculum saliency is repeated three times, while representation and what is difficult to understand is repeated twice. T1's map revealed that the teacher uses the TSPCK components interactively. This is an indication of integration that the teacher employs of the different components to enhance learning. For instance, he makes use of examples as representations, which aid understanding.

T3 and T2 also shared their conceptual teaching strategies when teaching the above (see Section 5.3.2): basic competency for teaching enzymes.

> *I first introduce the digestive system in which the learners must identify the parts of the digestive system ... this is just to remind them of what they did before. The learners then also provide the functions of those parts. Thereafter, I then explain how digestion takes place in different parts.* (T3)

> *I start the topic by introducing the digestive system, where learners need to identify the parts and provide functions for those parts. I use diagrams to help the learners to identify the parts. I also define chemical and mechanical digestion. By giving the definitions, the learners would distinguish between the two kinds of digestion.* (T2)

This narrative confirmed the confession made by teachers T2 and T3 earlier that they do not include the concept of enzymes in their teaching. However, in their narrative, there is evidence of topic specific PCK components. By drawing on the learners' knowledge which they gained in the previous topic, T3 and T2 demonstrated the component of learners' prior knowledge. To Mavhunga and Rollnick (2013), drawing on learners' prior knowledge is a TSPCK component helps to provide the teacher with the current level of learners' understanding of a concept. In addition, as discussed earlier, it helps to unearth misconceptions which the learners might have. T2's pedagogical choice to use diagrams is also an example of representation that the teacher uses to make content accessible to the learners. By looking at the teachers' conceptual teaching strategies, it revealed their PCK in teaching this concept of enzymes.

In analysing the teachers' narratives, it became clear that the teachers interpret the specific objectives differently, something which illuminated their understanding of the objectives. As explained earlier, T1 is experienced in teaching Biology at a senior level. For this reason, his PCK and subject matter knowledge in teaching enzymes confirms the idea of Abell (2008) who indicates that teachers PCK develops over time as a result of different experiences, such as teacher preparation programmes and teachers' own teaching and learning experiences. In this case, one could deduce that T1's teaching experience contributed to his PCK in teaching enzymes in Grade 8 classrooms. His experience in teaching the concept, further explains the observation made on the interaction between the TSPCK components (see Figure 5.3).

Admittedly, though, teachers are idiosyncratic in their pedagogies, hence, this further influences their pedagogical choices and subsequently also influences their practice. For instance, T1 showed a strong sense of subject matter knowledge (Shulman, 1986). He also showed that he knew the different enzymes and the substrates they act on – this is evident from the example he provided (starch digested into maltose). Furthermore, his ability to relate to real life examples such as a bee and a wasp, is an indication that he has broad sense of representations which he uses to enable learners to understand the concepts (Mavhunga & Rollnick, 2013). It further shows that the teacher uses examples which learners are familiar with, which is an indication that he draws on learners' prior knowledge. While T1 used examples, which were relevant to the learners, T3 and T2 used learners' knowledge from previous topics which they were taught before. In this way, the learners are given an opportunity to remember their previous knowledge on a topic, which can help them build on to the new knowledge. This is an example of learning which precedes from prior knowledge (Roschelle, 1995).

Due to the lack of experience in teaching Biology, the teachers T3 and T2 seemingly, were unable to unpack the basic competency where the concept of enzymes is located as espoused by Aydin et al. (2012) and Davidowitz and Rollnick (2011). The findings in this section might be an indication that when the teachers were introduced to the new Grade 8 Life Science syllabus, the professional development activities given to them did not thoroughly deal with the curriculum changes, as lamented by Garet et al. (2001). Thus, the advice given by the authors is that professional development aimed at addressing new changes in the curriculum, should focus on content, pedagogy or both, in order to avoid teachers having inadequate information as evidenced in this study. In such cases, learners suffer as they are taught incomplete information.

All in all, data presented in this chapter shows that the teachers had opportunities to learn from co-analysing the curriculum documents. Firstly, the teachers learnt about the areas that the learners grapple with, in the Life Science syllabus. These areas were related to scientific skills and the concept of enzymes. Secondly, the teachers had the opportunity to learn that the concept of enzymes and scientific inquiry are part of the Grade 8 Life Science syllabus. Furthermore, T1's narrative helped T2 and T3 gain knowledge on the teaching of enzymes. Thirdly, as the teachers shared their PCK on conducting practical investigations, they had the opportunity to learn and realise that what is termed as incorrect answers or 'not the expected result' in practical investigations, indeed creates opportunities for learning. Lastly the examiners' reports provided the participants and I, with the opportunity to establish how learners currently perform in the topic of enzymes and their level of inquiry skills.

5.4 Chapter Summary

In this chapter, I discussed the intervention workshop activities. This commenced with the activities done during the orientation workshop. In addition, I also discussed the documents which we analysed and then presented the findings. These documents included the examiners' reports, Grade 8 Life Science syllabus and learners recommended textbooks. The co-analysis of curriculum documents and examiners' reports confirmed that social interactions in professional development, such as workshops, contribute to collaborative learning. It further revealed that it also contributes towards looking for solutions to problems collaboratively. Furthermore, in this chapter, I discussed the TSPCK of the teachers in mediating the teaching of enzymes as well as their PCK on conducting practical activities.

In the next chapter, I will present, analyse and discuss the activities of the intervention workshop which was aimed at supporting teachers to gain knowledge on the concept of enzymes and an inquiry-based approach.

CHAPTER SIX: DATA PRESENTATION, ANALYSIS AND DISCUSSION (WORKSHOP INTERVENTION TWO)

6.1 Introduction

The main goal of this study was to mobilise the indigenous practice of making *oshikundu* to mediate learning of the concept of enzymes and an inquiry-based approach. In the previous chapter I presented, analysed and discussed data generated from phase one of workshop one, which was the orientation workshop. The aim of this workshop was to analyse curriculum documents and the examiners' reports. I also presented data from phase two of workshop one, where analysis of relevant documents was done. In this chapter, I thus present data that were generated through workshop discussions from workshop two, three, and four. These workshops were presented together. The reflections which were done by the teachers, are also used in the discussions. Data from these workshops were aimed at answering my research sub-questions 2 and 3 which are:

- How does the practical demonstration of making *oshikundu* by an expert community member enable and/or constrain Grade 8 Life Science teachers' interaction, participation and understanding of the enzyme concept?
- How does using the process of making *oshikundu* enable or constrain Grade 8 Life Science teachers' understanding of an inquiry-based approach?

The workshops were aimed at providing support to the teachers in understanding the concept of enzymes and an inquiry-based approach. The support was given using two approaches. Firstly, the practical demonstration of making *oshikundu* was used as a representation in this study. It was during the process of making *oshikundu* where the participants and I, hoped to get opportunities to learn about the concept of enzymes and an inquiry-based approach. Firstly, I present, analyse and discuss data from the practical demonstration of making *oshikundu*. In these discussions, I show whether the practical demonstrations enabled or constrained Grade 8 Life Science teachers' interaction, participation and understanding of the concept of enzymes. Secondly, I discuss how the TSPCK components were used to transform knowledge on the concept of enzymes, obtained from the practical demonstration of making *oshikundu*. Thirdly, I present and discuss data on how the practical demonstration of making *oshikundu* enabled or constrained the teachers' understanding of an inquiry-based approach.

6.1.1 Intervention workshop (two)

Data from document analysis (see Section 5.3.1) revealed four problems associated with mediation of learning enzymes and promotion of scientific inquiry. Firstly, the data showed that learners face problems in understanding the concept of enzymes. Secondly, data also revealed that learners grapple with questions on scientific skills. Thirdly, it was evident that the basic competency for teaching enzymes is implicit in the syllabus. This led to the fourth finding which showed that some teachers did not mediate the concept of enzymes. What follows is a discussion on how teachers were supported to acquire knowledge of the concept of enzymes and further how that knowledge was transformed using the five topic specific pedagogical content knowledge (TSPCK) components.

6.2 The Practical Demonstration of Making *Oshikundu*

In this section, I discuss the process undertaken to prepare *oshikundu*. The process of making *oshikundu* was used due its potential to mediate learning of science concepts.

6.2.1 The science behind the practical demonstrations of making *oshikundu*

As indicated in Section 4.5.2, the practical demonstration was done by an expert community member. In this demonstration, the community member was regarded as the custodian of this knowledge on how to make *oshikundu*. She made her presentation in *Oshiwambo*, a vernacular language to the teachers and me.

As the expert woman was doing the practical demonstration of making *oshikundu*, interactions occurred which were two-fold. Firstly, it occurred within the questions we asked of the local woman. These questions emerged from our observation of the practical demonstration of making *oshikundu*. Secondly, there was interaction which took place among us – the researcher and the participants. This came as a result of us trying to identify scientific knowledge from the activities which took place during the practical demonstration. These interactions are presented throughout this section.

As the woman was adding the flour to make *oshikundu*, T2 asked "*oshike meme to yeleke oufila uu fike opo*?" (Why is mom putting that amount of flour?). For example, she added three handfulls of *mahangu* (millet flour). The local woman responded that: "*Onda tala ko ma kende omu oshikundu ta shi ndilwa, oko hai yelel kele nge nge ota yi gwanamo"* (I am looking at the containers where *oshikundu* is going to be poured into, it has to be enough). This meant ensuring that the amount of volume (*oshikundu)* was sufficient for the six bottles which would be used. From this we learnt that the scientific skill of estimation was exhibited in this activity.

As she added *uushutu*[4] flour, she described what *uushutu* was. She said that: "*mbuno uushutu owuna o protein, oha yi ga ndja eenkondo*" (this flour is *uushutu*, contains proteins and it provides energy). She further explained that: "*oyafimana, osheshi oha yee ta ombawo ko ntaku*" (it is important as it bring *ombawo* to *ontaku*"). T3 asked: "*ombawo oyafimana meme mo shikundu*? (is *ombawo* important in *oshikundu*?). The local woman explained that: "*oha yi ya ndje oluvala li twima ko shikundu opo oshikundu shi ha mo nike shi toka*" (it provides brown colour to *oshikundu* so that it does not look white).

The local woman further explained: *"Shampa ontaku o duudhe oyina eenkondo"* (when *ontaku* is dark it has energy). "*Shama itoka, kayina eengono, ndee ka yi holike unene kova shamane*" (when it is white it does not have energy, and men do not like it). "*Ovashamane kavehole oshikundu shi hena ombawo*" (men do not like *oshikundu* without *ombawo*). This kind of question is an example that some of our questions were also aimed at providing knowledge about our cultural heritage (Cocks et al., 2012).

From these discussions, T1 suggested that *oshikundu* can also be used during topics of food testing in Life Science and Biology classrooms. For example, due to the presence of starch in *mahangu* flour, *oshikundu* can also be tested for the presence of starch.

The mixture of the three flours used in making *oshikundu*: millet (*mahangu*), malted[5] sorghum [*ongundo*] *uushutu* and water, is called *ombombo.* The local woman showed that the process starts with mixing *mahangu*, and *uushutu* with boiled water. Then, it is followed by stirring the *ombombo*. T1 was interested in knowing why the woman kept on stirring *ombombo.* "*Oha shi kwa fele oku ta tula oufila"* (it helps to break down flour particles). We then discussed finding the reason behind this and concluded this information. T3 indicated that the amount of dregs

[4] The first flour obtained from thrashing millet grains

[5] Flour made from germinated sorghum grains.

(*ehete*) will be reduced as the particles will be smooth due to the stirring. Thus, we concluded that the stirring reduced the amount of *ehete*[6] (dregs).

The local woman further explained that: "*ontaku oha yi hampurwa ontalala*" (*ontanku* is diluted while cold). "*Shampa ya hampurwa yi pyu, ota yi lulu*" (if it is diluted while warm, it would get sour). This explanation resonates with that of Nikodemus (2017) who explains that if *oshikundu* is diluted while warm, then the enzyme activities are activated faster due to the temperature. This means that, fermentation would start earlier and by the time one would want to drink *oshikundu* it would have become sour (Nikodemus, 2017). Thus, the local woman's justification could imply that if one dilutes *oshikundu* while it is warm, then the enzyme activities due to the favourable temperature would be activated and, in that way, fermentation would start shortly after diluting the *ombombo*. Once again, this gave us an opportunity to make a link between the cultural practice of making *oshikundu* and the science concepts embedded in this practice; for instance, in this regard the relationship between temperature and enzyme activities.

The local woman explained further that: "*ongudo*[7] *oyo ha yi shu gu nine"* (*ogudo* is added last), "*ha yi tu lwamo ngele ombombo ya ta lala*" (added when *ombombo* becomes cool). Dewar and Taylor (2000) explain that the purpose of adding malted sorghum flour (*ongudo*) to the cooled mixture, is to prevent the inactivation of enzymes that are involved in the fermentation, which are the yeast and lactic acid bacteria. In other words, if *ongudo* is added while *ombombo* is hot, enzymes would become denatured or inactivated, and this could reduce enzyme activities. As a result, this implies that a lack of enzyme activity might hamper the process of fermentation.

Furthermore, T3 asked the purpose of *ongundo* and why it was added later to *ombombo* and not at the same time with the two flours (*mahangu* and *uushutu*). The local woman explained that: "*omolwa sho ogundo ohayi pitha oshikundu"* (*ongudo* ferments *oshikundu*). "*Ngele mo shikundu ka mu na ongudo ita yi pi mbala"* (if *oshikundu* does not have *ongudo* it will not ferment fast). Scientifically, in the presence of *ongundo* (malted sorghum), fermentation is likely to take place in *oshikundu* due to the presence of sugar which is utilised to produce

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[6] *Ehete* is the suspended matter (particles) which tends to settle and form a sediment at the bottom of *oshikundu*.

[7] Flour made from malted mahangu or sorghum seeds.

alcohol (ethanol) (CH_3CH_2OH) and carbon dioxide (CO_2). Adhikari and Acharya (2015) explain that the enzyme amylase which is produced during malting, leads to the hydrolysis of starch and proteins which then releases sugar and amino acids. Thus, due to the presence of sugar in *ongundo*, *ongundo* plays the role of a catalyst which enhances fermentation in the process of making *oshikundu*. We were all aware that *ongundo* is added later because the flour turns *ombombo* from a thick to a thinner liquid state. The local woman also provided her explanation: "*Shampa yayulu, I ta yi shiva oku pilulwa*, *ehete ota lika la li ha pu"* (when it gets into a liquid state, it will not be possible to stir, *ehete* will be more). This means that as the woman stirs, the particles of the flour are broken down; as a result, only smaller or finer particles form the dregs. Importantly, if the dregs are more, they occupy a lot of space and as a result, less space is left for the *oshikundu*. From a scientific point of view, T3 then explained that: "*the bigger the particles the larger the surface area they take up*".

The woman further indicated that: *"Moshikundu oha mu tu lwa ashike ongundo ishona, ngeenge owe yi tu lamo ihapu, oshikundu otashipi diva, ndee natango ota shi pilile, ndee ta ye tamo o alukoholi"* (in oshikundu only a small amount of *ogundo* is added, if you put too much, *oshikundu* will ferment fast, and over ferment resulting in the formation of alcohol). T2 explained that *oshikundu* normally has a lower percentage of alcohol when it just ferments. For example, if it was made in the evening and then you drink it in the morning, there would be less alcohol content. However, if the same *oshikundu* is drunk in the afternoon of the next day, due to a longer period of fermentation, it would have a certain percentage of alcohol enough to make one drunk. T3 thus lent support to this idea as she explained: "*shaashi oshakonda"* (because it is sour).

The findings in this section confirm that language is indeed a mediatory tool used to enhance learning (Vygotsky, 1978). The psychological tool (language) *Oshiwambo* which was used by the local woman, was an accessible language to both the participants and me. Similarly, we also conducted our discussions both in English and *Oshiwambo.* This increased our level of participation (Naidoo, 2012; Sedlacek & Sedova, 2017), as we could suggest, ask questions analyse our ideas and identify the science concepts. In addition, our participation also revealed that the practical demonstration stimulated our interest to learn the science concepts around *oshikundu*, particularly those associated with the concept of enzymes and scientific skills. This finding further corroborates with Asheela's (2017) and Nikodemus's (2017) findings, where discussions first took place in the mother tongue *Oshiwambo* which led to the identification of the science concepts.

Based on this evidence, one can agree with Aikenhead and Jegede, (1999) that the border crossing from *Oshiwambo* to English was smooth which made it easy for us to discuss the statements in *Oshiwambo* in English. Furthermore, it was also evident that the use of *oshikundu* created a conducive learning environment for the teachers. As a result, their transition from their indigenous knowledge to scientific concepts was also smooth.

As evidenced by our asking questions during the practical demonstration of making *oshikundu*, this was an indication that the practical demonstration stimulated our curiosity. This finding validates the view of Bosman et al. (2016), Contant et al. (2018) and Nhase (2019) who opine that inquiry related activities arouse curiosity.

While these scholars were referring to learners, notably those in early childhood grades, data from this study proved that adults too, get curious. As alluded to earlier, the observation of the practical demonstration raised questions which were driven by our curiosity to find out and know more information. The questions were what helped us make sense of the scientific knowledge that emerged from the practical demonstration. This finding thus agrees with the views of Harlen and Qualter (2014; 2018) who stress that questions that stem from curiosity, play a major role towards learning. In addition, it was evident that the process of making *oshikundu* promoted the teachers' higher order thinking skills such as, posing complex questions, introducing consistent arguments, presenting solid opinions, critical thinking, analysing, evaluating and the skill to synthesise information and reason (Barak & Dori, 2009; Zohar & Dori 2003). The scientific knowledge which is embedded in the practical demonstration of making *oshikundu* is not straight forwardly placed. Thus, the teachers needed to use those skills in order to make sense of those activities that were taking place in the process of making *oshikundu* and to extract the science behind those activities.

Furthermore, the workshop acted as a social unit which consisted of the teachers, the community member and me. As we interacted socially during this practical demonstration, we were learning from each other. This too speaks to Vygotsky's (1978) socio-cultural notion of social interaction which postulate that learning takes place in a social setting. The knowledge which we acquired during the social interactions, contributed to common PCK (Carlson & Daehler, 2019). The community woman acted as the More Knowledgeable other (MKO)

Vygotsky (1978). As alluded to earlier, the practical demonstration of making *oshikundu* enabled the identification of scientific concepts. This is evident from the development of the mind maps shown in Figure 6.1 below.

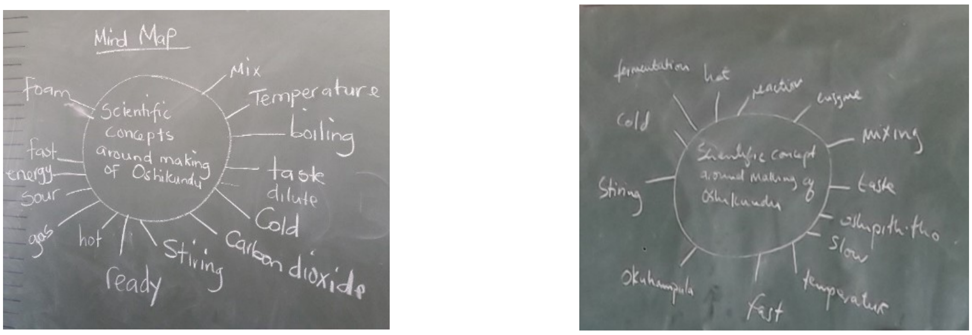

Figure 6.1: The scientific concepts in a mind map

The concepts in this mind maps were further developed into a concept map which is shown in Figure 6.2 below.

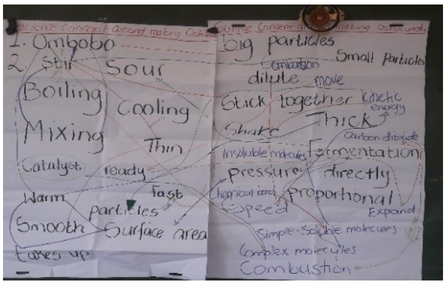

Figure 6.2: A concept map

The identification of scientific concepts is an indication that the practical demonstration of making *oshikundu* can be used in mediation of learning of a variety of science concepts. With the knowledge of enzymes which we obtained from the practical demonstration of making *oshikundu*, we further transformed this knowledge using the TSPCK components which I discuss below.

6.3 Improving Teachers' PCK of the Concept of Enzymes

In this section I discuss how the topic specific components were used to assist teachers in transforming their knowledge of enzymes.

6.3.1 Transforming teachers content knowledge of enzymes using the TSPCK components

The focus is on the development of CK on the topic of enzymes making use of the TSPCK model. This model enables transformation of science CK using five components (see Section 3.3). As alluded to earlier, the topic of enzymes is difficult for learners to understand. For instance, T2 reflected that "*the learners just do not know what an enzyme is*" and as a result they find the topic of enzymes abstract. She further explained that "*maybe it is because there is no relevant ideas to enzymes that they know*" (T2).

The participants were given a table (see Appendix I) where the components were described and how they should be used to transform CK to enhance meaningful learning. The discussions that follow reflect on how the TSPCK components were used. The components were discussed one by one and with each component we both considered these two aspects: Firstly, what does the component entail? Secondly, how does the component help us to transform the content knowledge of enzymes in a way that learners can comprehend it?

a) Learners' prior knowledge: This component places emphasis on elicitation of learners' prior knowledge and pays attention to their misconceptions if there are any. Mavhunga and Rollnick (2013) and Mavhunga et al. (2016) support the idea of allowing learners to share their prior knowledge. According to these scholars, this could help to unearth the misconceptions which the learners might harbour. Identification of learners' misconceptions is essential as it could reveal what makes it difficult for the learners to understand a topic. Additionally, Mavuru and Ramnarain (2017) emphasise that teachers need to consider using the learners' cultural backgrounds.

We looked at the prior knowledge that the learners brought to school about this topic. T1 indicated that learners already know the human digestive parts. This is the topic that they are taught before the topic of enzymes. In addition, T3 and T2 also noted that learners have knowledge about terms like 'rates of reactions' from Physical Science and 'fermentation' from Life Science. We also deliberated on the potential cultural beliefs that the learners could have around the practice of making *oshikundu*.

For example, T2 indicated that if *oshikundu* is failing to ferment, that is an indication that something bad is going to happen in the family. We then discussed those cultural beliefs. During the discussions, T1 indicated that in most cases what makes *oshikundu* go bad or fail to ferment, has to do with the water temperature which was used in the preparation. For example, if the water used was lukewarm, then *ombombo* would turn into *etepi*[8]. In that state, the prepared *oshikundu* would then not ferment properly. However, if *oshipithitho*[9] is added, it would ferment but the taste and the look would show that *ombombo* was *etepi*. Concurring, Nikodemus (2017) also explains that when *oshikundu* is prepared with water that is too hot, the enzyme activities are denatured. Drawing on Nikodemus (2017) and T1's view, some of the cultural beliefs could be misaligned with the scientific view. Yet, they should be considered important as they create opportunities for learning.

Analysis of this belief might suggest that learners who carry that belief, might not have knowledge of the term 'catalyst' and its function in a chemical reaction. One could then also conclude that lack of that understanding might hamper their understanding of the term 'enzyme'. This led to a discussion on how we could introduce the learners to the term 'catalyst'. In our discussion we referred to Figure 6.3 below.

Figure 6.3: Oshipithitho added to oshikundu

One of the questions in the worksheet asked teachers to explain the function of *oshipithitho*. This question developed questions and discussions that led to the term 'catalyst'.

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[8] Ombombo which had spoiled in such a way that instead of turning into a rich brownish color, turns white and the ingredients no longer mix well.

[9] *Oshikundu* which had already fermented.

Thus, with the discussion around the beliefs such as the one shared by T2, we moved to the component of what is difficult to understand?

b) What is difficult to understand? As suggested by Mavhunga and Rollnick (2013) and Mavhunga et al. (2016), this component describes teachers' insights into the concepts within a topic that are difficult to teach, for example, the misconceptions which learners have that could possibly hamper their understanding.

As teachers poured *oshikundu* into the bottles, in some of the bottles, *oshipithitho* was added, while in others it was not, as seen in the worksheet (see Appendix H). The function of *oshipithitho* enabled the teachers to discuss what it represents in a chemical reaction. The discussion about the purpose of adding *oshipithitho* to *oshikundu* helped us to arrive at the term 'catalyst'. This further enabled us to describe one property of an enzyme which is 'a biological catalyst'. The reason for adding *oshipithitho* in some bottles also helped us to explain the function of an enzyme, as a protein that catalyses or speeds up biological reactions by reducing the activation energy. This experiment and discussions contributed to the common pedagogical knowledge shared by the three teachers. The teachers in this regard were supported with an idea how to introduce the concept of enzymes to the learners. The practical demonstration used was also found to be a useful representation for conceptual understanding (Mavhunga & Rollnick, 2013).

Teaching science concepts in this manner, specifically those topics that appear abstract to the learners such as enzymes, help towards a better understanding of the concept (Mavuru & Ramnarian, 2017). We also looked at the main ideas around the concept of enzymes, and how the topic of enzymes should be taught. These are discussed in the components of curriculum saliency.

c) Curriculum saliency: This component demands that the teacher identifies the major concepts around the topic (the big ideas), and the prerequisite concepts learners need to know before the topic is presented. In addition, consideration of the interrelatedness between the concepts, how to sequence them and understanding of what should be taught now and what needs to be taught later, is pivotal (Mavhunga & Rollnick, 2013).

As discussed earlier on, T3 and T2 when teaching the competency where enzyme is located, provided definitions for chemical and mechanical digestion only. This narrative revealed their level of SMK and PCK of the concept of enzymes. Mavhunga and Rollnick (2014) explain that in cases when the teacher has inadequate SMK, a low PCK level is often observed and it is evident in the way the teachers transform the content they teach. In addition, this too reveals poor knowledge of curriculum saliency.

However, during the workshop discussions and the practical demonstration, the teachers were able to come up with the concepts associated with enzymes. These concepts were further arranged into a concept map as seen in Figure 6.4 shown below. This map shows the pre-concepts which learners need to understand before engaging deeply in the concept of enzymes. For instance, the map shows that the properties of enzymes ‘each enzyme has an optimum temperature’ is discussed first and later the influence of temperature on enzyme activities is discussed. When this approach is used in a classroom where the learners have an understanding of the properties of enzymes, the teacher can then move to complex discussions of enzymes such as rates of reactions (Nikodemus, 2017). The development of the concept map allowed me to track down teachers’ learning and their understanding of the topic.

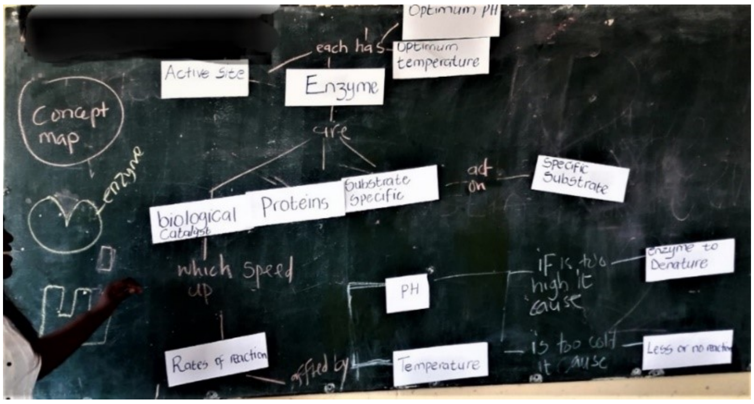


Figure 6.4: The mind-map for the concept of enzymes

The concepts were also sequenced and linked by words. Coming up with a concept map, is a reflection that these teachers had acquired content knowledge of enzymes from the practical demonstration. In addition, the discussions with T1 who is experienced in teaching Grade 11 and 12 Biology, also contributed to sharing of knowledge. The findings on the teachers’ knowledge regarding their ability to come up with concepts around enzymes, echoes with Vygotsky (1978) who postulates that the presence of a More Knowledgeable Other (MKO) plays an important role in enhancing learning. In addition to this, T1 also presented a lesson for us in a form of peer teaching, whereby he explained how to teach the concept of enzymes. His teaching in this regard showed his personal PCK which is shown in the episode below:

T1: We talk about enzymes which is a biological catalyst. When we were talking about oshikundu ... we talk of oshipithitho which acts as an enzyme in oshikundu to make oshikundu ready, or to speed up the rate of fermentation in oshikundu.

T1: Now we are moving on to chemical digestion, whereby we are going to talk about a specific enzyme that starts digestion in our mouth. This enzyme is called amylase. Amylase is the enzyme that acts on starch.

T3: Where is amylase found?

T1: It is found in the saliva.

T1: Starch is a sugar, a carbohydrate and it is an insoluble sugar. We were talking about insoluble molecules, starch is an insoluble molecule too. Amylase will convert starch to maltose.

T1: Without amylase the process of breaking down starch into maltose will be much less, which then explains how enzymes lower the activation energy. (Using a graph to explain) – without amylase the activation energy required for reaction to take place is higher, whereas in the presence of amylase the activation energy required is very low. So this means without amylase the breakdown of starch will be lower.

T2: How does that impact our nutritional level?

T1: Starch is converted to maltose and maltose is again converted to glucose. And our body needs glucose for respiration.

T1: This means that the lesser the amount of amylase, the lesser the conversion of maltose to glucose and thus the lesser the rate of respiration and the lesser the amount of energy released in your body.

This activity is a reflection that through professional development, teachers can learn from each other (Ngcoza & Southwood, 2015). It is also a reflection that in professional development activities, teachers share ideas to address challenges they face (Eun, 2008).

d) Representations: This refers to how learning content should be presented in such a way that it carries meaning to the learners. This can be achieved using aids that teachers consider having potential to supporting the teaching of content. These representations could be illustrations, metaphors, demonstrations, experiments, analogies, models or stimulations (Mavhunga & Rollnick, 2013; Mavhunga et al., 2016). Within this component, the discussions focused on what we could use in teaching enzymes for better understanding of the concept. The practical demonstration was therefore used as a representation. For instance, when teaching the effect of temperature on the rate of enzyme activity, the example shown in Figure 6.5 seemed to be appropriate to use.

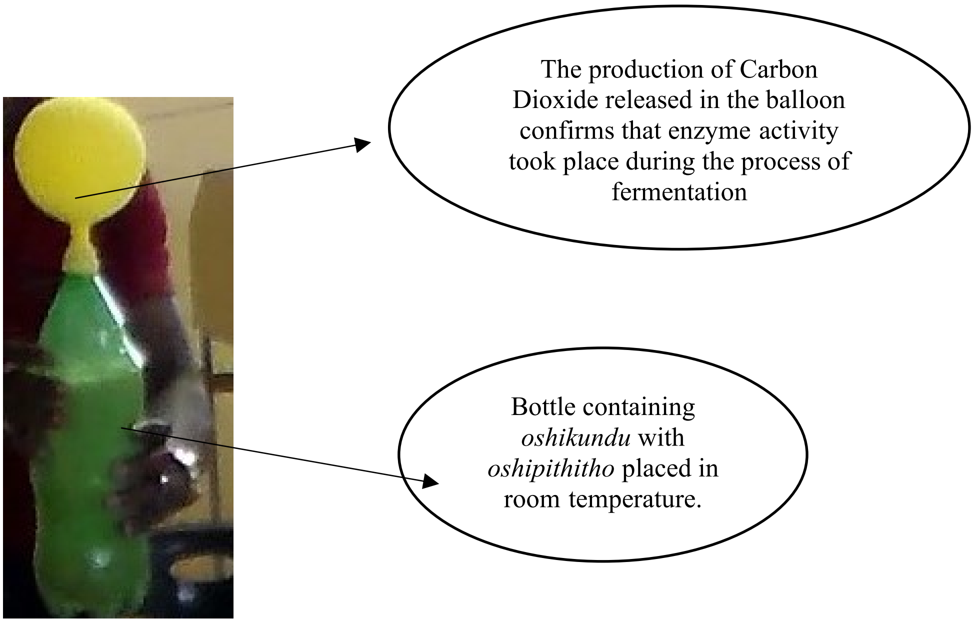


Figure 6.5: A bottle containing *oshikundu* with *oshipithitho* placed in room temperature

Another suggestion that could also be used as representations are the use of mind maps and concept maps. The concept map is shown in Figure 6.6 below.

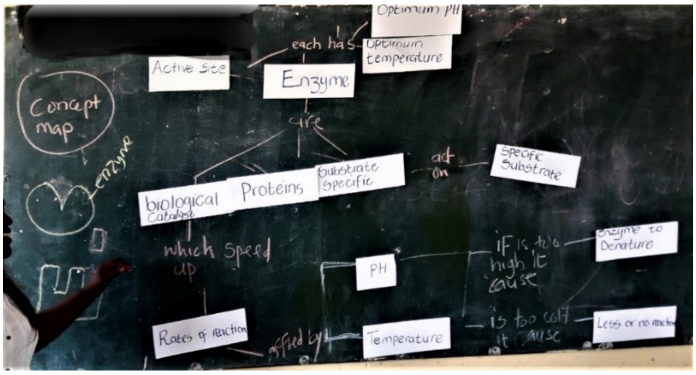


Figure 6.6: The concept map for enzymes and associated concept

The identification of concepts associated with the concept of enzymes shown in the concept map resonates with the TSPCK component of curriculum saliency (Mavhunga & Rollnick, 2013). To Kaseke and Nyamupangedengu (2019), in a concept map the concepts are linked by lines and words as reflected in Figure 6.6. This illustrates the connection between the concepts. In addition, linking these concepts in a concept map also shows how the concepts are sequenced, which also speaks to the component of curriculum saliency of the TSPCK construct. Sequencing the concepts in such an order echoes the views of Yaman and Ayas (2015) who explain that concept maps afford the learners (in this case teachers) an opportunity to organise their knowledge systematically and reflect on their understanding of a topic. As espoused by Tripto et al. (2016) it is clear that the teachers in this study could make use of a concept map as a tool to monitor their leaners' understanding or misunderstanding of the concept taught.

e) Conceptual teaching strategies: The category of conceptual teaching strategy looks at teaching strategies that can be used. The choice of the teaching strategies considers the misconceptions if there are any, educational purpose, as well as the learners. Having deliberated on the first four components, we discussed the strategies which we needed to use in teaching this topic taking into account the misconceptions, educational purposes and also the learners. The practical demonstration of making *oshikundu* used in this study was a suitable representation which enabled the identification and development of science concepts around the concept of enzymes. These concepts were then used to construct mind-maps. The concepts from the mind maps were further used to develop concept maps. The concept maps showed a good way of sequencing the concepts associated with enzymes, which would allow the learners to get an understanding of the concept.

All in all, data presented in this section revealed that the practical demonstration of making *oshikundu* was a suitable representation. This is motivated by the fact that it enhanced the development of CK in relation to the concept of enzymes. Furthermore, learning of this concept was motivated by the accessible language which was used during the practical demonstration. Due to the use of the vernacular language *Oshiwambo*, it was evident that the rate of participation was increased. That is, the teachers were more involved in the discussions, they could argue, debate and reason as the language was not a barrier at all. Consequently, their reflections showed that their CK on enzymes had improved. Moreover, the use of TSPCK components was also an effective mechanism to transform the knowledge on enzymes obtained from the practical demonstration of *oshikundu*. As mentioned earlier, the practical demonstration was also aimed at supporting teachers to get an understanding of an inquiry-based approach and I discuss this below.

6.4 Improving Teachers' PCK in the Concept Scientific Inquiry

Teachers reflected that the learners find it difficult to comprehend the concept of enzymes. This finding was also observed in the examiners' reports. Likewise, the examiners' reports also revealed that learners grapple with scientific skills. Moreover, the concern on the promotion of inquiry was also evident from the reflection of the teachers' PCK on how they conducted scientific investigations and from the remarks they made during the discussions (see Section 5.3.4). For example, T3 remarked that "*It might be time consuming because each one will need to present their opinions".* Additionally, T1 also reflected that "*slow learners find it difficult to find the solution on time".* The views shared by the teachers revealed a need for supporting teachers to get an understanding of what inquiry teaching and learning entails (Flick & Lederman, 2004). In this section, I thus discuss how teachers were supported to promote inquiry in their classrooms.

Essentially, reflecting back on my personal journey (see Section 1.4) and my positionality (see Section 4.3.6) I also found implementing an inquiry-based approach in my classrooms a challenge. Thus, I saw these workshops as a learning opportunity. While these were my reflections, it was also evident from the teachers' reflections and comments that there was a need to get an understanding of what inquiry entailed and how to implement it in science classrooms. It is against this caveat that the participants and I analysed the essential principals of inquiry education (NRC, 2000) and the predict-explain-explore-observe-explain (PEEOE) approach (Maselwa & Ngcoza, 2003). The teachers were first given an opportunity to get an overview of what inquiry-based teaching and learning entails. We then engaged in discussions on how to make use of an inquiry-based approach in our classrooms. To get the essence of implementing an inquiry-based approach in our classrooms, the teachers were involved in designing a worksheet which was aimed at promoting inquiry through practical investigations (see Appendix H). In addition, the essential features were used to explain what inquiry generally entails.

I now discuss the essential principles of inquiry from the NRC (2000). These principles act as an umbrella for all forms of inquiry, as espoused by Saad and Boujaoude (2012). According to the NRC (2000), inquiry classrooms need to be guided by the following principles;

a) Learners should be engaged in a scientifically oriented question;
b) Learners should design and conduct scientific investigations;

c) Learners collect evidence in response to questions;
d) Learners should formulate the explanations that they obtain;
e) Learners link the findings and explanations to scientific knowledge; and
f) Learners communicate and provide reasons and arguments to justify explanations.

While discussing these principles, moments were created where we discussed how to improve our pedagogical knowledge (PK) on how to promote inquiry in our classrooms. The participants used the opportunity to reflect on these principles. In one reflection the teacher showed a concern that "*some learners may become disengaged if others criticise them or do not consider their opinions"* (T2). The concern raised by the teacher created an opportunity for the teachers to understand their role in inquiry-based classrooms. A discussion of the facilitator role in inquiry classrooms which stemmed from the learner-centred approach was then discussed. Other concerns were also raised as explained: *"Sometimes you give the learners a task to go and come up with their hypothesis or research question, but they will take many days or at times will not just do the task"* (T3).

The reason why learners take much time to complete inquiry tasks is clarified by Peeters and Meijer (2014), who postulate that learners grapple with the formulation of research question(s) and with the design of investigation. As a result, they can take a long time to complete their tasks (Yoon, Joung, & Kim, 2012). T1 also lamented that: "*They will take time considering the number of lessons and the content that needs to be covered in that given time frame … time cannot allow".*

These findings concur with those of Harmon (2011) whose teachers also shared the fear of losing time by implementing inquiry over content. However, one can find comfort in Quigley et al. (2011) who stress that inquiry and content are mutually inclusive, and it is when they are viewed as different aspects that challenges arise. In a similar vein, Lamm (2017) opines that at first, using an inquiry approach might be considered a challenge, however, once the skills are acquired, then the teachers will no longer notice the challenges.

In another case, T2 reflected that *"sometimes, learners might ask irrelevant questions"* and she further added that, "*I will use the method, but will limit the learner's questions to prevent them asking irrelevant question*". The teacher's remark in this regard revealed that she views learners' questions as problematic. However, I do not fully agree with her suggestion, as Harlen and Qualter (2018) put it that questions normally stem from curiousity. Thus, they play a major role towards learning.

As a result, they should not be seen as a hindrance towards learning. To this end, T3 commented that "*the questions drive the learners learning*". The contribution made by T3 reflected an understanding of the need for questions in science classrooms. The essential principles help us to understand that scientific inquiry is not only promoted through practical investigations, but through other forms that are not practically based. The remark made by T2, which emphasised that teachers should, *"give more projects and surveys so they will find out information and through inquiring from different sources and later discuss such ideas in class",* is a reflection that T2 understood the various ways of promoting inquiry.

This reflection showed that T2's understanding of inquiry had improved by engaging with the essential features of inquiry. In addition, the reflection made by T3 also showed improvement in understanding of how to promote scientific inquiry.

For instance, she reflected that: "I *will give them an investigation to plan and they must use the inquiry method to come up with the question they will answer".* T3's reflection also revealed an understanding on how to promote scientific inquiry. She seemed to understand that in inquiry, learners have the autonomy to plan for their own investigations. Most importantly, she also understood that the learners must come up with their investigative questions that will guide their investigation.

As alluded to earlier, we designed a worksheet which helped us to unpack the PEEOE approach (see Section 2.2.2). Having some background on this approach, I took the lead for designing the sheet. The teachers also contributed positively to the design by providing suggestions and the kind of questions we could use. This approach of including the participants in the design of activities provided an indication that this study did not treat teachers as passive recipients of knowledge (Jacobs, 2015). On the other hand, it also acted as an indicator to the teachers that their contribution was valued. Likewise, this could mean that the facilitators did not attend the workshops with a completed outlined plan of the activities which teachers needed to cover. In this way the teachers were given more opportunities for their input (Ngcoza & Southwood, 2015).

One of the focus of the PEEOE approach, is to allow learners to *predict* before they make their observations (Maselwa & Ngcoza, 2003). As they write their predictions, the learners should provide *explanations* for their predictions (Maselwa & Ngcoza, 2003). While it is important for the learners to predict, T1 raised a concern explaining that learners' textbooks contain answers to the practical investigations. As a result, according to her observation, often learners know the answers to the investigations. Concurring on this matter, Kim and Tan (2011) lament that in such situations, learners might not be curious to find out things on their own, an essential attitude which is a requisite in inquiry classrooms (Nhase, 2019). Thus, making predictons is essential towards learning science as it stimulated eagerness to find out answers about what they are learning (Harlen & Qualter, 2018; Suarez et al., 2018). In addition, when learners predict, it also creates the opportunity for the teacher to find out learners' prior knowledge (Kibirige & Osodo, 2014).

This result further revealed that the design of the textbooks promotes the recipe approach where the learners will not explore possibilities of the result, but rather, will be testing for the given results (Kabapinar, 2010; Hodson, 1990). Consequently, learning for understanding is inhibited (Asheela, 2017), curiosity is reduced and the why questions are not promoted (Contant et al., 2018).

However, the learners must *explore*, then *observe.* As they make their observations, the learners should provide *explanations* for their observations (Maselwa & Ngcoza, 2003). During the design of the worksheet, the teachers realised and credited the approach as being a good one. For example, T2 indicated that unlike the usual way whereby questions are placed at the end of the investigation, in this worksheet they were written in between the activities and she found it useful. This is motivated by T1 who extracted that "*this is a good approach as it keeps the learners concentrating on the task and it also help to drive their thinking".* Sharing similar thoughts, T3 posited that learners are engaged in questions throughout the practical investigation. T1 thus concluded that this is a better way of assessing learners' progress compared to the usual way when they have to answer some questions at the end of the activities. He further elucidated that this might also help the learners to grasp content knowledge and understand the concepts they are investigating, as opposed to doing experiments for testing only.

Given the discussions on how teachers were equipped to promote inquiry, the process of making *oshikundu* also created opportunities for the teachers to use their inquiry skills such as prediction, observation, reasoning and questioning. This is explained in the sections that follow.

6.4.1 Making predictions and providing explanations for the predictions made

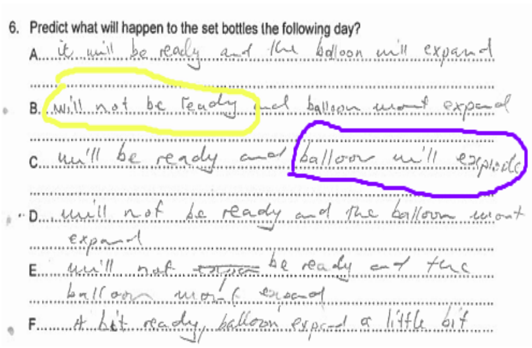
The teachers involved in this study discussed and agreed to make their predictions as a group. This is a reflection that the teachers had autonomy over their work, and they were working collaboratively together.

This further reflects that the teachers also acknowledged the importance of group work which allows sharing of information. The predictions which I discuss here are the ones they did for bottle B and C. However, in this section I discuss the prediction made on Bottle B only which was set as follows: Bottle B is for *oshikundu mixed with oshipithitho placed in a cool environment*. As they were making their predictions, they also provided reasons for their predictions which they needed to agree on as a group.

For instance, T3 noted that, *oshikundu* in bottle B would not be ready due to the cool room temperature. On the other hand, T2 used her experience at home as she said, "*when we brew oshikundu at home and put it in the refrigerator, the next morning it would be ready*". T1 commented that "*it would be ready but not well done"*. Contesting T1's idea, T2 indicated that "*yes oha shipi ka shona"* (yes, it gets ready a bit). Giving some clarity, T2 added, "*me kende B omwatulwa oshipithitho*" (in bottle B *oshipithitho* is added). T3 said: "*Ohoo*" (aha), "*eheno mboli, otashipi*" (yes it will be ready). T1 conclusively agreed, "*heno shapo*" (*in that case yes*).

The engagement of the teachers in this discussion showed that they were not just active, but they were also interested in their discussions. To Mavuru and Ramnarain (2017), this is brought about by the use of resources and examples that are familiar to the teachers. In addition, their participation also increased (Kuhlane, 2011; Sedlacek & Sedova, 2017). Furthermore, this finding also demonstrates that the teachers were using their argument and reasoning skills as espoused by Zohar and Dori (2003). This was evident in the arguments that they were giving (Barak & Dori, 2009). For example, when T2 indicated that *oshikundu* could ferment in the refrigerator, T1 and T3 were not convinced and opposed T2's view. Nevertheless, their debate finally brought them to an agreement that *oshikundu* in bottle B would ferment. The experience of the debates and arguments were also motivated by the different personal PCK which the teachers might have. So, each teacher was making their point, based on their personal PCK (Carlson & Daehler, 2019).

While it was evident that the teachers had agreed that the *oshikundu* in bottle B would ferment due to the presence of a catalyst which is *oshipithitho*, their worksheet revealed contrasting findings. This is noticed from the teachers' extracts below:


6. Predict what will happen to the set bottles the following day?
A. it will be ready and the balloon will expand
B. will not be ready and balloon wont expand
C. will be ready and balloon will explode
D. will not be ready and the balloon wont expand
E. will not ~~expand~~ be ready and the balloon won't expand
F. A bit ready, balloon expand a little bit

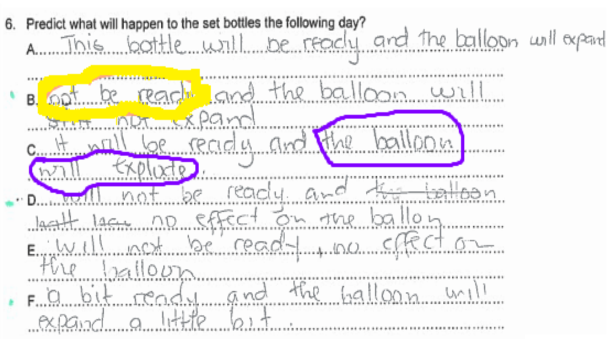

6. Predict what will happen to the set bottles the following day?
A. This bottle will be ready and the balloon will expand
B. not be ready and the balloon will still not expand
C. It will be ready and the balloon will explode
D. will not be ready and ~~the balloon~~ will has no effect on the balloon
E. will not be ready, no effect on the balloon
F. a bit ready and the balloon will expand a little bit.

Figure 6.7: T1's written prediction **Figure 6.8: T3's written prediction**

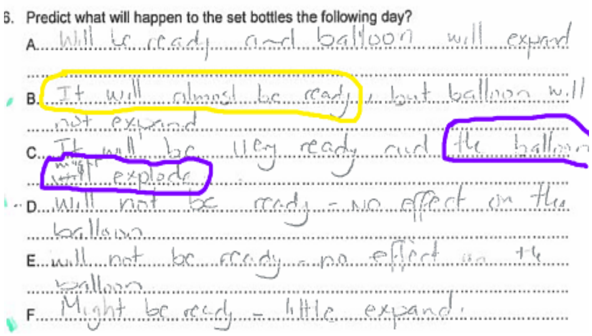

6. Predict what will happen to the set bottles the following day?
A. Will be ready and balloon will expand
B. It will almost be ready but balloon will not expand
C. It will be very ready and the balloon might explode
D. Will not be ready - no effect on the balloon
E. will not be ready no effect on the balloon
F. Might be ready - little expand.

Figure 6.9: T2's written prediction

The written predictions made by the teachers above, confirm Vygotsky's (1978) view of learning. That is, according to Vygotsky, mental processes begin as actual social relationships among people on the inter-psychological level. Then later the newly learned information will be processed further on the intra-psychological level (individual level) in the form of internalised psychological processes (Vygotsky, 1978). At the social level, the teachers agreed that *oshikundu* in Bottle B would be ready. This knowledge was collective knowledge shared by the teachers. The teacher then takes this collective PCK in, they think and reason about it to find a way to personalise it (personal PCK) (Carlson & Daehler, 2019). According to Vygotsky, this process involves internalising the newly learnt knowledge. The teachers externalised this knowledge to show their PCK in a unique personal way as their personal PCK. Looking at

Figures 6.7, 6.8 and 6.9 above, it is evident that even though teachers did their predictions as a group, their written predictions differed. That is to say, what was agreed upon orally as a group, was revealed differently as information in their writings. For instance, both T1 and T3 predicted that the balloon would explode. In contrast, T2 wrote "*the balloon might explode*". Once again, the prediction written by T2 attests to Vygotsky's notion of learning. Her written prediction revealed that in their group, learning took place at a social level, but through phases of prolonged processes in the mind of the teacher, the shared knowledge became part of her cognitive processes as an individual (Carlson & Daehler, 2019; Vygotsky, 1978). Thus, this finding shows us that knowledge, which is shared at a social level, might not necessarily be the same as individual knowledge. With that said, the teachers also did predictions on bottle C which I present in the following section.

6.4.2 Prediction for bottle C

During their predictions for bottle C, the teachers also had an opportunity to engage deeply about the changes that would take place on the balloon placed on bottle C.

T2 proposed that the balloon would explode. On the other hand, T1 contested that: "*Ahawe ita li topa*" (No, it will not explode). T1 further clarified that: "*ee balona ota lifulu*" (the balloon will expand). Adding to the debate, T3 commented that: "*ee balona ota li topa, ita lifulu ashike*" (yes the balloon will burst, it will not just inflate). She motivated her argument referring to the variable, 'the sun' as the contributing factor. She said: "*ekende ota litulwa po mu tenya, ndee ta shipi, ndee ta li topa*" (the bottle will be placed in the sun, it will get ready, and it will explode). Being curious, I asked: "*ee balona ta li topa? Yelifilenge!*" (Will the balloon explode? Clarify for me!).

T2 then provided this explanation: "*ahawe mee Ester, e balona ita li topa ndele ta li ningi o sound nenge li pomboke.*" (No mom Ester, the balloon will not explode and make sound or break). T2 explained that: "e *balona shampa lya fulu sigo opo nkatu yo numba, omuku mbu u li me baloona ota wu ta meke oku zamo*" (when the balloon expands to a certain point, the particles inside the balloon are going to start escaping out). She then added the particles gained kinetic energy for movement. T1 elucidated that what makes the balloon expand is carbon dioxide gas, produced during fermentation.

After their predictions (see Figures 6.7, 6.8, 6.9) the teachers also illustrated their predictions. In their predictions for bottle C the teachers noted the following: "*will be ready and balloon will explode*" (T1); *"it will be ready, and the balloon will explode"* (T3); and *"it will be very ready, and the balloon might explode*" (T2).

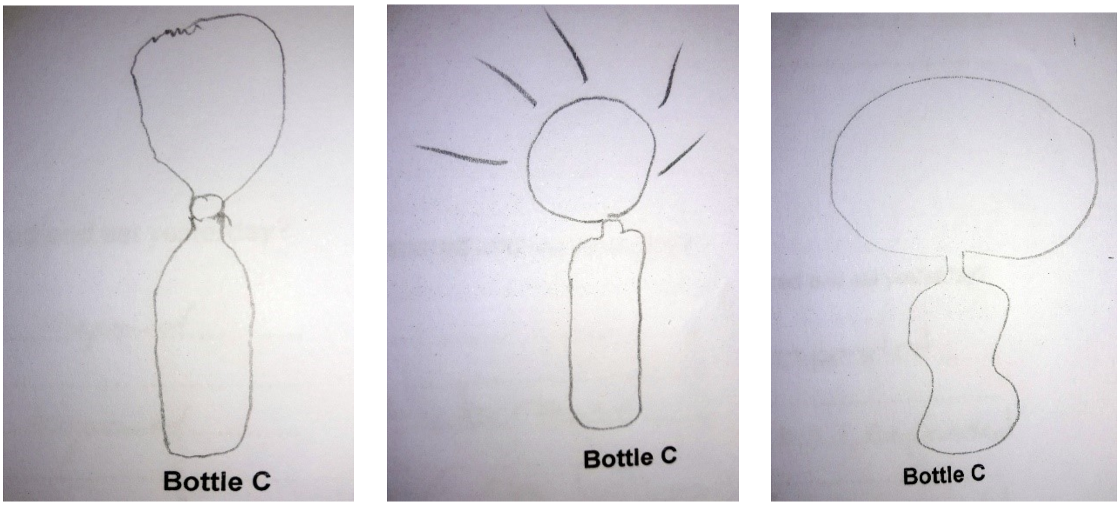


Illustration of T1 *Illustration of T3* *Illustration of T2*

Figure 6.10: Different illustration of teachers' predictions for bottle C

It is evident from these diagrams that each teacher presented a unique drawing. These drawings reflected their visualised ideas of how they interpreted their predictions. For example, T1's interpretation shows that the balloon will explode. This might be supported by the puncture seen on the surface of his balloon.

T3 on the other hand, to emphasis her prediction, added additional lines. One could infer that the lines could represent something that is coming out of the balloon. But what is interesting is that this information did not appear in her written prediction or in her explanations for the predictions she provided. This finding thus corroborates with Scheiter et al. (2017) who postulate that diagrams have the potential to reveal relevant information, and generations of inference.

In additon, the findings also revealed that diagrams and illustrations are also good representations which could be used in our classrooms (Mavhunga & Rollnick, 2016). One of the qualities that make a diagram valuable in a class is that it has the ability to reveal information which might not have been given in writing 'like in this prediction' (T3) or been said. In the case of T2, in her prediction she used the phrases such as "*will be very ready"* and *"might"*. Her diagram thus shows an inflated balloon, and its size shows what she meant by very ready. Perhaps she meant more carbon dioxide will be produced and released in the balloon. So, the more the carbon dioxide, the bigger the balloon. Similarly, in her argument she insisted that the balloon would not explode, but she also used the phrase might explode. This indicated that she was not sure whether the balloon would explode or not. Hence, her diagram also showed a smooth surface which would support her argument. The set experiment was then observed. Some of those observations are discussed in the section that follows.

6.4.3 Observations of the set experiment: Bottle A and Bottle C

As the teachers were doing their observations, the observations they made on the balloons of bottle A and bottle C seemed to surprise them. This stimulated their curiosity to find out the reasons for their observations. Below are the pictures which show the appearance of the balloons.

Figure 6.11: Bottle A

Figure 6.12: Bottle C

During their observations, the balloons of bottle A and C appeared to be the same size (Figures 6.11 and 6.12). *Oshipithitho* was added to both *oshikundu* in bottle A and C, yet, they were placed in different environments (Bottle A was placed at room temperature; Bottle C was placed in direct sunlight). Based on their observation, the balloon on bottle A and the one on bottle C appeared to have similar sizes. This was not clear to T2 as she expected balloon C to be larger than the one of A. T2 explained that the temperature to which bottle C was exposed was higher than the one of bottle A, yet they appeared similar.

It was noted that both bottles contained the catalyst to speed up the reaction. Yet, their environments were different. Based on their observation, the balloon on bottle A and the one on bottle C appeared to have similar sizes. This finding surprised some of the teachers. T2 expected balloon C to be larger than the one on A. She explained that bottle C was exposed to direct sunlight; consequently, it was exposed to higher temperatures. Her argument in this regard was that the higher the temperature, the faster the process of fermentation and the more the amount of Carbon Dioxide produced – the amount of Carbon Dioxide gas in this regard would then determine the size of the balloon. While that was her thinking, T3 also provided her opinion for the observed result and explained that for bottle C, the process of fermentation had stopped. This is because all the glucose that was in the *oshikundu* had been used up during fermentation – as a result the amount of Carbon Dioxide remained constant. In her worksheet, she explained that "*this oshikundu is ready, and it was placed in direct sunlight, the balloon becomes bigger and particles started to escape due to high temperature*". This finding of T3 revealed a strong knowledge of SMK, as scientifically during fermentation, the sugar is utilised to produce alcohol (ethanol) (CH_3CH_2OH) and carbon dioxide (CO_2) (Dewar & Taylor, 2000).

The explanation provided by T3 seemed to have provided clarity on the findings of bottle C. This is supported by two findings observed by T2. Firstly, T2 made a remark that the particles of Carbon Dioxide might also have escaped from the balloon in bottle C, which might have contributed to the reduction in size. Secondly, in her worksheet T2 wrote, "*oshikundu is ready and CO_2 was produced but particles escaped because of heat*". This finding revealed that T2 now understood the reason behind the appearance of balloon C. Furthermore, this finding showed that learning had taken place. The exposure of the teachers to the practical demonstration of making *oshikundu*, contributed towards the teachers learning of the concept of an inquiry-based approach.

It is evident from the discussions above that the practical demonstration enabled the teachers to use and develop their inquiry skills. This implies that if it used in the classroom context, learners might also be able to acquire and develop their inquiry skills.

6.5 Chapter Summary

In this chapter I discussed how the teachers were supported in gaining knowledge on the concept of enzymes and an inquiry-based approach. The practical demonstration of making *oshikundu* by the local expert community member, was used as a representation to help the teachers grasp those two concepts. Furthermore, I discussed how this knowledge which was obtained from the practical demonstration of making *oshikundu* was transformed using the TSPCK components.

CHAPTER SEVEN: SUMMARY OF FINDINGS, RECOMMENDATIONS AND CONCLUSION

7.1 Introduction

The goal of my study was to mobilise the indigenous practice of making *oshikundu* to mediate learning of enzymes and an inquiry-based approach. In order to achieve this goal, I employed a qualitative research design to generate data using a variety of methods. I used document analysis, workshop discussions and journal reflections. Data in this study were analysed using an inductive approach and the discussions were made using relevant literature, Vygotsky's socio-cultural theory and Shulman's pedagogical content knowledge (PCK), together with the topic specific pedagogical content knowledge (TSPCK).

To achieve the goal of this study, the research was guided by the following main research question:

How can the process of making *oshikundu* be used to support Grade 8 Life Science teachers to understand the concept of enzymes and an inquiry-based approach?

To answer this research question, the following sub-questions were addressed:

1. What lessons can Grade 8 Life Science teachers learn or not about enzymes and an inquiry-based approach through co-analysing the curriculum documents?
2. How does the practical demonstration of making *oshikundu* by an expert community member enable and/or constrain Grade 8 Life Science teachers' interaction, participation and understanding of the enzyme concept?
3. How does using the process of making *oshikundu* enable or constrain Grade 8 Life Science teachers' understanding an inquiry-based approach?

In the preceding chapters, I presented, analysed and discussed data generated from the intervention workshops. In this chapter, I present a summary of findings, recommendations, suggested areas for future research, limitations of the study and reflections. The chapter ends with a conclusion.

7.2 Summary of Findings

Herein, I present my findings in relation to my three research sub-questions. In doing this I am highlighting to what extent these were answered.

7.2.1 Research Sub-question one

> What lessons can Grade 8 Life Science teachers learn or not about enzymes and inquiry-based methods through co-analysing the curriculum documents?

The findings from this study revealed that the teachers learnt several lessons from the analysis of the curriculum documents and the examiner's reports.

From the analysis of the broader curriculum, the teachers realised that indeed, the curriculum calls for the promotion of scientific inquiry. Specifically, the teachers learnt that the learners are required to acquire cognitive skills and scientific process skills. Furthermore, the teachers gained knowledge that they have to search for resources in the environment, in order to improvise where there is a shortage.

In addition, through co-analysis of the syllabus, they learnt that the curriculum calls for the use of an inquiry approach, through any form of investigation including practical investigations.

Furthermore, from this study, it was noted that the concept of enzymes is implicitly presented, and is not straightforwardly put, but rather located in the topic of chemical digestion. Data in this study also revealed that some teachers do not include the concept of enzymes in their teaching. However, through co-analysis of the curriculum and learners' textbooks, the teachers, notably those who did not include the concept of enzymes in their teaching, realised that the enzyme concept is part of the Grade 8 Life Science curriculum. However, their PCK in the topic of enzymes remained inadequate. Additionally, the teachers also learnt lessons from the co-analysis activity of the examiners' reports.

Firstly, from the analysis of the examiners' reports, the teachers also realised that learners have poor scientific skills which could stem from minimal exposure to practical investigations. This concern was confirmed from the examiners' reports that practical investigations are not well conducted in science classrooms. However, teachers' comments in this regard revealed that the teachers also had concerns on how they would promote some of the practical skills in their classrooms. This is shown in the extract below on the remark made in one of the examiners' reports that learners lack the knowledge of the importance of making a test fair.

T3, for instance, argued that learners are taught the importance of repeating a test even though it is not practical, "*to make the test fair*". The teachers did not welcome the remark made by the examiners' report on repeating a test to show what is meant by a fair test. They lamented that it is quite impossible to repeat a practical investigation to demonstrate what is meant by a fair test (T1, T3 & T2). Making her argument clear, T3 explained *"even if I wanted to do that where will I find the resources, we are already struggling to find resources to do a practical activity, it is a waste"*. Lending support, T1 added, *"It is going to be costly"*.

The arguments shared above reveal the frustration that teachers experience when it comes to the syllabus demands which are beyond their control. In addition to the examiners' reports on learners' performance in the concept of inquiry, the teachers also noted some interesting information concerning learners' performance in the topic of enzymes.

During the review of the examiners' reports, the teachers realised that the topic of enzymes is poorly performed at senior secondary grade level. This information was important as it made the teachers realise that they need to prepare the learners with the knowledge of enzymes while at Grade 8 level. As teachers had the opportunity to reflect on their practice during the co-analysis activities, rich data also came through which is significant in this study and these data sets are summarised below.

Firstly, it came through that the schools lack resources for conducting practical investigations. This lack influences teachers' practice of practical investigations (Asheela, 2017; Ramnarain & Schuster, 2014).

Secondly, two factors that influence the teachers' PCK on conduct of practical investigations were identified. In the first place, teachers' beliefs on how and where to conduct practical investigations were found to be an influential factor. For example, the belief that practical investigations cannot be conducted in overcrowded classrooms, the fact that some chemicals are flammable, and the nature of the learners being playful, were among the factors that shaped the belief of the teachers.

In the second place, teachers understanding of practical investigations also contributed to their PCK on conduct of practical investigations. Data thus revealed that their understanding of how to conduct practical investigations had an influence on their practice.

While these findings were from the teachers' narratives, data in this study revealed that some of the teachers' beliefs and understandings were changed positively, after engaging the teachers in co-analysis activities and discussions.

Data revealed that the teachers shared positive views on the use of practical investigations in science classrooms. Finally, teachers in this study also demonstrated that they have knowledge on how to improvise for resources to conduct practical investigations, notably those that are not suitable for use in a school environment. This study drew the conclusion that, although teachers showed a positive view in the use of practical investigations in science classrooms, it was noted that teachers lacked knowledge on how to use them, specifically to promote inquiry.

7.2.2 Research sub-question 2

> How does the practical demonstration of making *oshikundu* by an expert community member enable and/or constrain Grade 8 Life Science teachers' interaction, participation and understanding of the enzyme concept?

It was observed that the practical demonstration of *oshikundu* allowed for social interaction to take place between the participants and the expert community member. Most importantly, the vernacular language used *Oshiwambo*, was an accessible language to both the participants, myself and the local expert woman. The language thus promoted active participation (Sedlacek & Sedova, 2017).

It also emerged that the practical demonstration of making *oshikundu* stimulated our curiosity. This raised questions which were driven by our curiosity to find the answers. The questions helped us to make sense of the scientific knowledge that emerged from the practical demonstration. In addition, data from this study revealed that the workshop acted as a social unit in which the participants and I were learning from one another, and the expert community member was the more knowledgeable other (MKO) in this setting (Vygotsky, 1978).

Furthermore, the process of making *oshikundu* proved to be appropriate in supporting teachers to acquire knowledge on enzymes. For example, concepts were identified and subsequently mind-maps and concept maps were designed. In addition, it was evident that the process of making *oshikundu* promoted the teachers' questioning, arguments, critical thinking, and reasoning which are higher order thinking skills, which they used to make sense of those activities. The study thus concluded that it was through the use of those higher order thinking skills that the teachers eventually identified and developed scientific knowledge about the concept of enzymes. The interactions that revealed such skills are given below.

The teachers were asked to predict what would happen to *oshikundu* in bottle B? T3 noted that, *oshikundu* in bottle B will not be ready due to the cool room temperature. On the other hand, T2 used her experience at home as she said, "*When we brew oshikundu at home and put it in the refrigerator, the next morning it would be ready*". T1 commented that, "*it would be ready but not well done"*. Contesting T1's idea, T2 indicated that, "*yes oha shipi ka shona"* (yes, it gets ready a bit). Giving some clarity, T2 added, "*me kende B omwatulwa oshipithitho*" (in bottle B *oshipithitho* is added). T3 stated, "*Ohoo*" (aha) and "*eheno mboli, otashipi*" (yes it will be ready). T1 conclusively agreed, "*heno shapo*") (in that case yes). This is evidence that the teachers were debating, they were reasoning, and they were thinking critically.

In addition, findings from this study also revealed that using the topic specific pedagogical content knowledge (TSPCK) components was also helpful in transforming the knowledge on enzymes into knowledge which learners could comprehend. The TSPCK components acted as guidelines which guided us on how we could approach and teach the concept of enzymes. In using these components, it was observed that the teachers' PCK in teaching enzymes was improved. Specifically, the teachers acquired knowledge on the concepts around enzyme, how to sequence those concepts, and the different representations such as the process of making *oshikundu*, mind-maps and concept maps which can be used in order to ensure meaningful learning.

7.2.3 Research sub-question question 3

> How does using the process of making *oshikundu* enable or constrain Grade 8 Life Science teachers' understanding of an inquiry-based approach?

Findings in this study revealed that taking the teachers through the principles of inquiry, equipped them with knowledge on what inquiry means and how it can be enacted in science classrooms. Most importantly, studying the principles of inquiry helped us to understand that scientific inquiry is not only promoted through practical investigations, but through other forms that are not practically based as well.

Likewise, introducing the teachers to the predict-explain-explore-observe-explain (PEEOE) approach (Maselwa & Ngcoza, 2003), also provided the participants with PCK on how to ensure inquiry is promoted through practical investigations. However, while inquiry is a curriculum requirement, findings revealed that the teachers involved in this study showed concern about the use of an inquiry-based approach in their classrooms. Their challenges ranged from time constraints, learners' inadequate knowledge of inquiry processes and classroom management. Despite these teachers' concerns, findings revealed that they still acknowledged that practical investigations were useful in teaching science.

Furthermore, findings revealed that the teachers were interested in the discussions. This motivated their engagement in the activities during the workshops. Findings also revealed that interesting information emerged from the practical activity of *oshikundu*. Firstly, that indeed knowledge that is discussed at the social level is not internalised the same way by all those who are part of that social interaction, but, instead that every person does it as an individual. This is evident from the teachers' externalised knowledge at the personal level (personal PCK). Secondly, that diagrams can reveal data that has not been spoken or written down.

7.3 Recommendations

The study suggests that there is a need to support Grade 8 Life Science teachers with the subject matter knowledge (SMK) of enzymes. This is important as Aydin et al. (2012), Davidowitz and Rollnick (2011) point out that when teachers have inadequate SMK, then they might find it difficult to teach that topic. The process of making *oshikundu*, a local cost-effective resource used in this study, proved to be efficient in mediating the learning of enzymes. Thus, the study recommends its use. In addition, the teachers also need to be supported on how to teach the concept of enzymes to the learners. The study thus, suggests the use of topic specific pedagogical content knowledge (TSPCK) as a lens as emphasised by Mavhunga and Rollnick (2013). Above all, the study acknowledges that the content in the curriculum and textbooks is not an easy thing to change, yet, the lesson objective in which enzymes is located needs immediate attention to ensure it is being correctly taught.

This study further recommends that there is a need for teachers to gain an understanding on the broader aspect of inquiry-based approaches. The essential features from the NRC (2000) are key features that inform classroom inquiry. The study also recommends that there is a need to support teachers on how to ensure practical investigations in their classrooms are inquiry-based. This is best achieved with the predict-explain-explore-observe-explain (PEEOE) approach (Maselwa & Ngcoza, 2003). The study also recommends that to achieve the above two recommendations, teachers should be involved in authentic practical investigations such as the process of making *oshikundu* and using the PEEOE approach to get the essence of inquiry-based practical investigations using local cost-effective resources. This might also help to shift their beliefs of practical investigations, especially those that conflict with the use of inquiry in their classrooms.

7.4 Areas for Future Research

This study has opened opportunities for possible further research which involve a bigger sample in terms of schools and the number of teachers. Secondly, a study of this nature could be considered to be conducted for four weeks, one workshop per week. In those workshops, more concentration should be placed on the development of knowledge of inquiry methods. Furthermore, attention should also be pointed to the expert community member so that the participants can gain more knowledge on cultural heritage. The rationale is to provide the participants enough time to familiarise themselves with the knowledge they gained from the workshops, thus, giving the researcher ample time to assess the effect of the intervention workshop as well. Thirdly, another study could also look at how the teachers teach the concept of enzymes using inquiry approaches.

7.5 Limitations of the Study

There are three limitations to this study. The study only involved three teachers and this sample size is small and does not represent the whole population of Grade 8 Life Science teachers in the Omusati region and the country at large. For these reasons, this data cannot be generalised. Nevertheless, data from this study provided some insights on how Grade 8 Life Science teachers understand and mediate the concept of enzymes, as well as an inquiry-based approach in their classrooms.

Secondly, the workshops were conducted after teaching hours; this meant that the teachers might have come to the workshops tired from their normal teaching work. This might further have affected their participation in the workshop activities. In addition, the TSPCK components were not used during the analysis of the curriculum documents and this was a lost opportunity. As a result, if I were to do this study again, I would use the TSPCK as a lens to analyse curriculum documents.

Thirdly, I did not collect observational data of teachers' implementation of the knowledge they gained from the intervention workshops. However, I videotaped those workshops. Yet, data from classroom observations would have been useful. In addition, I also did not have the opportunity to watch these videos with the teachers, which is another lost opportunity to do stimulated recall interviews which lends itself as a validation technique.

7.6 Reflections

I started my research journey in 2015 when I enrolled as an education Honours student with Rhodes University and continued in 2018 when I proceeded with my Master's degree in science education as a full-time student at Rhodes University. As indicated earlier, it was during my Honours programme when I was introduced to the concept of indigenous knowledge by Prof Ngcoza and Mrs Kuhlane. I was further introduced to the concept of easily accessible resources by Mrs Asheela. The introduction of these two concepts opened my eyes on how I could alleviate challenges which I faced in my classrooms. This knowledge was further strengthened as a full-time student at Rhodes University, Grahamstown in 2018, when during lectures, I was introduced to indigenous practices behind lightening. From this lecture by my supervisor, Prof Ngcoza, I learned aspects about integration of indigenous knowledge that I could apply in my classroom.

In addition, during my lectures, Prof Ngcoza also introduced me to one of the approaches – predict-explain-explore-observe-explain (PEEOE) – which is an approach that promotes scientific inquiry during practical investigations. The introduction of these two constructs of science teaching, thus inspired me to pursue a study that looked at how using indigenous knowledge such as the practice of making *oshikundu*, could be used to mediate the concept of enzymes using an inquiry-based approach. This would be done by means of intervention workshops. Because *oshikundu* is a cultural practice, it warranted the need for an expert on how it is prepared. A local expert woman was then invited to conduct the practical demonstration on the process of making *oshikundu*.

My research journey was a challenging and a rewarding experience. This was due to the learning experiences I gained through the conduct of this research. Firstly, the research design course I attended at Rhodes University provided me with insight into how I could come up with a proposal for my study. This experience was further strengthened by the feedback which I obtained through the different presentations I made on my proposal. The proposal was approved by the education higher degree committee. However due to the undergoing changes on ethics in research at Rhodes University, the proposal needed an ethical clearance certificate. This process was an overwhelming one, as both myself and my supervisor were not well informed on how this clearance had to be obtained through the newly introduced online system. Nevertheless, the approval was eventually granted. Even though the experience with the Rhodes University Ethical Committee was not pleasant, I had opportunities to learn particularly that, any study which involves humans, runs the risk of affecting the participants, such as inducing emotional discomfort and embarrassment. This was new knowledge to me. This knowledge further guided me throughout my study during data collection, as well as the writing of the thesis.

Secondly, from this study I had the opportunity to learn that the process of making *oshikundu* could indeed be used to teach the concept of enzymes and promote inquiry methods. However, I also missed opportunities which could have contributed to the knowledge generated in this study. Thus, if I had to do this study once again, there are various things that I would improve. Firstly, I would use more follow-up questions. This would then allow me to get a deeper understanding of the information that I obtained. For instance, when the local woman was demonstrating how *oshikundu* was prepared, there were instances that she indicated a procedure or information, but I did not follow-up by asking the reasons behind those activities. This weakness resulted in this study providing little knowledge on the cultural heritage which is promoted and learnt through the process of making *oshikundu*. Secondly, during the writing of my thesis, I also realised that some of the remarks and comments made by the teachers during intervention workshops, could have provided insightful information if I had made follow-ups and prompted for more clarification. Thus, this experience has illustrated to me the value of asking questions for clarity and to find reasons for certain remarks or comments made during interactions. This would be one of my strategies which I would employ in future studies. All in all, the experiences from this study contributed to my academic and professional growth.

7.8 Conclusion

This study sought to mobilise the indigenous practice of making *oshikundu* to mediate learning of enzymes and to promote inquiry-based methods. To realise this goal, I collected data to answer the sub-research questions. I used document analysis, workshop discussions and journal reflections. This study began with intervention workshops. The first workshop was aimed at finding out the lessons that Grade 8 Life Science teachers either learnt or not about enzymes and inquiry-based approaches, through co-analysing the curriculum documents. The findings revealed that the teachers did learn lessons from this exercise. Among the lessons learnt, was that the concept of enzymes is part of the Grade 8 Life Science curriculum. However, their knowledge of enzymes was still inadequate. The second sub-research question aimed at finding out how the practical demonstration of making *oshikundu* by an expert community member and topic specific pedagogical content knowledge (TSPCK) components, enabled and or constrained Grade 8 Life Science teachers' interaction, participation and understanding of the enzyme concept. Data revealed that the teachers were active, their participation was high, and they also learnt knowledge about enzymes. The study acknowledged that the indigenous language used in this study was the motivator for the teachers' participation. Furthermore, data revealed that the use of the TSPCK components, provided the teachers with the opportunity to gain insights into how they could teach the concept of enzymes. Finally, the third sub-research question aimed at finding out how using the process of making *oshikundu* enabled or constrained Grade 8 Life Science teachers' understanding of an inquiry-based approach. The findings revealed that the practical demonstration created opportunities for the teachers to use their inquiry skills. When looking at the findings from this study, I felt that all my research questions were answered. The knowledge gaps found in this study have been presented as areas for further research, along with recommendations that have been provided so that teachers become fully aware of and also consistently practice, an inquiry-based approach in their classrooms.

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Appendices

Appendix A: Ethical clearance

Rhodes University Ethical Standards Committee
PO Box 94, Grahamstown, 6140, South Africa
t: +27 (0) 46 603 8055 f: +27 (0) 46 603
8822 e: ethics-committee@ru.ac.za
www.ru.ac.za/research/research/ethics

22 February 2019

Ms Ester Shinana
montuwethu@gmail.com

Dear Ms Shinana

Re: HUMAN SUBJECTS ETHICS APPLICATION
Mobilizing the indigenous practice of making oshikundu using the inquiry method to support Grade 8 Life Science teachers in mediating learning of enzymes
Reference number: Shinana20181202
Submitted: 2018/12/02

This letter confirms that the above research proposal has been reviewed by the Rhodes University Ethical Standards Committee (RUESC) – Human Ethics (HE) sub-committee.

The committee's decision is **Approved. Gatekeepers permission has been received.**

Please email the gatekeepers permission to Mr Siyanda Manqele, Ethics Coordinator, email : s.manqele@ru.ac.za . Upon receipt thereof, you will be sent a final approval letter. The gatekeeper's permission as listed in your application.

Please note that ethics approval will only for a year. An annual progress report is required in order to renew approval for the following year.

Please ensure that the ethical standards committee is notified should any substantive change(s) be made, for whatever reason, during the research process. This includes changes in investigators. Please also ensure that a brief report is submitted to the ethics committee on completion of the research. The purpose of this report is to indicate whether the research was conducted successfully, if any aspects could not be completed, or if any problems arose that the ethical standards committee should be aware of. If a thesis or dissertation arising from this research is submitted to the library's electronic theses and dissertations (ETD) repository, please notify the committee of the date of submission and/or any reference or cataloguing number allocated.

Sincerely,

Prof Jo Dames

Appendix B: Directorate letter of consent

REPUBLIC OF NAMIBIA

OMUSATI REGIONAL COUNCIL

DIRECTORATE OF EDUCATION, ARTS AND CULTURE

Team Work and Dedication for Quality Education

Tek +264 65 251700 Private Bag 529

Fax: +264 65 251722 OUTAPI

Enq: xxxxx 01 September 2018

Ref: 12/3/9/1

Ms. Ester Ndakondja Lineekela Shinana

P.O. Box 2447 Oshakati

Subject: Request for Permission to Conduct Educational Research in Omusati Region.

1. This letter serves to notify you (Ms. Ester Ndakondja Lineekela Shinana) that permission has been granted to conduct an educational research on emphasis made by the curriculum to promote the use of indigenous knowledge in science classrooms, at the following schools in Omusati Region: xxxxx SS and xxxxx JSS.

2. Please be informed that the research to be conducted at school should by no means whatsoever disrupt teaching and learning.

3. We hope and trust this exercise will enhance quality education in the Region.

All official correspondence must be addressed to the Chief Regional Officer.

Thank you for your understanding

Yours faithfully

[signature] 08/11/2018

Laban Shapange
Director of Education, Arts and Culture

OMUSATI REGIONAL COUNCIL
DIRECTORATE OF EDUCATION,
ARTS AND CULTURE
2018 -11- 08
OFFICE OF THE DIRECTOR
PRIVATE BAG 529, OUTAPI
REPUBLIC OF NAMIBIA

cc: Inspector of Education for Oshikuku Circuit

Teamwork and dedicati
quality education

Appendix C: Principals' letters of consent

MINISTRY OF EDUCATION, ARTS AND CULTURE
OSHIKUKU CIRCUIT
OMUSATI REGION

Tel: [redacted] [redacted]
Fax: [redacted]
Email: [redacted]@gmail.com

P.O.Box [redacted]
[redacted]

Enq: Mr. [redacted]
Cell: [redacted]

14 September 2018

Dear Mrs. Ester Ndakondja L. Shinana

Re: Permission to contact an educational research at [redacted]

This letter serves to notify you that the permission has been granted to you, to conduct an educational research on emphasis made by the curriculum to promote the use of indigenous knowledge in science classrooms (grade 8) at [redacted]

However, please be informed that the research to be conducted at should by no means disrupt teaching and learning processes.

We hope and trust this exercise will enhance the quality education in return.

Thanking you for your understanding.

Yours faithfully

....

[redacted]

Acting Principal

[redacted]
2018 -09- 14
[redacted]

Republic of Namibia

MINISTRY OF EDUCATION, ARTS AND CULTURE
OMUSATI REGION
[redacted]

Office of the School Principal
Teamwork and dedication for quality education

Tel: (065)[redacted]
Fax: (065)[redacted]

Private Bag[redacted]
Oshakati

Enquiries: Mr.[redacted]
Cell [redacted]

10 September 2018

Dear Mrs Shinana Ester Ndakondja Lineekela

RE: PERMISSION TO CONDUCT AN EDUCATIONAL RESEARCH WITH TWO TEACHERS

With reference to your request to conduct a study at our school, I would like to inform you that the permission has been granted to conduct the study with the two teachers at our school.

However, please take note that the research should not disturb teaching and learning at the school.

We wish you all the best for your study, and we hope that this study will enhance quality education in our school notably science discipline.

Yours sincerely

[redacted]

Head of Science and Mathematics

[redacted]
10 SEP 2018
[redacted]

Appendix D: Teachers' consent letters

Participant

xxxxxxx Secondary School/xxxxxxx Senior Secondary School

Subject: Invitation to participate in an educational research study

Dear Teacher

Dear Teacher

My name is Ester Ndakondja Lineekela Shinana currently registered as a full-time Master's full thesis in Science Education student (student number: 15S8844) at Rhodes University. I am hereby requesting and seeking for permission to conduct a research study at xxxx Secondary School / xxxx Secondary school.

The aim of this study is to mobilise the use of Indigenous Knowledge (IK) in grade 8 Life Science lessons. The Namibian Life Science curriculum for grade 8 / 9 (2015) recommends the use of IK in Life Science lessons. This curriculum also promotes teaching of scientific investigation skills as well as scientific knowledge. However, teaching of scientific investigations and knowledge can be challenging. These challenges are caused by the lack of resources in our schools. It is with such background that this study will use the process of making *Oshikundu,* an everyday local resource in Omusati region, to mediate learning of the concept of enzymes in grade 8 Life Science classrooms. Given the context of this study, the wealth of indigenous knowledge, your experience in teaching enzymes and experience in practical activities that you will bring to this study makes your participation in this study important. Your participation in this study is voluntary. That is you have the right to withdraw from the study may you feel to do so. This should be noted that, your withdrawal in this regard will not have any negative impact of some sort.

This study is going to be conducted in two phases which are made up of workshops. Phase one, is divided into two workshops. The first workshop is for the orientation workshop. In this workshop we will familiarise ourselves with the research process and share our expectations for the study. In the second workshop, we are going to co-analyse curriculum documents. In the third workshop, a local expert woman is going to join us to demonstrate the process of making *oshikundu*. In addition we will set up the practical investigation. During the fourth workshop, we are going to observe the practical investigation we set up.

With your permission I am planning to videotape the workshops. However, if you do not feel comfortable with that, I will respect your decision and would rather take field notes. I would ensure confidentiality and anonymity in this study. That is your real names will not be used in the study and they will not appear in the final thesis paper either. In terms of hiding your identity, I will use pseudonyms. Since the workshops are going to be videotaped, the pictures from the videos of the workshops will not show your faces to further hide your identity. However, since I will be doing research *with* you, anonymity might be a challenge and so I will give an option for you to use your real names if you want to.

The discussions of the first workshop are aimed to help me find out how the teachers mediate the topic of enzymes. We will further discuss to find out how the teachers conduct practical activities. In the second workshop, I will then introduce the concepts of the PEEOE approach, principles of scientific inquiry, and IK. Data from the workshop discussions and reflections will be used to analyse and provide an insight on how the workshop intervention supported the Grade 8 Life Science teachers to learn about the concept of enzymes using a scientific inquiry approach coupled with indigenous knowledge. This data will help to answer research question 2 and 3.

There will be four workshops and each will be conducted on a separate day. The practical work of *oshikundu* will be done by a community expert. We will make use of the practical work to learn the concepts of science including enzymes. In addition, the two teaching approaches which we are going to employ in our study, the PEEOE approach, as well as the principles of scientific inquiry are also going to be experienced during the workshops.

As I mentioned earlier, your participation in this study is of importance. However, your participation in this study is voluntary and you have the right to withdraw at any given time of the study may you want to do so. It should be noted that your withdrawal in this study will not have any negative impact of any sort.

Upon completion of the study, the research results will be published. Thus it will be accessible to everyone. If you require any further information, please do not hesitate to contact:

Ester Shinana email: montuwethu@gmail.com. Cell: 0026481288862/ 0027 670733420

My Supervisor: Prof Kenneth Ngcoza K.Ngcoza@ru.ac.za

Rhodes University Ethical Standards Committee email: ethics-committee@ru.ac.za Tel : 0027 (0) 466038055

Thank you for your time and I hope that you will respond favourably to this request.

Yours sincerely

Ms E. Shinana

Rhodes University

Med in Science Education Student

Reply slip

I agree to participate in the study on condition that I can withdraw at any time

Name:……………………………………………………………………………..

Signature:……………………………………………………………………

Appendix E: Community member's consent letter

Dear Mem

Re: Permission to voluntarily assist in brewing Oshikundu to Life Science teachers

My name is Ester Ndakondja Lineekela Shinana currently registered as a full-time Master's full thesis in Science Education student (student number: 15S8844) at Rhodes University. I am hereby requesting and seeking for permission to conduct a research in a grade 8 classroom.

The aim of this study is to mobilise the use of Indigenous Knowledge (IK) in grade 8 Life Science lessons. In this study we plan to use the process of brewing Oshikundu to discuss how this process can be used to teach the Life Science curriculum. With this aim, I am humbly requesting you to help us during this study to come and demonstrate to us how Oshikundu is brewed. Your acceptance of this request is voluntary and as such there will not be any form of payment for this activity. When doing this demonstration, with your permission the photographer will videotape the activities. However if you are not comfortable with that, I will respect your decision and rather take field notes.

As I indicate above in showing us how Oshikundu is made, there will be no payment for such an activity. Thus it is just a request in a form of assistance which in this case we will highly appreciate as we have less knowledge in this process. Thus your acceptance to this request will be highly appreciated.. If you require further information, please do not hesitate to contact :

Ester Shinana email: montuwethu@gmail.com. Cell: 0026481288862/ 0027 670733420

My Supervisor: Prof Kenneth Ngcoza K.Ngcoza@ru.ac.za

Rhodes University Ethical Standards Committee email: ethics-committee@ru.ac.za

Tel : 0027 (0) 466038055

Thank you for your time and consideration in this matter.

Yours sincerely

Ester Shinana

Translated letter

Ko mundali omufimanekwa

Eindilo opo ndi ndu le oku ninga oshi nya nga nda lwa she li hongo

Edinalange aame Ester Ndakondja Lineekela Shinana. Ondili omulongwa longi ko shi pupudilo sho popanda she ndina Rhodes University. Oshi pupudilo eshi oshi li mo South Africa. Elalakano lange onda fane ka ndi ka ni nge oshi nya nga dalwa eshi mo dodo oni 8 mo shilongwa osho hashiifanwa o Life Science.

Elalakano lo shi nya nga da lwa eshi, oku ya mee nghundafana no va ho ngi vakwetu opo tu tale ondu nge nghene ha tu ndulu o ku ka ndu lapo ou pya kandi wo ku hena ii longifo longo mee fikola ndetu. Mo shinyangadalwa eshi ohattu ka longifa Oshikundu opo tu longe elalakano ilo ndi tye oshitopolwa sho mo shi longwa osho nda tumbula po mbada.

Mee ngundafana ndo shi nya nga da lwa eshi, ohatu k aka la twa pu mbua omunhu out e tu ilikile onghe oshi kundu ha shin du ngwa. Mo lwasho neh, oto indililwa nefimane ko meme, op utili yambele uuye u tu ndu ngi le oshikundu opo eenghu nda fan a nde tu ndi shiive oku ya moi longa. Eshi hai tumbula oshitya okuli yamba, onda hala ndi fa tu lu le apa ku tya ngee nge owa itavele meme, oto ka fu twa eshi to ka ndunga oshi kundu, nde le oku li wa fela ashike.

Tangi omundali omufinakwa, , omayele oye mwaashi otapandulwa. Ko ma pulo no ma yelifilo, mai kufa ko no mola yange,

Ester Shinana 0812888862 ilo ko mukulunhu wange, Tatekulu Professor Ngcoza 0788852143,

noshoyo, ovataonateli vo ka komitiye ka Rhodes University Ethical Standards Committee email: ethics-committee@ru.ac.za Ongodi yo ko pala : 0027 (0) 466038055

Weni

Ester NL Shinana

Edina lo mu kulunhu::……………………………………………………………………………..

Oku Shaina: :………………………………………………………………………….

Appendix F: The various phases of the data gathering process

Phase	Data collection method to be used to gather data	Data to be gathered	Purpose	Research question
Phase 1	**First workshop : Orientation** Meeting with the participants. **First work shop [Document analysis]** **To co-analyse the curriculum documents: the following documents will be analysed:** • The National Curriculum for Basic Education 2010 • The Life Science Curriculum Grade 8 • Life Science Grade 8 textbooks • Examiners' reports	• Participants provide their expectations from the study. • Discuss on meeting time. • Analyze the grade 8 Life Science curriculum and textbooks. • Journal reflections. • Discuss with the teachers how they teach the topic enzymes. • Also discuss how they conduct practical work.	• For the participants to outline their expectations and to collaboratively select meeting times which are convenient for both participants. • To get an insight on how the teachers used to teach enzymes and practical work before the intervention. By co-analysing these documents I will get an insight in the following: • How inquiry-based learning is promoted	Data from the discussion will help to answer sub-research question 1. Data from documents will be used to strengthen my context and to answer sub-research question 1.

		• To co-analyse the National curriculum and Life science Grade 8 curriculum to find out to which extent the curriculum provides guidelines on the use and promotion of an inquiry approach and scientific inquiry in science classrooms. • To co-analyse both the Life Science Grade 8 curriculum, as well as Life Science Grade 8 textbooks to find out how the topic of enzymes is presented. • To co-analyse the examiners' reports to find out how learners perform in terms of the concept enzyme and inquiry skills.	• How the topic of Enzymes is presented in the Life Science curriculum and the recommended Grade 8 Life Science textbooks. • How learners perform.	

Phase 2	**Second workshop** Intervention – workshop discussions.	Introduce the teaching approaches which are going to be employed in this study: • Principles that guide inquiry classrooms • PEEOE approach • Design worksheet to familiarize themselves to the PEEOE approach • Journal reflections	The participants to know the principles that guide inquiry classrooms and the PEEOE which they will use to improve their promotion of scientific inquiry and conduct of practical work in their classrooms.	Data from the workshops will help answer sub-research question 3.
	Third workshop Intervention – Workshop discussions.	Invite a local woman who is an expert in making *oshikundu* to demonstrate the process of making *oshikundu.* • Make predictions and provide explanations for the predictions made. • Discussions of enzymes begins. • Construct mind map with science concepts. • Journal reflections.	• Demonstrate the practical activity. • Provide learning opportunity to learn about the concept enzyme and how to promote scientific inquiry.	Data from the work shop will help answer sub-research questions 2 and 3.

	Fourth work shop Intervention – work shop discussions.	• Make observation on the practical activity of *oshikundu*. • Provide explanations for observations. • Strengthen the mind map and construct a concept map. • Journal reflections.	• To observe what happened to the 3 bottles with *Oshipithitho* and 3 bottles without *Oshipithitho* in 3 different environments. • To get an understanding of what enzymes are using concrete examples. • To get the experience of how to teach enzymes in a more contextualised and authentic manner.	Data from the work shop will help answer sub-research questions 2 and 3.

Appendix G: Examiners' reports

EXTRACT 1 (ENZYMES)

2015

- Many candidates answered this part of the question poorly. It seemed as if they did not understand the question or *they did not understand the functions of enzymes or how enzymes work.*

2016

- Candidates often used "*substance*" instead of "*substrate*".

2017

- A common mistake was that the candidates gave lipase as an answer. Maybe they assumed that the stomach was the liver.

2018

- Majority of learners could not define enzymes correctly, as most of them defined it as "biological catalyst or as biological protein" and could thus not score any marks. The term "catalyst" was written as catalistic/ catalyse instead of using the chemical reaction they were just making reference to reaction.
- Most learners cannot spell substrate correctly, they made reference to substance, subtract between enzyme and substrate.
- The majority of learners made reference to "enzyme activity stops" instead of "reaction stops".
- Most learners could provide a description (describe) but could not provide an **explanation** why the enzyme denatured.
- Most learners could not spell the names of the enzymes correctly. They also don't know the difference between **enzymes** and **substrate** and make statements like, "starch breakdown amylase into maltose", or "enzymes breakdown soluble nutrients into insoluble food".

EXTRACT 2 (PRACTICAL SKILLS AND SCIENTIFIC INQUIRY SKILLS)

2015

- Requesting learners *to draw, is based on the competencies* of *Scientific Processes* and it is a *practical skill*. Schools, therefore, are not required to offer drawing as a Subject in order for learners to master this competency. Learners should be requested, more regularly, to do labelled drawings whilst keeping all the rules regarding a biological drawing in mind.

2016

- It is important to do more practical work to enhance understanding of scientific concepts.
- Most candidates clearly lacked drawing skills
- The majority of candidates did not perform well in this **paper 3 (Practical paper for grade 12 Biology)**. Many candidates gained very low scores and only a few performed excellently and were awarded high marks. Some answers were left blank, and this seemed to be through lack of knowledge rather than lack of time.
- Some processes, are very difficult for candidates to explain in their own words, and marks are more accessible if the correct wording is known (p. 58)

2017

- Learners find it difficult to interpret diagrams and tables.
- Answers in Life Science need to be expressed scientifically, but the learners do not possess the tools to do so.
- Learners could not interpret the diagram
- Biology Practical paper: Teachers *should do practical work with the learners* to understand the content better (p. 44).
-

2018

- Teachers need to emphasise the skills required for making drawings.
- If candidates mastered the skills they should be able to do a drawing of any organism.

Appendix H: Workshop sheets for T1 – T3

T1

[redacted]

Work shop worksheet

Implementing the PEEOE approach

Practical demonstration on making of Oshikundu Day 1

Activity 1

Procedure

1. Observe how the iocal woman is preparing Oshikundu and discuss the cultural practices and beliefs associated with making of Oshikundu.
2. On the flip chart provided, note down the science concepts which are emerging from these discussions and from other discussions which we will engage in through this activity.
3. Once the local woman finishes to make Oshikundu
   - Pour approximately equal volumes of dilute mixture (Oshikundu) into six bottles of approximately equal volumes.
4. Why is it important that the volume of the mixture is kept equal?

for fai'r test

   - Mark the six bottles as A, B, C, D, E, and F
     - i) A is for Oshikundu mixed with oshipiththo kept at room temperature.
     - ii) B s for Oshikundu mixed with oshipiththo placed in cool environment.
     - iii) C is for Oshikundu mixed with oshipiththo placed in direct sunlight.
     - iv) D is for Oshikundu without oshipiththo placed in room temperature.
     - v) E is for Oshikundu without oshipiththo placed in a cool environment.
     - vi) F is for Oshikundu without oshipiththo placed in direct sunlight.
   - Cover the bottles with deflated balloons. Leave them to overnight for further observations the following day.
5. Briefly explain why oshipiththo is added to bottle A, B, & C and not to bottle D, E, & F?

D, E, F, to act as conrol

1

8. Provide explanations for your predictions you made for bottle:

A. balloon expand due to fermentation

B. Temperature is low

C. balloon explode because more carbon dioxide is produced

D. will not be ready because there is no oshipith tho and the temperature is low

E. not ready and no effect on the balloon because there is no oshipithitho and the temperature is low

F. A bit ready because the temperature and the pressure are direct proportion

Day 2

Observation of set experiment

1. Observe what has happened to the bottles which were prepared and set yesterday?

A. got ready and the balloon expand

B. Got ready and the balloon expand

C. Got ready and the balloon expand

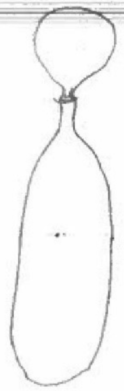
D. A bit ready and the balloon expand a bit

E. did not get ready, no change on the balloon

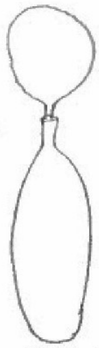
F. Got ready and the balloon expand a little bit more than D

3

2. Illustrate your observations below



Bottle A

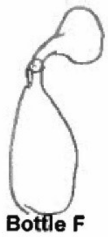


Bottle B

Bottle C

Bottle D

Bottle E



Bottle F

3. Explain your observation for bottle

A. Oshikundu is ready and Carbon dioxide is produced

B. Got ready and CO_2 produced

C. Got ready ~~b~~ and CO_2 produced

4

D. ~~Got ready a little bit and balloon expand~~ a little bit due to less CO_2 produced

E. not ready and no change for the balloon because no CO_2 produced

F. little bit ready and less carbon dioxide produced because there was no oshipithitho added

a). What happened to the balloon placed on bottle C?

The balloon expand

b) Explain your answer

because too much CO_2 produced, and the particles escaped due to high temperature and the balloon become small.

c) What happened to the balloon placed on bottle F?

balloon expand a bit

d) Explain your answer

little carbon dioxide was produced and there was no oshipithitho

e) Briefly explain what does the result of bottle B and C tell us?

fermentation has taken place, and CO_2 is produced and made the balloon to expand

f) Briefly explain what the results of bottle A and D tell us about the function of oshipithitho

Oshipithitho act as a catalyst to speed up the reaction

g) Suggest a biological term for oshipithitho

Catalyst

Continue with summary given..........

5

T2

Work shop worksheet

Implementing the PEEOE approach

Practical demonstration on making of Oshikundu Day 1

Activity 1

Procedure

1. Observe how the local woman is preparing Oshikundu and discuss the cultural practices and beliefs associated with making of Oshikundu.
2. On the flip chart provided, note down the science concepts which are emerging from these discussions and from other discussions which we will engage in through this activity.
3. Once the local woman finishes to make Oshikundu
   - Pour approximately equal volumes of dilute mixture (Oshikundu) into six bottles of approximately equal volumes.
4. Why is it important that the volume of the mixture is kept equal?

For fair test

   - Mark the six bottles as A, B, C, D, E, and F
     i) A is for Oshikundu mixed with oshipiththo kept at room temperature.
     ii) B s for Oshikundu mixed with oshipiththo placed in cool environment.
     iii) C is for Oshikundu mixed with oshipiththo placed in direct sunlight.
     iv) D is for Oshikundu without oshipiththo placed in room temperature.
     v) E is for Oshikundu without oshipiththo placed in a cool environment.
     vi) F is for Oshikundu without oshipiththo placed in direct sunlight.
   - Cover the bottles with deflated balloons. Leave them to overnight for further observations the following day.
5. Briefly explain why oshipiththo is added to bottle A, B, & C and not to bottle D, E, & F?

To speed up the process of making oshikundu to be ready faster.

1

6. Predict what will happen to the set bottles the following day?

A. Will be ready and balloon will expand

B. It will almost be ready, but balloon will not expand

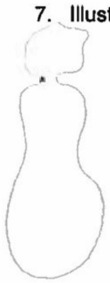
C. It will be very ready and the balloon ~~will~~ might explode

D. will not be ready - no effect on the balloon

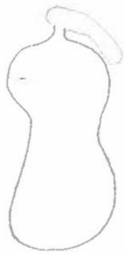
E. will not be ready - no effect on the balloon

F. Might be ready - little expand.

7. Illustrate your predictions below

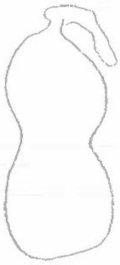


Bottle A

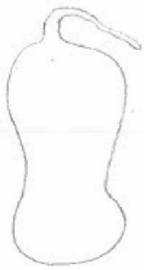


Bottle B

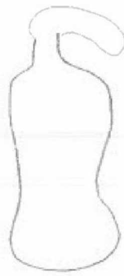
Bottle C



Bottle D



Bottle E



Bottle F

2

8. Provide explanations for your predictions you made for bottle:

A. The balloon will expand because fermentation will take place because temperature is cool

B. Minimum temperature but it will be almost ready

C. Balloon will explode because there is high temperature, more carbon dioxide

D. There is no oshipithitho and the temperature is low

E. It will not be ready because there is low temperature

F. Because of high pressure and high temperature. (direct proportion)

Day 2

Observation of set experiment

1. Observe what has happened to the bottles which were prepared and set yesterday?

A. Oshikundu is ready - Balloon expanded

B. Oshikundu is ready - Balloon expanded

C. Oshikund is ready - Balloon expanded

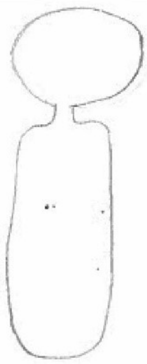
D. Oshikundu is a bit ready - balloon expanded a bit

E. Oshikundu is not ready - No change on balloon

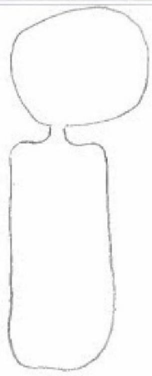
F. Oshikundu is ready - Balloon expanded a little bit more than D

3

2. Illustrate your observations below

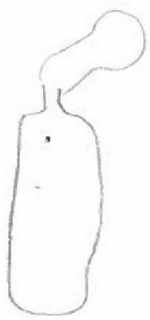


Bottle A

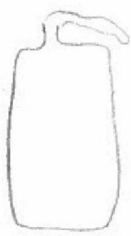


Bottle B

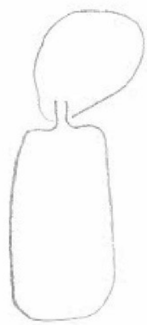
Bottle C



Bottle D



Bottle E



Bottle F

3. Explain your observation for bottle

A. Oshikundu is ready and CO_2 is produced

B. Oshikundu is ready and CO_2 is produced

C. Oshikundu is ready and CO_2 was produced but particles excaped because of heat

4

D. Oshikundu was ready a bit and balloon expanded a bit because of less CO_2 produced.

E. Not read, oshikundu, balloon did not change size as no CO_2 was produced.

F. A little bit ready oshikundu and less CO_2 produced, no oshipithitho

a) What happened to the balloon placed on bottle C?

The ballon expanded

b) Explain your answer

Too much CO_2 was produced and particles escaped because of high temperature and it becomes smaller.

c) What happened to the balloon placed on bottle F?

Balloon expanded a bit

d) Explain your answer

little CO_2 is produced and there was no oshipithitho

e) Briefly explain what does the result of bottle B and C tell us?

Fermentation has taken place and CO_2 is produced making balloons expand.

f) Briefly explain what the results of bottle A and D tell us about the function of oshipithitho

Oshipithitho acts as a catalyst to speed up the reaction

g) Suggest a biological term for oshipithitho

Catalyst

Continue with summary given..........

5

Day 3: Science concepts associated with the process of making oshikundu

Activity 2

1.

a) Which process is responsible for oshikundu to release the air in the balloons?

Fermentation

b) Predict the air which is in the balloons

CO_2

c) Explain your prediction

Gas produced during Fermentation

2. Testing for the air which is in the balloon

a) Predict what will happen if you place a burning splint above bottle with oshikundu?

Goes off

b) Explain your prediction

CO_2 Does ~~CO~~ not support combustion

- Now take a burning splint and place it above the bottle with oshikundu

c) Observe what happen

The burning splint went off

d) Explain the observation you made

The gas produced (CO_2) does not support combustion

e) Which science concept is associated with your observation?

Combustion

6

T3

Work shop worksheet

Implementing the PEEOE approach

Practical demonstration on making of Oshikundu Day 1

Activity 1

Procedure

1. Observe how the local woman is preparing Oshikundu and discuss the cultural practices and beliefs associated with making of Oshikundu.
2. On the flip chart provided, note down the science concepts which are emerging from these discussions and from other discussions which we will engage in through this activity.
3. Once the local woman finishes to make Oshikundu
    - Pour approximately equal volumes of dilute mixture (Oshikundu) into six bottles of approximately equal volumes.
4. Why is it important that the volume of the mixture is kept equal?

To make a fair test / experiment

    - Mark the six bottles as A, B, C, D, E, and F
        i) A is for Oshikundu mixed with oshipithitho kept at room temperature.
        ii) B s for Oshikundu mixed with oshipithitho placed in cool environment.
        iii) C is for Oshikundu mixed with oshipithitho placed in direct sunlight.
        iv) D is for Oshikundu without oshipithitho placed in room temperature.
        v) E is for Oshikundu without oshipithitho placed in a cool environment.
        vi) F is for Oshikundu without oshipithitho placed in direct sunlight.
    - Cover the bottles with deflated balloons. Leave them to overnight for further observations the following day.
5. Briefly explain why oshipithitho is added to bottle A, B, & C and not to bottle D, E, & F?

To make Oshikundu ready; while other ones will be set as controls

1

6. Predict what will happen to the set bottles the following day?

A. This bottle will be ready and the balloon will expand

B. not be ready and the balloon will ~~Still~~ not expand

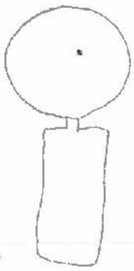
C. It will be ready and the balloon will explode .

D. will not be ready and ~~the balloon~~ ~~ball~~ ~~has~~ no effect on the ballon

E. will not be ready , no effect on the balloon

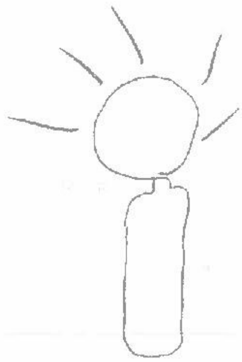
F. a bit ready and the balloon will expand a little bit

7. Illustrate your predictions below



Bottle A

Bottle B



Bottle C

Bottle D

Bottle E

Bottle F

2

8. Provide explanations for your predictions you made for bottle:

A. The balloon will expand because fermentation will take Place.

B. Because the temperature is ~~too~~ cool the balloon will remain

C. Balloon will be explode because too much Carbondioxide produced and high temperature

D. Because there is no oshipithitho and the temperature is low

E. The temperature is very low / Cool environment. The balloon remains

F. little bit ready because the temperature is high and pressure because they are directly proportional.

Day 2

Observation of set experiment

1. Observe what has happened to the bottles which were prepared and set yesterday?

A. The balloon expands

B. The balloon expand more, because oshikundu is ready

C. The Oshikundu is read and the ballon expands

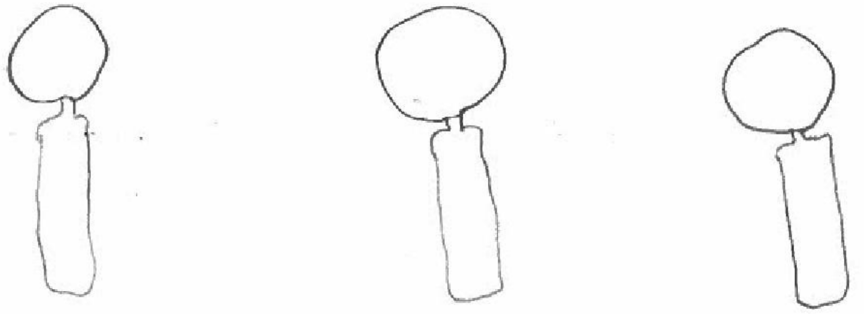
D. The balloon expands a little bit, because Oshikundu is a bit read

E. Oshikundu not ready, no change in the balloon

F. Oshikundu is ready the balloon expand but not that much and its more than D

3

2. Illustrate your observations below



Bottle A   Bottle B   Bottle C

Bottle D   Bottle E   Bottle F

3. Explain your observation for bottle

A. Oshikundu is ready, carboondioxide is produced

B. Ready Oshikundu, balloon becomes bigger because more Carboondioxide Produced

C. This Oshikundu is eady and it was placed in the direct sunlight, the balloon becomes bigger and particles started to escape due to high temperature.

4

D. Oshikundu is a bit ready, balloon expanded a bit because of less Carbondioxide produced

E. Oshikundu is not ready, the balloon remains the same because no production of CO_2

F. ready a little bit and less carbondioxide is produced thus the balloon expanded a bit

a) What happened to the balloon placed on bottle C?

The balloon expands

b) Explain your answer

Because too much carbondioxide is produced and the particles escaped ~~and~~ due to high temperature and the balloon becomes smaller

c) What happened to the balloon placed on bottle F?

The balloon expand a bit

d) Explain your answer

little carbondioxide is produce and there was no oshipithitho

e) Briefly explain what does the result of bottle B and C tell us?

- fermentation has taken place.
- Production of carbondioxide makes the balloon to expand

f) Briefly explain what the results of bottle A and D tell us about the function of oshipithitho

Oshipithitho act as a catalyst to speed up the reaction, thus the balloon in A is bigger compared to D

g) Suggest a biological term for oshipithitho

Catalyst

Continue with summary given..........

Day 3: Science concepts associated with the process of making oshikundu

Activity 2

1.

a) Which process is responsible for oshikundu to release the air in the balloons?

Fermentation

b) Predict the air which is in the balloons

Carbon dioxide

c) Explain your prediction

gas produced during fermentation is CO_2

2. Testing for the air which is in the balloon

a) Predict what will happen if you place a burning splint above bottle with oshikundu?

It will go off

b) Explain your prediction

because CO_2 does not support combustion

- Now take a burning splint and place it above the bottle with oshikundu

c) Observe what happen

The splint went off.

d) Explain the observation you made

The splint went off because the gas produced does not support combustion.

e) Which science concept is associated with your observation?

Combustion

6

Appendix I: Table for TSPCK components

CONTENT SPECIFIC COMPONENTS	INDICATORS	ANALYSIS
Learner Prior Knowledge (LP)	What learners already know and includes common misconceptions known in a topic.	
Curricular Saliency (CS)	Refers to the identification of the most important meaning of the major concepts in a topic, without which understanding of the topic would be difficult for learners. It also includes the knowledge to logically sequence the learning and the knowledge of pre-concepts needed prior to teaching a topic.	
What is difficult to understand (WD)	Refers to gate keeping concepts which are difficult to understand often because they cause conflict with previously established understanding.	
Representations (RP)	Refers to a combination of representations at *macro*, *symbol* and *sub-microscopic* levels that may be employed to support an explanation. Example, illustrations, metaphors, analogies, models, stimulations.	
Conceptual Teaching Strategies (CTS)	Refers to teaching strategies derived from the considerations made from the other components e.g. (particular misconception, particular learner/learners, and particular educational purpose. It excludes general teaching methodologies.	

Appendix J: Episodes and themes from workshops

Table 1: Episodes from intervention workshops

Episode	Descriptions of activities	Emerging themes
1. Introduction	Introduction of teachers • Greeting teachers • Welcoming teachers • Thanks giving • Teachers introduce themselves • Give an overview of the study • Discussion of ethical issues	• Orientation to the workshop
	Developing of workshop rules by participants • Punctuality • No phones • Respect of others views • Meeting time for the workshop activities	• Creating conducive learning environment • Emphasises time management, respect
	Outlining the workshop expectations • Learn best way to conduct practical activities (T4F) • Fitness of inquiry approach in class with mixed ability learners (T1M) • Fitness for inquiry approach in overpopulated classrooms (T1M)	• Teachers expectations towards the workshop

2. Analysis of past examination questions and examiners review in relation to enzyme and practical investigations	Areas learners grapple with in science classrooms • Noted that learners lack knowledge on importance of repeating a test. • Learners are taught theoretically of this importance (T3) • Repeating of test not possible due to lack of resources(T1M, T3F, T4F) • Noted that learners lack knowledge on how to set up a control in an experiment • Learners fail to transfer knowledge if question ask differently (T4F)	**Lack of practical skills** • Lack of understanding of repeating a test. • Lack of knowledge in setting up of control in experiment. **Lack skill of application of knowledge** • Lack of skill in knowledge application in different context. **Lack of resources inhibit mediation for scientific skills (Fair test)**
3. Analysis of the curriculum for practical investigations	• Curriculum advocate for practical investigations • Suggestions for practical is given • Learners plan for their practical investigations (T3F) • Provide instructions for learners to follow step by step (T1M) • Belief in getting expected answer for practical investigations (T1M,T3F,T4F) • Agree for conducting a pre- test to ensure results match text books (T1M) • Pre-test to ensure chemicals did not expire(T3) • Inhibit conduct of practical activities (T3) ➢ No resources (laboratory) ➢ Unsafe for learners to conduct practical in overpopulated classrooms **as:** ➢ Learners are playful ➢ Some materials are flammable	• Practical investigation part of the curriculum requirement • Evident teachers conduct practical activities. • Poor conduct of practical activities ➢ Provide instructions for a step by step way to conduct practical ➢ Based on getting expected outcome ➢ Do pre-test to ensure chemicals are usable • Factors that inhibit conduct for practical work ➢ No laboratory ➢ Learners safety is at risk

4. Analysis of the Biology examiner's report on enzyme	• Learners perform poorly (Examiners' report) • Learners have poor understanding of enzymes (Examiners' report) • Finds teaching the topic challenging to teach (T2F) • Topic is easy (T1M) • Learners belief the topic is difficult(T1M) • Topic is abstract to the learners (T1M, T2F) • No relevancy to everyday experiences (T1M, T2F)	• Enzyme poorly performed • Teachers find topic challenging to teach • Topic is abstract to the learners
5. Enzyme and the Life science curriculum	• Enzyme implicit in the curriculum	• Enzyme implicit in the curriculum
6. Analysis of the three recommended text books on enzymes	• All text books failed to sequence the concept • Only one textbook define enzyme • Platinum textbook provided detail information on enzyme • Solid foundation and Living Life science provide poor details on enzyme	• Two of the three recommended text books provide insufficient information
7. teachers interpretation of the curriculum on enzymes	• T1M teach the topic • Use real life example to teach the concept of enzymes • He sequence the concepts from simple to complex • T3F and T4F does not teach the concept of enzymes only define the concept chemical digestion and chemical digestion	• Teachers narrative of pPCK differ on mediation of enzyme differ
8. Developing of TSPCK in the topic of enzymes	• Exploring the topic specific PCK components • The concept was used to explore the components • Development of concept map **lead to** • Teacher T3, T4 had an opportunity to improve their PCK in enzymes • T1 strengthen his PK in mediation of the concept of enzymes	• Teachers PCK at topic level improved as they explore the TSPCK components

9. Practical demonstration of making *oshikundu*	• Using locally available resource • Using the process of making *oshikundu* to identify concepts around the topic enzyme and scientific process skills • Use of vernacular language (*oshiwambo*) to communicate	• Mediation for enzyme using the process of making *oshikundu* • Learning of scientific process skills • Use of vernacular language promote participation
10. Sharing ways of improvising for practical investigations	• Improvise were opportunities arise (T1M, T3F, T4F) • Not possible to improvise for all activities (T1M) • Some indigenous practices produce alcohol (Fermentation) (T1M, T4F) • Advice on how to ensure relative low alcohol content is produced (T3F)	• Collaborative learning
11. Teachers beliefs about practical activities	• Promote learning (T1M) • Increase understanding of content(T1M) • Learners discover things on their own (T1M) • Practical activities promote learners interest (T4F) • Knowledge obtain from one practical activity can be used to in other topics (T3F)	• Teachers acknowledges that practical activities has academic benefits
12. Discussions on how to promote scientific inquiry	• Discussions on what is meant by inquiry education • General principles that guide any kind of inquiry classroom • The PEEOE approach specifically for practical investigations aimed at promotion of inquiry • Some answers to practical are in the learners books (T1M)	
13. Designing workshop sheet	• Teachers and I sat and design the workshop sheet	• Designing workshop activities together promote active participation

	• Teacher familiarise themselves with the PEEOE approach	
14. Setting up of bottles for the experiments	• Discuss how to set up the bottles • Suggest label bottle with a paper (T4F) • Label might fall off when wet (T3F) • Use marker pen to write on the bottle (T3F) • Agreed with the suggestion of the marker pen (T1M) • All participants agreed on using the marker pen to label bottle (T1M, T3F, T4F) • Considering the meniscus to ensure right amount of volume is used	• Debating, arguments, reasoning took place • Collaboratively looking for solution • Used measuring skills
15. Making prediction before the observations	• Predictions made in groups • All participants needed to agree on the predictions • Teachers show interest in the activities • Used reasoning skills as they were making predictions • Not everything that the teachers agreed at social level is what they put on their paper. • Used reasoning skills during their discussions for their predictions • The teachers draw their predictions in a form of a diagram • Teachers demonstrated their drawing skills	• Group prediction increase interaction • Promote arguments, reasoning and making conclusions to come to an agreement • Teachers show interest • Teachers used reasoning skills • Socially discussed ideas are presented uniquely by individual teachers • Use of drawings to illustrate their thinking
16. Observation of the experiments	• The teachers observed the balloons were not appearing as they expected • They did not see a good relationship between temperature and rates of activities in bottle A and C (T4F) • Explain that fermentation stopped in bottle C	• Observations create an opportunity for engagement with data they collected • Use reasoning skills to make sense of data

Table 2: Summary of themes from workshop episodes

Research question 1: What lessons can Grade 8 Life Science teachers learn or not about enzymes and an inquiry-based approach through co-analyzing the curriculum documents?		
Code	**Developed sub-themes**	**Themes**
Introduction	• Orientation to the workshop • Creating conducive learning environment • Emphasizes time management, respect • Teachers expectations towards the workshop	Orientation workshop
Analysis of the curriculum for practical investigations	• Practical investigation part of the curriculum requirement • Evident teachers conduct practical activities. • Poor conduct of practical activities ➢ Provide instructions for a step by step way to conduct practical ➢ Based on getting expected outcome ➢ Do pre-test to ensure chemicals are usable • Factors that inhibit conduct for practical work ➢ No laboratory ➢ Learners safety is at risk	Teachers learnt that practical investigations and inquiry are part of the Grade 8 Life Science curriculum.
Analysis of past examination questions and examiners review in relation to enzyme and	**Lack of practical skills** • Lack of understanding of repeating a test. • Lack of knowledge in setting up of control in experiment.	Teachers gain knowledge on learners' performance in practical investigations and inquiry.

practical investigations	**Lack skill of application of knowledge** • Lack of skill in knowledge application in different context. **Lack of resources inhibit mediation for scientific skills (Fair test)**	
Analysis of the three recommended text books on enzymes	• All text books failed to sequence the concept • Only one textbook define enzyme • Platinum textbook provided detail information on enzyme Solid foundation and Living Life science provide poor details on enzyme	Life Science Grade 8 Textbook include the concept of enzymes and not well presented.
Analysis of the Biology examiner's report on enzyme	• Enzyme poorly performed • Teachers find topic challenging to teach • Topic is abstract to the learners	Teachers' views on the use of inquiry teaching approach
Teachers' interpretation on teaching the concept of enzymes.	Teachers narrative of pPCK differ on mediation of enzyme differ.	The concept of enzymes not taught in some classrooms.
Teachers' belief on practical investigations	• Promote learning (T1M) • Increase understanding of content(T1M) • Learners discover things on their own (T1M) • Practical activities promote learners' interest (T4F)	Practical activities contribute positively in science lessons

	Knowledge obtain from one practical activity can be used to in other topics (T3F)	
Sharing ways of improvising for practical investigations	• Improvise were opportunities arise (T1M, T2F, T3F) • Not possible to improvise for all activities (T1M) • Some indigenous practices produce alcohol (fermentation) (T1M, T2F)	Collaborative learning
Research question 2: How does the practical demonstration of making *oshikundu* by an expert community member enable and/or constrain Grade 8 Life Science teachers' interaction, participation and understanding of the enzyme concept?		
Practical demonstration of making *oshikundu*	• Mediation for enzyme using the process of making *oshikundu* • Active participation, • Conducive learning environment • Learning of scientific process skills Use of vernacular language promote participation	The science behind the practical demonstration of making *oshikundu*
Exploring the TSPCK components with the concept of enzymes.	• Exploring the topic specific PCK components. • The concept was used to explore the components • Development of concept map lead to; • Teacher T2, T3 the opportunity to improve their PCK in enzymes T1 strengthen his PK in mediation of the concept of enzymes	Improving teachers' PCK in the concept of enzymes
Research question 3: How does using the process of making *oshikundu* enable or constrain Grade 8 Life Science teachers' understanding an inquiry-based approach?		

Discussions on the concept of inquiry	• Discussions on what is meant by inquiry education • General principles that guide any kind of inquiry classroom • The PEEOE approach specifically for practical investigations aimed at promotion of inquiry Some answers to practical are in the learners' books (T1M)	Improving teachers' PCK in the concept of inquiry
Designing the workshop worksheet using the PEEOE approach	• Teachers and I sat and design the workshop sheet • Teacher familiarise themselves with the PEEOE approach	
Setting the bottles for the experiments	• Debating, arguments, reasoning took place • Collaboratively looking for solution Used measuring skills	
Making predictions before the observations	• Group prediction increase interaction • Promote arguments, reasoning and making conclusions to come to an agreement • Teachers show interest • Teachers used reasoning skills • Socially discussed ideas are presented uniquely by individual teachers Use of drawings to illustrate their thinking	
Making observations for set experiments	• Observations create an opportunity for engagement with data they collected Use reasoning skills to make sense of data	

Table 3: Showing themes and the relevant literature and theory

		Theory	
Developed themes	**Themes**	**Literature**	**Theoretical framework**
Orientation to the workshop • Creating conducive learning environment • Emphasizes time management, respect • Teachers expectations towards the workshop	Orientation workshop	Jacobs (2015) Lee, & Shea, (2016) Merriam (2009) Ngcoza and Southwood (2015) Saad and Boujaoude (2012)	Carlson et al., (2019) Gess-Newsome (2013)
• Practical investigation part of the curriculum requirement • Evident teachers conduct practical activities. • Poor conduct of practical activities ➢ Provide instructions for a step by step way to conduct practical ➢ Based on getting expected outcome ➢ Do pre-test to ensure chemicals are usable • Factors that inhibit conduct for practical work ➢ No laboratory ➢ Learners safety is at risk	Lesson learnt from analysis of the curriculum documents and textbooks	Cobin and Strauss (2008) Life Science Syllabus (2015) NCBE (2016)	Vygotsky (1978)

Ananlysis of the recommended textbooks • All text books failed to sequence the concept • Only one textbook define enzyme • Platinum textbook provided detail information on enzyme Solid foundation and Living Life science provide poor details on enzyme.			
Lack of practical skills • Lack of understanding of repeating a test. • Lack of knowledge in setting up of control in experiment. **Lack skill of application of knowledge** • Lack of skill in knowledge application in different context.	Examiner's reports	Abu-Hannieh et al. (2018) Asheela (2017); Examiners' reports 2015; 2016; 2017; 2018 Kapenda et al.(2002) Kandjeo-Marenga (2008) Mavuru and Ramnarain (2017) Nikodemus (2017)	Mavhunga & Rollnick, (2013)

Lack of resources inhibit mediation for scientific skills (Fair test) **Findings on performance of enzymes;** • Enzyme poorly performed • Teachers find topic challenging to teach • Topic is abstract to the learners		Ramnarain and Schuster (2014)	
Teachers' narrative of pPCK differ on teaching of enzyme.	Teachers' TSPCK in the topic of enzymes	Garet et al. (2001) Roschelle, (1995) Rennie (2011)	Aydin et al. (2012) Davidowitz and Rollnick (2011) Mavhunga et al. (2016) Mavhungta and Rollnick (2013) Shulman (1986) Vygotsky(1978)
• Poor conduct of practical activities ➢ Provide instructions for a step by step way to conduct practical	Teachers' PCK in conducting practical investigations and promotion of scientific inquiry	Asheela (2017) Dudu (2017) Eun (2008)	Carlson and Daehler (2019) Vygotsky (1978) Zohar and Dori (2003)

➢ Based on getting expected outcome ➢ Do pre-test to ensure chemicals are usable • Factors that inhibit conduct for practical work ➢ No laboratory ➢ Learners safety is at risk		Kalz & Tenier (2018) Kim & Tan (2011) Ngcoza & Southwood (2015) Nompula (2012) Peeters & Meijer (2014) Quegley et al. (2011) Ramnarain & Hlatswayo (2018) Yoon et al.(2012) Miller (2010) Miller (2011) Barak & Dori (2009) Singh & Richards's (2006)	
• Promote learning (T1M) • Increase understanding of content(T1M) • Learners discover things on their own (T1M) • Practical activities promote learners' interest (T4F)	Unexpected answers create learning opportunities; Practical activities contribute positively in science lessons	Asheela (2017) Blanchard rt al. (2010) Da Silva et al. (2015) Easterly & Myers (2011)	Mavhunga & Rollnick (2019) Sedlacek & Sedova (2017) Vygotsky (1978)

Knowledge obtain from one practical activity can be used to in other topics (T3F)		Harlen & Qualter, (2014; 2018) Kalz & Tenier (2018) Lamm (2017) Wells (2011)	
• Improvise were opportunities arise (T1M, T2F, T3F) • Not possible to improvise for all activities (T1M) Some indigenous practices produce alcohol (fermentation) (T1M, T2F)	Teachers share how to improvise for resources to conduct practical investigations	Asheela (2017) Eun (2008) Kibirige & Tsamago (2013) Nompula (2012)	Sedlacek & Sedova (2017) Vygotsky (1978)
• Mediation for enzyme using the process of making *oshikundu* • Active participation, • Conducive learning environment • Learning of scientific process skills Use of vernacular language promote participation • Using higher order thinking skills	The science behind the practical demonstration of *oshikundu*	Adhikari & Acharya (2015) Aikenhead & Jegede, (1999) Cocks, et al. (2012) Dewar & Taylor, (2000) Harlene & Qualter (2014 ; 2018) Kuhlane (2019) Naidoo (2012)	Vygotsky, (1978)

		Nikodemus, (2017) Sedlacek & Sedova (2017)	
• Exploring the topic specific PCK components. • The concept was used to explore the components • Development of concept map lead to; • Teacher T2, T3 the opportunity to improve their PCK in enzymes T1 strengthen his PK in mediation of the concept of enzymes	Improving teachers PCK in the concept of enzyme	Mavuru & Ramnarain (2017) Nikodemus (2017) Ngoza & Southwood (2015) Yaman & Ayas (2015) Tripto et al. (2016)	Mavhunga & Rollnick (2013) Mavhunga et al. (2016) Vygotsky (1978)
• Discussions of the concept of inquiry • Designing the workshop worksheet using the PEEOE approach • Setting the bottles for the experiments • Making predictions before the observations • Making observations for set experiments	Improving teachers PCK in the concept scientific inquiry	Barak & Dori (2009) Carlson & Daehler (2019) Contant et al. (2018) Dewar & Taylor (2000) Harlen & Quarter (2014; 2018) Hodson (1990) Jacobs (2015)	Mavhunga & Rollnick (2013) Mavhunga et al. (2016)

		Kabapinar (2010) Kim & Tan (2011) Kuhlane (2019) Lamm (2017) Maselwa & NNcoza (2003) Ngcoza & Southwood (2015) NRC (1996) NRC (2000) Peeters & Meijer (2014) Quigley et al. (2011) Saad & Boujaoude (2012) Suarez et al. (2018) Yoon et al. (2012) Zohar & Dori (2003)	