Exploring how Grade 10 Biology teachers implement practical activities on food tests in Otjozondjupa Region, Namibia

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By

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Declaration of Originality

I, Julia Nelago Shoopala (17S813); hereby declare that this thesis is my own original work and has not been previously submitted in any form for assessment or for a degree in any other higher education institution. All ideas, quotations and other materials used in this study derived from the work of other people have been acknowledged using complete references according to Rhodes University Education Department Guidelines.

15 June 2022

Signature Date

Dedication

This thesis is dedicated to

My dear parents Mr and Ms Damian and Zita Shoopala.

For your love, unwavering support, generosity and encouragement that helped me to rise above the times when the tides were too strong for me alone.

Thank you for giving my academic life so much meaning.

To my children

Sasha Nghikeno, Godrick Andreas and Haven Andreas

For enduring long months of not being able to see mummy while I pursued my studies and allowing me to sacrifice the valuable time that I should have spent with you, for always believing in me and providing me with the remote motivation that kept me going.

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Dorothea Shikongo

Thank you for always being the deputy mother in my absence.

God bless you.

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Abstract

The Namibian examiners' reports have repeatedly reported that Biology is generally poorly performed in most schools and the topic on food tests has been identified as one of the problematic areas. My assumption is that this could be due in part to the lack of inadequate hands-on practical activities that are conducted in most schools in Namibia. In my view, for students to understand food tests and its associated concepts, they need to do hands-on practical activities. It is against this background that in this study I explored enablers and/or constraints when Grade 10 Biology teachers mediate learning of food tests using hands-on practical activities.

This study is underpinned by an interpretive paradigm, within which a qualitative case study approach was employed. For my baseline data, I used a questionnaire and I also interviewed two Grade 10 Biology teachers using semi-structured interviews. Afterwards, the two Grade 10 Biology teachers were observed while teaching the topic of food tests. The lessons were videotaped and thereafter I conducted a stimulated recall interview watching the videos with each of these teachers. Further, we also discussed and reflected as a group on the mediation of learning on food tests. I used Shulman's Pedagogical Content Knowledge (PCK) as my theoretical framework. Within PCK, I used the five Topic-Specific Pedagogical Knowledge (TSPCK) components by Mavhunga and Rollnick as my analytical framework. A thematic approach to data analysis was employed to come up with categories, sub-themes and themes.

The findings revealed that Biology teachers do not have a dedicated laboratory for conducting Biology practicals and would instead conduct them in a common laboratory that is employed for both Physical Science and Biology or in their classrooms. There are inadequate resources to complement hands-on activities and teachers lack the capacity, skills and necessary knowledge needed to deliver practical work. The two participants did not bother to do enough practical work and instead taught Biology as a very theoretical topic, which disadvantaged learners for Paper 3, which serves as an alternative to course work. The study also revealed that teachers failed to conduct Biology practicals. They claimed to be doing so, but there were few practicals/experiments being carried out in those schools. The participants stated that the issue of time to conduct practical experiments for food tests was not sufficient. They complained that the processes were exhausting and tiresome and left them drained as they ran around trying to implement the practical experiments. Furthermore, a large number of learners results in overcrowded Biology classes and makes it difficult for the teachers to control them, which affected the teachers' ability to perform practical experiments. The participants said that the high number of learners makes it difficult for them to accommodate all students in the laboratories, and that the laboratories themselves do not accommodate many learners.

The study, thus, recommends that there should be continuous professional development programmes in schools to assist Biology teachers who have challenges in doing hands-on practical activities. Additionally, improvisation in terms of field trips that deal with biological aspects such as food and chemical manufacturers and hospitals should be carried out to allow learners to gain appreciation of the practical aspects of Biology in education.

Keywords: Biology, Food Tests, Hands-on Practical Activities, Pedagogical Content Knowledge, Topic-Specific Pedagogical Content Knowledge, Visualisation

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List of Abbreviations and/or Acronyms

CPD	: Continuous Professional Development
DNA	: Deoxyribonucleic Acid
DNEA	: Directorates of National Examination and Assessment
MBEAC	: Ministry of Basic Education, Arts and Culture
MEAC	: Ministry of Education Arts and Culture
MEC	: Ministry of Education and Culture
MoE	: Ministry of Education
MOPSE	: Ministry of Primary and Secondary Education
NCBE	: National Curriculum for Basic Education
NIED	: National Institute of Education and Development
NSSC	: National Senior Secondary Certificate
NSSCO	: Namibian Senior Secondary Certificate Ordinary
PCK	: Pedagogical Content Knowledge
PD	: Professional development
PEEOE	: Predict-Explain-Explore-Observe-Explain
RNA	: Ribonucleic Acid
SMK	: Subject Matter Knowledge

SRI : Stimulated Recall Interview

SSI : Semi-structured Interview

STEM : Science, Technology, Engineering and Mathematics

TSPCK : Topic-Specific Pedagogical Content Knowledge

UNESCO : United Nation Educational, Scientific and Cultural Organisation

ZIMSEC : Zimbabwe, Ministry of Education Circular

ZPD : Zone of Proximal Development

CHAPTER ONE: SITUATING THE STUDY

1.1 Introduction

This study aimed at exploring how Grade 10 Biology teachers implement practical activities on food tests in their classrooms. It was triggered by the current state of teaching hands-on practical activities in Biology in Namibian secondary schools as it seemed that teachers are not effectively carrying out hands-on practical activities (Asheela et al., 2021). As a result, students perform poorly, especially in practical related questions.

In this chapter, I describe the international and national context of the study. The problem statement and the purpose and significance of this study, the research goal and the research questions. The theoretical framework underpinning the study is also highlighted. Finally, the key concepts used in the study are defined and the thesis outline is given. The chapter concludes with a summary of the chapter.

1.2 Context of the Study

Worldwide, it has been recognised that science education is indispensable and hence it is encouraged that science should be effectively taught in schools. This suggests that a successful practical lesson should be inquiry-based rather than deductive-based (Ramnarain, 2021). Consequently, Gott and Duggan (2016) stated that there is agreement among educationists universally that for students to better understand science concepts, Biology teachers should afford them opportunities to engage in hands-on practical activities (Asheela et al., 2021).

According to Ramnarain (2021), hands-on practical activities have become a well-established part of secondary school science, especially Biology. In fact, since 1988, the National Curriculum of England has emphasised hands-on practical activities and current science teaching involves students carrying out these as an entity of Biology, Chemistry and Physics lessons. Since the 19th-century, hands-on practical activities have been part of the science teaching in the United States of America and European secondary schools. This suggests that hands-on practical activities are of great significance in curricula, especially in practical subjects such as Biology (Asheela et al., 2021; Singer, 2015). Studies have revealed that in the United Kingdom, hands-on practical activities have been adopted by teachers as a coping strategy to deal with heterogeneous groups of students (Hodson, 1990). However, teachers' attitudes towards hands-on practical activities are pitiable; as a result, they seem to do them, just to fulfil the minimum requirements of the syllabus (Kibirige & Teffo, 2014).

For instance, in his study conducted in South Africa, Dekkers (2005) found that Biology teachers in Limpopo Province made little use of hands-on practical activities. Similarly, a study conducted in Kenya by Rutto and Kptingel (2014) revealed that students were less exposed to hands-on practical activities during science lessons. Likewise, in Ghana, countless Biology teachers did not use hands-on practical activities during science lessons and instead focused more on theory (Perry, 2015). Thus, the way some science teachers teach Biology lessons encourages memorisation instead of sound investigative-oriented learning (Shinana et al., 2021). Resultantly, students are deprived of opportunities to plan inquiries, perform their own experiments and manipulate materials and apparatus to enhance the construction of their own knowledge of scientific concepts (Hofstein & Mamlok-Naaman, 2017).

As an attempt to remedy this conundrum, in Zimbabwe, the Ministry of Education Circular No. 6 of 2001 stipulates that an Ordinary-Level Biology timetable should have at least two theory periods and four practical periods per week. The Science, Innovation and Technology Policy (Ministry of Education [MoE], 2012) states that conducting hands-on practical activities during science lessons encourages interest across genders and permits every student to undertake direct practical experimentations frequently. Nevertheless, most students countrywide have continued to perform poorly in Biology Paper 4 which is a practical examination paper as compared to Paper 1 and 2 which are theory examination papers (Zimbabwe School Examinations Council [ZIMSEC], 2014). In response to the problem, the Ministry of Primary and Secondary Education (MOPSE) has put in place a Science Education In-Service Teacher Training Programme for Ordinary-Level science teachers under the Better Schools Programme Zimbabwe. Additionally, annual conferences on Science and Mathematics education have been conducted to educate teachers on new methodologies of teaching science subjects (Mwenje, 2012).

Despite the measures taken by the MOPSE in Zimbabwe to improve the teaching of Biology practical lessons in secondary schools, there has been growing concern among students and parents as the ZIMSEC Report for 2016 revealed the lowest pass rate of 38.38% in Ordinary-Level Biology. That was the lowest pass rate in the past five years (Ruparanganda & Mukundu, 2017). Furthermore, the ZIMSEC Examiners' Report for 2017 raised concern about the low performance of students countrywide in Biology Paper 4 (ZIMSEC, 2018). Given the above concerns and observations, it is not clear how Biology practical lessons are taught in secondary schools. That is, although MOPSE has put in place some measures to equip teachers with knowledge and skills on how to conduct Biology practical lessons, it is not clear how teachers teach these lessons. We seem to be having a similar challenge in Namibia.

After Namibian independence in 1990, the Ministry of Education and Culture (MEC) introduced a new education system aimed at reviewing *inequality* and *inequity* within that system (MEC, 1993). The mission of the education system was to equip students with the necessary knowledge, skills and attitudes that would enable them to enter institutions of higher learning in and outside Namibia and meet the social demands without fear. In recent times, however, there have been ongoing debates concerning the teaching of hands-on practical activities by secondary school Biology teachers. According to Kapenda et al. (2001), for instance, Biology teaching in Namibia is theoretical and the teaching of hands-on practical activities seems to be neglected in most secondary schools. In other words, the teaching of hands-on practical activities involves just theory-driven instructions and is not a way for students to acquire practical skills. In most secondary schools, hands-on practical activities are not conducted because of the inadequacy of the teachers' professional teaching skills that they bring to the classrooms (Asheela et al., 2021; Kapenda et al., 2001).

Yet, in Namibia, teachers are expected to teach hands-on practical activities to provide learning opportunities that will enable students to acquire the intended learning outcomes (MoE, 2009). The assumption is that it is through hands-on practical activities that students can get involved in different activities that may enhance their abilities to handle information, solve problems, develop experimental skills and learn how to plan investigations. Consequently, Imanda (n.d.) reported that most students tend to perform poorly in Biology, and it is thought that among the reasons that have contributed to this poor performance might be the pedagogy used in the teaching of hands-on practical activities. Hence, the teaching of hands-on practical activities has been questioned, criticised and associated with the poor performances of students in Biology Paper 3 (Ministry of Education, 2009). In his study, Nakanyala (2015) observed that Biology teachers can enhance teaching by using good teaching methods, including practical work. In addition, teachers should have the ability to employ practical investigations in their classrooms to bring about good teaching. Further, he stated that students are motivated not only by teachers who know how to teach science but also by those who help them learn through practical work and make learning fun (Nakanyala, 2015).

In developing countries, it seems that hands-on practical activities are rarely conducted, and the traditional transmission method still prevails (Asheela et al., 2021; Kandjeo-Marenga, 2012; Mavuru & Dudu, 2020). Similarly, Amoonga and Kasanda (2011) found that teachers in Namibian schools prefer to use the lecture method and concentrate on teaching rules more than employing innovative teaching strategies in teaching Biology. Further, they argued that hands-on practical activities are conducted mainly in the form of demonstrations. Thus, such practices could deny students the opportunity to develop practical skills as emphasised in the Biology curriculum (Amoonga & Kasanda, 2011).

1.3 The Namibian Biology Curriculum

The general objectives of teaching hands-on practical activities in science include motivating and stimulating students' interest in science, enhancing the learning of scientific concepts and enabling students to handle and manipulate equipment (Hodson, 1990). However, in Namibia, the Senior Secondary Biology curriculum is divided into three domains, A (Knowledge with understanding), B (Handling information, application and solving problems) and C (Practical skills and abilities). The present study focused on domain C which deals with hands-on practical activities (Kandjeo-Marenga, 2011). Domain C indicates the intended learning outcomes for hands-on practical activities, for example, to enable students to develop experimental and investigative skills as stipulated in the Namibia Senior Secondary Certificate Ordinary-Level curriculum (MoE, 2009). All these learning outcomes can be achieved by the Biology teacher through giving innovative and appropriate teaching to the students. Therefore, Biology teachers are required to teach hands-on practical activities with appropriate teaching pedagogies that have the potential to develop students' abilities to acquire experimental and investigative skills.

1.4 Performance of Namibian Learners in Biology Hands-on Practical Activities

The poor performance in science subjects is reported to be worrisome worldwide (United Nations Educational, Scientific and Cultural Organization [UNSECO], 2010; Science, Technology, Engineering and Mathematics [STEM], 2016). Namibia cannot be excluded from this problem because the poor results have a negative impact on the teaching and learning of Biology. Due to poor results of science subjects generally, students opt for other subjects for example, Social Science and Commerce just to mention a few and neglect Natural Science subjects. Ajayi (2012) reported that students themselves, teachers, the government's commitment, parents' or guardians' attitudes and schools' management can in numerous ways contribute to students' poor academic performances. However, Asheela et al. (2021) indicated that carrying out hands-on practical activities, practical demonstrations and practical investigations are among the requirements of the Biology spectrum. Although the National Curriculum for Basic Education (MoE, 2016) advocates for the use of practical activities/demonstrations, it is not clear why students perform poorly in Paper 3 which tests the students' practical skills.

According to the National Institute for Educational Development (NIED) Examiner's Reports (2015–2021), it was evident that an experiment on food tests was discussed, but students lacked practical involvement in such experiments. Consequently, it was notably evident in *questions 2* and *4*, that a practical approach was unfamiliar to the learners. Similarly, the NIED Examiner's Report (2018) revealed that students did not bear in mind that the presence of reduced sugar cannot be seen if the Benedict solution was not added to the food tested. As a result, it could be argued that the students were not exposed to the reducing sugar test which is clearly seen as a practical activity or demonstration.

The poor performance in science subjects in particular Biology, especially in practical related questions, was also cited in the Examination Reports for the Namibian Senior Secondary Certificate (NSSC). The NSSC is offered on two levels (Ordinary and Higher Levels) according to the subject policy guide for Natural Science and Health Education (a subject for grades 4-7), Life Science (grades 8-9) and Biology (grades 10-12) (MoE, 2009). In Grade 10, Biology has three examination papers which are written by students at the end of the year. Paper 1 is multiple choice, Paper 2 is structured questions and Paper 3 is the alternative to practical work.

Paper 3 is an alternative to the practical paper in Biology assessments; however, students lack the techniques for answering questions and this means that they are not exposed to hands-on practical activities.

Yet, in the Biology syllabus, there are suggested practical investigations at the end of each section that need to be done by the students. Notably, however, is that most of these require laboratory preparations (MoE, 2010). However, this is not expected to be a challenging situation in the Otjozondjupa region, especially in the Okahandja Circuit since most of the schools have well-equipped laboratories. Furthermore, the topic of food tests is one of the topics identified as challenging in terms of understanding and applying it to different life contexts, due to the lack of exposure to practical lessons (NIED Examiner's Reports, 2016, 2017, 2018 & 2019). It is against this background, therefore, that the current study explored how Grade 10 Biology teachers implement practical activities on food tests in their classrooms.

1.5 My Personal Experience

I was born in the northern regions of Namibia in Onkatambilili village; growing up in a house full of boys, I did everything that the boys did. When my elder sister was not around, I helped the boys to cook since I was still young. During holidays I visited my grandmother and there I learnt a lot of indigenous skills for example, cooking, pounding Mahangu and making *oshikundu* just to mention a few. When I did not do those chores properly, she would say "Anoo to ningi omweethi nani" this translates to "So you are becoming untidy now"? My grandmother always used to say that one day I will become a teacher just like my uncle and not like my mother or sister that were nurses.

I started my primary education at our village school, until after independence were one of my uncles decided to take me to a town school in Oshakati. There I completed my primary school in 1999. In 2000, I started my secondary education at a boarding school near Windhoek. Here I was introduced to Physical Science and Life Science as some of my subjects. I grew to love Life Science more because there we did hands-on practicals such as maintaining gardens and that was a lot of fun. As for all the other subjects, nothing was interesting at all as there were no practicals or no projects.

After high school, I enrolled at a teacher's college where I did Integrated Natural Science 8-10 as my major and Mathematics 5-7 as my minor. During my years at the college, we did a few practical activities in the chemistry laboratory and that was it. Although most lecturers taught about learner-centred education or hands-on practicals, they did not really practice it. Very little was interesting. In 2017 I enrolled at Rhodes University, where my teaching career took a drastic turn as I was properly introduced to hands-on practical activities. There was one session when Professor Ngcoza brought one of his former scholars to the NIED hall. Here I was introduced to Asheela's 2017 study on the use of easily accessible resources to conduct hands-on practical activities. She demonstrated how to prepare *oshikundu*. This reminded me of how a former colleague came from a workshop at NIED and then asked me to prepare *oshikundu* so that he could conduct a practical with his learners. In 2019 at Rhodes University in South Africa, I met Mama Nolingo a community expert. Mama was preparing *Umqombothi* and some of the methods used were the same used to prepare *oshikundu* in Namibia, Malawi and other African countries. Despite Africa's immensity and diversity, which include about 1 000 indigenous languages, African indigenes show distinct, consistent and enduring commonalities transcending geographic boundaries and ethnicity. Hence, in the African context, we can talk about unity in diversity (Goduka, 1999). In both processes, science concepts emerged, and this meant that both processes could be used as vehicles to mediate the learning of those concepts.

From my personal experience as a teacher, the topic of food tests is difficult to comprehend from the learners' perspective. Without the guidance of a teacher's knowledge, the learners themselves are lost on the best possible way to incorporate scientific inquiry into learning. Learners themselves are required to take a leading role in the hands-on approach to learning science, particularly food tests, to be exposed to the actual practice of learning. Although questions are meant to test learners' knowledge on whether they have managed to comprehend and understand what they are studying, in many instances they are a drawback to learners' participation in the actual learning since they often withdraw from participating or taking part in learning if the questions are difficult to answer. There is a need for teachers to answer clear cut questions in a sequence that will help learners better understand the chronological flow of knowledge during learning.

On another note, teachers' education does not necessarily cover all aspects in such a manner that even if learners ask a question related to the subject topic but outside the scope of the syllabus, the teacher might not be in a position to respond to such a question. Such cases often affect teacher confidence and self-efficacy when teaching. That might send a negative message to learners if a teacher cannot confidently respond to a question. Hence, teachers often fear that a hands-on approach to learning in food science might result in a situation where they can lose control of the learning process itself.

Teachers' Pedagogical Content Knowledge (PCK) remains critical in guiding a hands-on approach to learning. Gray and Fernandez (2020) claimed that hands-on approaches have the potential for learner interaction in the creation process, which will provide impetus to a synthesis of knowledge from many sources. Learners themselves are not empty vessels without knowledge but their understanding of the knowledge they have needs to be reinforced from an expert point of view. Professional development is the only mechanism to assist educators to gain more PCK in their areas of focus. However, due to the limited time spent on workshops and other training organised for educators, particularly during the holiday period, knowledge acquired is limited. It, therefore, compromises continuous learning or developments in the scientific area of education.

> The idea that professional development (PD) can foster improvements in teaching is widely accepted. PD is required by virtually every teaching contract in the country, and teachers participate in PD every year. (Kennedy, 2021)

In conclusion, I can now strongly say that all teachers need to be part of courses of this nature because it could help teachers make links between theory and practice. In support of meeting Namibia's strategic plan, Vision 2030, to establish the country's road map towards achieving higher levels of industrialisation and development, a programme called Continuing Professional Development (CPD) was put in place by the University of Namibia – this falls under the Education and Training Sector Improvement Program and the National Professional Standards for Teachers.

1.6 Problem Statement

The current state of teaching hands-on practical activities in Biology in Namibia seems to be a problem and this is worrisome. Research suggests that poor teaching, among other factors, limits the learning of scientific skills in schools (Nakanyala, 2015). According to the MoE (2017; 2018), the examiners' reports on Biology Paper 3 (Applied Practical Skills) show that students in the Otjozondjupa region performed poorly in hands-on practical activities when compared to Paper 1 (Multiple choice) and Paper 2 (Structured questions). The examiners' reports further indicated that it is clear from students' answers that only a few senior secondary schools seem to do hands-on practical activities in Biology.

In light of this, Nghipandulwa (2011) noted that science hands-on practical activities, in most Namibian schools, are a dream as few science teachers seem capable of doing them. Moreover, assessment of hands-on practical activities has been criticised as inadequate as it fails to assess students' practical skills. In consequence, students fail to relate their practical experiences to aspects tested in the final examination. Therefore, it became expedient to explore how Grade 10 Biology teachers implement practical activities on food tests in particular.

1.7 Purpose and Significance of the Study

The purpose of the study was to explore how Grade 10 Biology teachers implement practical activities on food tests in Otjozondjupa Region. It was hoped that the study would help Biology teachers to determine whether the hands-on practical activities they use in their classrooms follow and achieve the learning objectives of practical work outlined in the subject's syllabus and help students develop practical skills.

The results of this study might also help me and other Biology teachers to change our attitudes towards doing hands-on practical activities in the teaching and learning of Biology. The findings of this study might also contribute to new knowledge that might help Biology teachers find solutions to the problems of students who are not performing well in the practical examination paper (Paper 3) in Biology. In addition, Biology teachers might also benefit from this study by finding out whether the hands-on practical activities that they do at their schools are adequate to make their students ready for the Biology final examination.

1.8 Research Goal and Research Questions

In the next section, I discuss the research goal and research questions. I begin with the research goal.

1.8.1 Research goal

The main goal of this study was to explore how Grade 10 Biology teachers implement practical activities on food tests in their classrooms.

To achieve this goal, the study was guided by the following research questions:

1.8.2 Research questions

1. What are Grade 10 Biology teachers' perspectives and pedagogical insights on the use of hands-on practical activities when mediating learning of food tests?

2. How do Grade 10 Biology teachers mediate learning of food tests using hands-on practical activities?

3. How do discussions and reflections enable and/or constrain Grade 10 Biology teachers' understanding of carrying out hands-on practical activities to mediate learning of food tests?

1.9 Theoretical and Analytical Framework

The study was guided by Shulman's (1986) PCK theory. Shulman (1986) introduced the concept of PCK as a distinctive body of knowledge for teaching. Shulman (1986) posited that the development of PCK involves a dramatic shift in teachers' understanding. In this regard, Shulman averred that "From being able to comprehend subject matter for themselves, to becoming able to elucidate subject matter in new ways, reorganise and partition it, clothe it in activities and emotions, in metaphors and exercises, and examples and demonstrations, so that it can be grasped by students" (p. 13). Essentially, Shulman (1986) was interested in how teachers cross-transfer the Subject Matter Knowledge (SMK) they gain to students in the classroom setting.

Within PCK, I used the Topic-Specific Pedagogical Content Knowledge (TSPCK) as the analytical framework (Mavhunga & Rollnick, 2013) and the specific topic was food tests in the context of my study. Within this theory, I focused on the following concepts: learners' prior concepts, subject matter representations, instructional strategies, curriculum materials and curricular saliency.

1.10 Data Gathering Techniques

The following were the data gathering techniques used in this study: questionnaires; semi-structured interviews (SSIs); observation; stimulated recall interviews (SRIs); and discussions and group reflections.

1.11 Definitions of Key Concepts

The cognitive domain: This is defined as the concept that involves knowledge and the development of intellectual skills. This includes the recall or recognition of specific facts, procedural patterns and concepts that serve in the development of intellectual abilities and skills (Nakanyala, 2015).

Hands-on practical activities: Any teaching and learning activity which involves students observing or manipulating real objects and materials, extracting information from complex systems, testing hypotheses, analysing and evaluating variable data, demonstrations, discussions, simulations and exercises (Asheela et al., 2021; Millar & Miller, 2014).

Pedagogical Content Knowledge (PCK): This is a theory that states the type of knowledge that is unique to teachers and is based on how teachers relate their pedagogical knowledge (what they know about teaching) to their SMK (what they know about what they teach). It is the integration or the synthesis of teachers' pedagogical knowledge and their SMK that comprises PCK (Shulman, 1986).

Poor Performance: This refers to the lack of accomplishment of practical skills measured against the assessment objectives and the achievement of below 40% in practical works (Lunetta et al., 2007).

Practical skills: An individual's competency and process skills that are acquired while performing a scientific activity (Bennet & Kennedy, 2001).

Teachers' perceptions of practical work: These are defined as how teachers see and understand hands-on practical activities in the context of teaching Biology (Hornby, 2015).

1.12 Thesis Outline

This thesis consists of six chapters.

Chapter One: Situating the Study

In this chapter, I described the international and national context of the study. The general objectives of teaching hands-on practical activities in science were discussed as outlined in the Namibian Biology curriculum. Further, the performance of Namibian students in Biology hands-on practical activities was stated. The chapter also provided the statement of the problem, the purpose and significance of this study, the research goal and research questions. The theoretical framework and data gathering techniques of the study were highlighted. Finally, the key concepts used in the study were defined, and the thesis outline was given.

Chapter Two: Literature Review and Theoretical Framework

This chapter contains a comprehensive review of the relevant literature and sources that were consulted. The review was drawn from several concepts and constructs from previous researchers mainly related to the enablers and/or constraints when Biology teachers carry out hands-on practical activities to mediate the learning of food tests. It also presents the theoretical framework of the study.

Chapter Three: Research Design and Methodology

This chapter presents the research methodology. I first present the research paradigm followed by the research design. Within the research design, I present a qualitative case study – the research goal and questions, research site, sample and sampling techniques. It also describes the data gathering methods, validity and reliability of the instruments and data analysis techniques. Further, it also contains ethical considerations.

Chapter Four: Data Presentation: Questionnaires and Semi-structured Interviews

This chapter focuses on data presentation and analysis on the subject topic that explored how Grade 10 Biology teachers implement practical activities on food tests.

Chapter Five: Data Presentation: Stimulated Recall Interviews, Group Discussion and Reflections

This chapter provides a discussion on the subject topic from the findings in line with the literature review.

Chapter Six: Summary of Findings, Recommendations and Conclusions

This chapter provides a summary of the whole research study through a discussion of the findings. Also presented in this chapter are the recommendations from the study and areas for further research. This chapter ends with some conclusions.

1.13 Chapter Summary

This chapter outlined the context of the study. The statement of the problem and the purpose and significance of this study, the research goal, research questions and theoretical framework of the study were highlighted. Finally, the key concepts used in the study were defined and the thesis outline was given. The next chapter contains a comprehensive review of the relevant literature and sources consulted. The theoretical and analytical frameworks underpinning this study are also discussed.

CHAPTER TWO: LITERATURE REVIEW AND THEORETICAL FRAMEWORK

2.1 Introduction

The importance of the literature review in any research study cannot be over-emphasised. According to Creswell (2014), a literature review provides a background of what has been researched previously in that line of study with emphasis on revealing past findings on the subject topic. Put differently, it provides some insights on key issues in relation to the subject area. On the other hand, a theoretical framework guides the theme of the study and the theory underlying the study.

In this chapter, I thus discuss relevant literature that informed this study. Firstly, I discuss the Namibian Biology curriculum where the goal of Biology is to provide students with scientific skills and knowledge through hands-on practical activities. I also explore literature around hands-on practical activities and visualisation. This is followed by the discussion of the aims and objectives of doing hands-on practical activities, types of hands-on practical activities and teachers' views and benefits of hands-on practical activities. Thereafter, I also discuss the constraints regarding hands-on practical activities and the potential of hands-on practical activities. The chapter ends with the discussion of Shulman's (1986) PCK which is the theoretical framework that underpinned this study.

2.2 The Namibian Biology Curriculum

Even though the concept of curriculum was highlighted earlier in the previous chapter on the phenomenological basis for hands-on practicals elaborated in curriculum documents, the Namibian Biology curriculum concept will be further considered in detail in this chapter. The chapter will begin by deliberating on what the term 'curriculum' necessitates. The concepts of curriculum as planned, and curriculum as subsisted experience is also discussed. According to Connelly and Lantz (1991) and Egan (2003), one of the biggest experiments in curriculum studies is how to define the concept of 'curriculum'. According to Egan (2003), the derivation of the word curriculum can be drawn from its Latin origin. The dictionary describes the curriculum as "a course; a regular course of study or training, as at a school or university", or as "a course, especially, a specific fixed course of study, as in a school or college, as one leading to a degree (Hornby, 2015, p. 359).

Hickman et al. (2021) maintain that the curriculum is not the final version, as it is nothing more than a notion and idyllic in the process of a recommendation that it represents some sensible plan for bringing us out of illiteracy and resulting in future advancement through education. It refers to the means and materials with which teachers interact to achieve identified educational outcomes (Carl, 2012). To Carl, a curriculum comprises all the prearranged and unforeseen experiences that the school gives away as part of its educational responsibility. Moreover, it is the way the content is planned and derived. This comprises the structure, organisation, balance and presentation of the content in the class.

On the other hand, the curriculum is considered by Ezeanya-Esiobu (2019) as the cumulative effect of how a teacher is directed in accomplishing the intelligence and moral chastisement necessary for the responsibilities of an intelligent citizen in a free society. It is not just a course of study or a checklist of goals or objectives – it encompasses all of the learning experiences that learners face when under the supervision of the teacher (Ezeanya-Esiobu, 2019). Chen et al. (2020) on the other hand, declare that there is a need for a definition that embraces at least four major dimensions of educational development and administration, which explains the planners' objectives, the procedures used to carry out those proposals and the actual experiences of the learners as a result of teachers' direct attempts to carry out the planners' intentions and also the "hidden" learning that occurs as a result of the curriculum's and indeed the school's structuring. Bharvad (2010) differentiates between two concepts: planned curriculum and curriculum as lived experience. As a result, the researcher will describe the discrepancy between the curriculum as developed and the curriculum as lived experience in the next section.

The goals of Biology are to produce students who can understand the use of their natural environment to satisfy human needs, and how environments change in ecologically sustainable ways (Ministry of Basic Education, Art and Culture [MBEAC], 2018). Furthermore, Biology uses a systematic way of acquiring and producing knowledge to equip students with the necessary knowledge, skills, attitudes and values that will help them to be scientifically equipped to face challenges in the world markets (MoE, 2018). In light of this, it is clearly stated in the NSSC Syllabus of 2018 that one of the goals of Biology is to provide students with scientific skills and knowledge through hands-on practical activities (Asheela, 2017; Asheela et al., 2021; Ndevahoma, 2019).

Shinana (2019) and Asheela et al. (2021) indicate that hands-on practical activities capture students' interest, stimulate questioning and thinking and enhance active participation (Sedlacek & Sedova, 2017). Hodson's (1990) critique, however, is that hands-on practical activities can be misunderstood and confuse students and do not produce the desired outcomes in students. He argues that this is compounded in part by the fact that most schools' hands-on practical activities seem to follow a recipe approach with little focus on meaningful learning. His findings resonate with King et al.'s (2001) who indicate that hands-on practical activities that they observed were done as fun activities, in which the students worked on the activities without engaging their minds and skills.

In this regard, Nhase (2019) cautions that hands-on practical activities should not be conducted just for fun whereby students only use their hands to manipulate the materials. Instead, they also need to use their minds and words to write down their explanations. Essentially, the hands-on practical activities should enable learners to gain scientific and experimental skills that they can then apply in real-life situations (Gwekwerere, 2016) after they completed their studies, or if they wish to pursue a career in the science field. It is for these reasons that Asheela et al. (2021) advocate that the predict-explain-explore-observe-explain (PEEOE) approach be employed to promote learning of content knowledge during hands-on practical activities as well as inquiry skills (Nhase, 2019; Shinana et al., 2021).

Asheela et al. (2021) further specify that hands-on practical activities are powerful in promoting conceptual development and understanding of science through experiences. This suggests that hands-on practical activities allow students to observe or manipulate objects and materials they are studying (Shinana et al., 2021). Furtak and Penuel (2019) describe hands-on practical activities as activities that enable students to be actively involved or participate in the learning process (Sedlacek & Sedova, 2017). That is, hands-on practical activities allow students to comprehend the significance of experiencing reality in science. Notwithstanding these ideals, it seems the current situation in Namibia is that even teachers with fully equipped laboratories are failing to properly implement hands-on practical activities as reflected in several examiners' reports (NIED, 2015–2021). Therefore, training workshops conducted by the Directorate of Education would be appropriate to equip teachers on how to conduct hands-on practical activities in Biology.

It is against this caveat that Asheela (2017) avers that there is a need for training workshops for teachers to equip them with the knowledge and know-how of conducting hands-on practical activities in Biology. Consequently, Millar (2004) asserts that well-planned and effectively implemented science practical activities stimulate and engage students at varying levels of inquiry. On the other hand, the Biosciences Federation (2005) reports that poor teaching of practical work may cause an impediment to students' attitudes towards science. Assessment objective C of the Biology syllabus (MEAC, 2015) requires science teachers to assess practical work which is aimed at developing students who can: (i) use and organise techniques, apparatus and materials (ii) observe measure and record and (iii) handle, process and evaluate experimental tasks. Considering these learning outcomes given above, the syllabus clearly calls for the use of an inquiry approach in Biology classrooms.

Moreover, the MBEAC (2018) states that assessment objectives in line with the subject syllabus articulate the following specific objectives that require students to do hands-on practical activities in Biology.

- Plan an experiment or investigation, including making reasoned predictions of expected results and suggesting suitable apparatus and techniques;
- Name appropriate apparatus for the measurement of time, temperature, mass and volume, including burettes, pipettes and measuring cylinders;
- Recall familiar techniques to record observations and make deductions from them;
- Describe or comment on experimental arrangements and techniques;
- Recall of simple chemical tests, e.g., for food substances and the use of hydrogen carbonate indicator, litmus and Universal Indicator paper;
- Draw an appropriate conclusion, and justify it in line with the data using an appropriate explanation;

- Recognise, observe, record and measure images of familiar, and unfamiliar, biological specimens;
- Make a clear line drawing from an image of a specimen, calculating the magnification and adding labels as required;
- Record readings from diagrams of apparatus, including reading a scale with accuracy and precision and taking repeated measurements, where appropriate, to obtain an average value; and
- Describe, explain or comment on experimental arrangements and techniques (MBEAC, 2018, p. 8).

Regarding the above objectives, it seems that some constraints limit the teachers and students to explicitly carry out the expected hands-on practical activities. For instance, some of the identified constraints are lack of training and support, poor assessment policy guidelines, language policy, workload and frequent curriculum changes that are challenges teachers seem to be experiencing in the implementation of the NSSC Biology curriculum. Moreover, the non-existence of textbooks and laboratory facilities particularly in rural and township Namibian schools hinders the usage of hands-on practical activities and the successful implementation of the NSSC Biology curriculum (Aloovi, 2016). In addition to these challenges, teachers' conceptions, beliefs and attitudes are considered elements that similarly influence their activities (Shinana, 2019). As a result, in most secondary schools, hands-on practical activities are not constantly conducted because of the inadequacy of the teachers' professional teaching skills and lack of resources and exposure (Choudhary, 2016).

Nonetheless, alternatives such as easily accessible resources are plenty, for example, in relation to food tests in the context of my study. The testing of food particularly in Biology should not be equated to a lack of resources since food is readily available at all times. That suggests that learners' exposure to doing hands-on practical activities cannot be an excuse. Food is any substance consumed to provide nutritional support for the body and an organism ingests the substance. It is then assimilated by the organism's cells to provide energy, maintain life and stimulate growth (Biosciences Federation, 2005). Food is made from a variety of proteins, fats and carbohydrates in different proportions with small amounts of vitamins, minerals (ions) and water. Carbohydrates, fats and proteins are often larger molecules that can be broken down into smaller molecules.

Food tests are designed to detect specific organic molecules in some common foods (Choudhary, 2016). The organic molecules that are supposed to be tested are proteins, carbohydrates and lipids. Food tests provide a great opportunity to introduce students to some qualitative chemical tests. All these chemical tests can be learnt, but it is even better if the chemistry behind them is understood (Choudhary, 2016).

During food tests, therefore, the nutrient content of unidentified food samples is determined using chemical reagents to test the unknown for specific nutrients. Hence, students are required to carry out food tests on a variety of food substances (MoE, 2018). In addition to the hands-on practical activities, learners should describe these tests: The Benedict's test for reducing sugars (qualitative only), the Iodine test for starch, the Biuret test for proteins, the ethanol test for fats as well as the dichlorophenol indophenol test for ascorbic acid (vitamin C) and also be able to evaluate the results (MoE, 2018). This suggests that visualisation plays an important role during hands-on practical activities.

2.3 Hands-on Practical Activities and Visualisation

Hands-on practical activities can provide additional experience by deepening the understanding of practical skills in science classrooms. According to Namibia (MoE, 2018), there are benefits associated with hands-on practical activities such as increased awareness of moving away from inductive reasoning to hypothetical-deductive reasoning in order to distinctively distinguish between data that will be collected and the explanations that students will derive. Henceforth, it will help students to differentiate between a theory and practice using an empirical view of learning by discovering new skills as they practice (Millar, 2010). That is, students use their senses while doing observation. As students are busy doing observations, they will then learn how to hypothesise to derive questions that will improve their generalisations as well as their approach to explanations.

Furthermore, Millar (2010) argues that when observation and measurement are complemented with hands-on practical activities it creates information on real-world experiences among students. The real world provides further interpretation, which in most cases students cannot bring forth if they have not followed the correct steps. In this regard, Millar (2010) explains that hands-on practical activities give a real worldview so that students can predict and compare information collected and sometimes through prediction, disagreements and agreements may arise. Moreover, if there are agreements, that means there is increased confidence between match explanations and the real world; however, if disagreements occur, it means one may start to question the explanations given (Millar, 2010). This suggests that the information that is collected requires precise explanations, hence the use of scientific hands-on practical experiences in Biology is useful when applying prediction. The following illustration provides a detailed route on the approach.

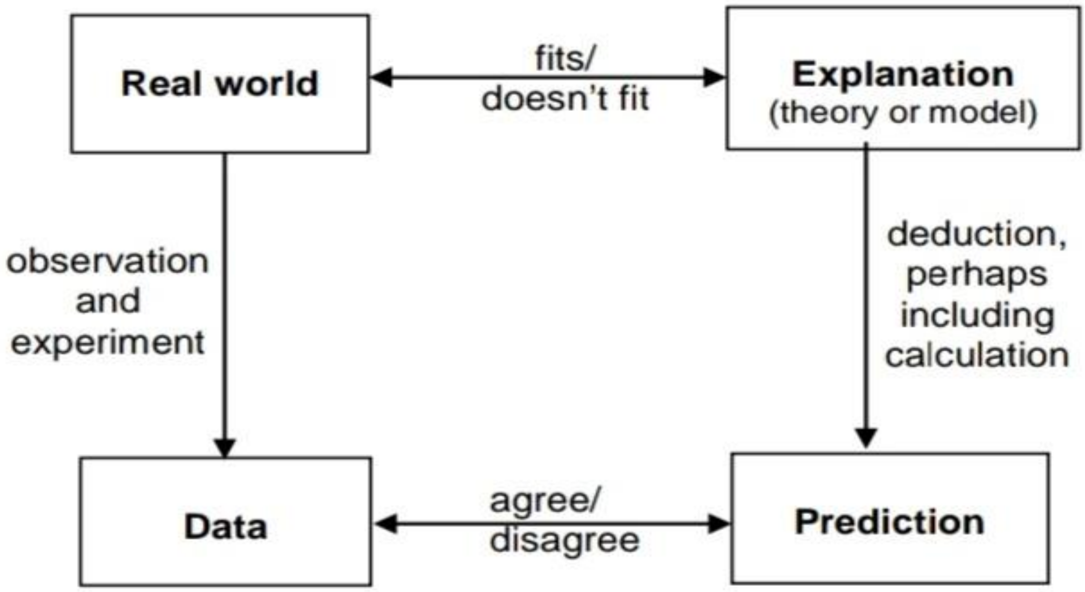

Figure 2.1: A model of scientific reasoning (adapted from Giere, 1991, p. 21)

Apart from the model of scientific reasoning and the explanations given above, another approach given is the inquiry-based method, using specifically the PEEOE approach (Asheela et al., 2021). This approach entails students making predictions and providing explanations for their predictions before doing the hands-on practical activities and observations. They then have to write down the explanations for their observations.

Essentially, the PEEOE approach is an inquiry-based teaching approach which is compatible with mediating scientific inquiry involving the stages of predict, explain, explore, observe and explain. During the prediction stage, students 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 students' prior knowledge (Kibirige & Osodo, 2014; Mavhunga

& Rollnick, 2013). In the explanation stage, the students provide explanations for their predictions. The students then explore by conducting hands-on tasks, investigating and collecting data and evidence. During the observation stage, the students observe the outcome of the experiment and write explanations thereof. They then discuss their observations, while concurrently they check their predictions against their observations. The students then have to provide explanations for their observations. In doing this, the students might make sense of their observations, which might help them visualise and understand the phenomena being investigated.

Louis (2017) enumerates that most students, approximately 65% of the student population in schools are visual students. She further states that visual students are those that need to see images to internalise what is taught. Therefore, it is important to use visuals in science teaching because it boosts the learning of a large group of students in the class. Images are effective ways to make sure that the information gets stored in long-term memory (Louis, 2017). This suggests that visualisation plays an important role in how students make sense of science concepts.

It is worrisome to note that most schools in Namibia have no functional laboratories where hands-on practical activities could take place and this limits teachers' innovative thinking and reasoning skills which affects their PCK. Additionally, it limits opportunities for students to do something with their hands and explore.

Practical work in any science teaching and learning is an action which learners do independently or in groups and hold or perceive the object they are studying (Millar, 2010). In light of this, in Namibia, the Biology curriculum applauds hands-on practical activities in each topic whereby learners can witness and advance their scientific skills (Nhase, 2019; Ramnarain, 2021). Millar (2010) has stated that witnessing practicals is important for encouraging student understanding. Asheela et al. (2021) also reverberated the same idea that hands-on practical activities benefit learners' understanding of science ideas as they are reinvigorated to forecast, elucidate, discover, detect and describe when carrying out practical activities. Such contentions are supported by Woodley (2009) and Asheela et al. (2021) who hypothesised that quality hands-on practical activities support learners' advancement in their attention to scientific concepts and making sense of them. This is in line with Martiningsih et al. (2019) who proclaimed that practical activities encourage learners' inquisitiveness to learn Biology.

Although one can embrace much material through hands-on practical activities, some researchers doubt their utility in the science classroom and learning. Graham et al. (2018), for example, believe that practical work is misinterpreted, disordered and does not yield anticipated outcomes in learners. Responding to this, Asheela et al. (2021) reminds us that hands-on practical activities should not only be about learners manipulating objects with their hands, but also about them recording scientific concepts that they may use to progress, such as mind maps and other concept maps.

To Asheela (2017), a lack of resources and laboratory apparatus may explain the underuse of hands-on practical activities. According to Asheela et al. (2021), teachers should use easily accessible materials when conducting hands-on practical activities. These scholars believe that easily accessible materials may stimulate social interactions among students (Sedlacek & Sedova, 2017; Vygotsky, 1978). A study in Namibia done by Nikodemus (2017) states that hands-on practice and enrichment assist young people to understand science topics. Indigenous knowledge and practices should indeed be incorporated into hands-on activities, as suggested by Nikodemus (2017), to allow students to effortlessly transition between cultural science and school science (Aikenhead & Jegede, 1999).

Shinana's (2019) study also found that hands-on practical activities are advantageous in the teaching of science, and she advocated those teachers should be involved in genuine practical investigations by employing local and low-cost resources such as [1]*oshikundu* to mediate learning. Hands-on practical activities should also be regarded as a type of visual representation (Mavhunga & Rollnick, 2013).

Visual representations, as per Lioyd (2015), are essential communication abilities for our biological and socio-cultural survival. According to Lioyd (2015), visualisation is a language of imagery which include shapes, colours, patterns, arcs, rhythms, animals, individuals and

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[1]*oshikundu* is. Oshikundu is non-alcoholic traditional beverage which is made from fermenting three flours (namely ongudo, uushutu and mahangu). It is a stable drink for Namibian tribes mostly the Aawambo people and is rich in carbohydrates, proteins, vitamins as well as minerals (Shinana, 2019).

numbers are some of the representations. Visualisation in science education, according to Rundgren and Yao (2014), is a cognitive domain which has the role of making invisible ideas visible and, more importantly, exhibiting and making explicit abstract concepts. Eilks et al. (2012), for example, investigated the role of imagery in chemistry education when learning about sub-microscopic explanations. To these scholars, visual representations help students understand and enhance learning by generating effective reactions, according to the study.

In Nyamakuti's (2021) study, for instance, as is the context of this study, community members' practical presentations are considered as pictorial imagery that could mediate learning of the idea of enzymes in Grade 10 Biology classrooms. This is coherent with Mavhunga and Rollnick (2013), who state that representations play a significant role as teaching aids that can help the learner make sense of what is being taught. This suggests that visual representations are important in how learners know science concepts.

2.3.1 The role of hands-on practical activities in Biology

The Namibian Senior Secondary Certificate Ordinary (NSSCO) level syllabus is a "two-year course leading to examination after completion of the Junior Secondary phase" (MEAC, 2018, p. 1). The syllabus was specifically framed to fulfil the objectives of the curriculum. One of the curriculum approaches is to provide intuition and understanding of global issues, dissemination of prosperity, intensifying and resolving increasing conflicts, the industrial explosion as well as increased connectivity (MEAC, 2018). The aims and objectives of conducting hands-on practical activities are to explore teachers' abilities to apply Pedagogical Content Knowledge to be able to give students a practical approach to carrying on activities. In light of that, in the Biology curriculum, the hands-on practical approach prepares students to learn with understanding rather than memorisation.

In addition to the above narration, the syllabus for Biology Grade 10 seeks to achieve the following aims:

1. Provide, through well-designed studies of experimental and practical science, a worthwhile educational experience for all students, whether they go to study science beyond this level and, in particular, to enable them to acquire sufficient understanding and knowledge to:

- Become confident citizens in a technological world, to take or develop an informed interest in matters of scientific importance.
- Recognise the usefulness, and limitations, of the scientific method and appreciate its applicability in other disciplines and everyday life;
- Be suitably prepared for studies beyond the NSSCO level in pure sciences, applied sciences or science-dependent vocational courses.

2. Develop abilities and skills that:
    - Are relevant to the study and practice of Biology;
    - Are useful in everyday life;
    - Encourage efficient and safe practice;
    - Encourage effective communication.
3. Develop attitudes relevant to Biology such as:
    - Concern for accuracy and precision;
    - Inquiry;
    - Initiative;
    - Integrity;
    - Inventiveness;
    - Objectivity.
4. Stimulate interest in, and care for, the environment.
5. To promote awareness that:
    - Scientific theories and methods have developed, and continue to do so, as a result of the cooperative activities of groups and individuals.
    - The study and practice of science are subject to social, economic, technological, ethical and cultural influences and limitations;
    - The applications of science may be both beneficial and detrimental to the individual, the community and the environment;
    - Science transcends national boundaries and the language of science, correctly and rigorously applied, is universal (MEAC, 2018, pp. 2-3).

In light of the above aims, it is befitting to say that hands-on practical activities should be prioritised to engage students not only for theoretical purposes but to allow them to develop critical thinking skills which are needed in problem-solving and finding practical solutions

(Asheela et al., 2021). Despite challenges experienced so far, which include a lack of teaching aids and laboratory facilities, at least teachers could improvise where it necessary to reach the aims of hands-on practical activities.

In doing so, teachers should be able to incorporate the following:

- describing the term practical activities;
- describing the purpose of practical activities in Biology;
- describing a broader understanding of food tests;
- describing what is required to teach food tests;
- describing the use of easily accessible resources when mediating learning of food tests; and
- describing what in-class activities help one to teach food tests.

In order to achieve the aims and objectives of doing the hands-on practical activities, as alluded to earlier, a teacher's approach should take into consideration the PEEOE approach as one of the strategies in getting students to explore scientific inquiries (Asheela et al., 2021). Students' focus and attention should get them to critically think about how to predict, explain, explore, observe and explain in that order. In the context of my study, given the nature of practical activities in food tests, the right procedures must be followed to reach the aims and objectives of hands-on practical activities. In other words, the aims and objectives of the hands-on practical activities are to try by all means to use easily available resources and cost-effective strategies to enable as well as minimise the constraints.

2.3.2 Types of hands-on practical activities

Hands-on practical activities are aplenty in Biology hence, teachers should consider which type might be appropriate to the context of their schools in terms of the resources available. With reference to the study conducted in Namibia, there are two types of hands-on practical activities – "group experiments and teacher demonstrations intermingled with lectures" (Kandjeo-Marenga, 2008, p. iii). In an attempt to face and apply scientific intellectual thoughts and abilities as requirements in the natural sciences, the National Curriculum for Basic Education also requires that scientific procedures be examined to reduce deficits in experiments for scientific inquiries (MoE, 2010).

Hands-on experiences seem to be the practical approach that ensures that teachers use available resources in their locality. In contrast, the challenges are that teachers seem to concentrate mostly on "observations, recording observational results and writing conclusions" (Kandjeo-Marenga, 2008, p. iii). That seems to narrow the options that teachers give students to work independently and make conclusions based on their practical involvement. In addition, Kandjeo-Marenga (2008) remarks that group experiments give learners the benefit of the doubt when it comes to acquiring skills articulated in the new Namibian Biology curriculum.

2.3.3 Teachers' views and beliefs on the use of hands-on practical activities

Teachers' PCK remains one of the components essential in applying hands-on practical activities. Two of the approaches discussed in-depth above are the interactive teacher interventional strategies and the authoritative interventional strategies (Kandjeo-Marenga, 2008). These two strategies are believed to have different approaches when it comes to the handling of hands-on practical activities. On one hand, the interactive teacher interventional strategies give students unlimited opportunities for students to discuss, deliberate, demonstrate, observe, interact and conclude for the betterment of the content knowledge of the subject as well as enhance their mental cognitive skills (Kandjeo-Marenga, 2008). On the other hand, authoritative interventional strategies are quite rigid with limited questions of close-ended types (Kandjeo-Marenga, 2008). Most teachers prefer interactive teacher interventional strategies because they enable students to ask "open-ended questions, share, shape, select, check and make key scientific ideas" (Kandjeo-Marenga, 2008, p. iii).

According to Hodson (1990, p. 34), some of the reasons that teachers should indulge their students fully in practical activities are:

- to motivate, stimulating interest and enjoyment;
- to teach laboratory skills;
- to enhance the learning of scientific knowledge;
- to give insight into the scientific method, and develop expertise in using it; and
- to develop certain 'scientific attitudes', such as open-mindedness, objectivity and willingness to suspend judgment.

It is, therefore, the duty of every teacher to make learning worthwhile. The objectives of such hands-on practical experiences might not be achieved if teachers do not take into consideration the kinds of scientific knowledge the learners will acquire through conceptions. Teachers in particular in society are viewed as transmitters and change agents who bring the necessary learning tools and implementation of hands-on practical roles. One of the most important goals of hands-on- experiences is to achieve pedagogical transformation of subject matter, learners and academic purposes into engagements that would eventually lead to teachers meeting PCK targets (Geddis & Wood, 1997). Notwithstanding the targets needed to reach the desired transformational pedagogical matters, some teachers express certain difficulties in creating an enabling environment for hands-on practical activities for learners (Asheela, 2017; Ndevahoma, 2019; Shinana, 2019). These scholars reiterate that despite difficulties and challenges experienced by teachers there is room for improvement if necessary, enabling conditions are in place.

For instance, one of the recommended approaches that would bring much-needed improvement is the use of easily accessible resources considering the cost-effective measures that the teachers have to take into consideration (Ndevahoma, 2019). On the other hand, it has been reported that some schools lack some essential resources that are in line with modern Biology education (Mukagihana et al., 2020). This would include, among other things, an electrophoresis unit, a polymerase chain reaction instrument, a spectrophotometer, a voltmeter and gram-stain reagents (Mukagihana et al., 2020). Most importantly, some laboratory equipment, such as electrophoresis and polymerase chain reaction, are more important in molecular Biology that is now part of the secondary school Biology curriculum to analyse biological macromolecules such as DNA, RNA and proteins (Mukagihana et al., 2020).

However, Asheela (2017) argues that previous knowledge, native knowledge and practical work are the keys to hands-on practical activities. Therefore, Biology teachers ought to be encouraged to increase students' prior knowledge and strategies on the alternatives for practical activities that will increase conceptions options (Kandjeo-Marenga, 2008). What could be expressed as a gap in knowledge is that food has not been taken seriously in the Biology curriculum, and as a result, the students need to do hands-on practical activities. It is also regrettable, to say the least, that there are schools that are inadequately funded or are less equipped to conduct food tests. These challenges culminate in teachers teaching topics on food tests by theory only. Nonetheless, the significance of food test implementation in the Namibian curriculum is something that is undersupplied in most Namibian schools. It is against this background that this study sought to explore how Grade 10 Biology teachers implement practical activities on food tests using hands-on practical activities.

2.3.4 Some constraints regarding hands-on practical activities

Hands-on practical activities can be constrained by various factors, and I discuss these below.

Overcrowding

Shinana (2019) asserts that overcrowded classrooms seem to overwhelm teachers to the extent that more scientific inquiry cannot be conducted properly. In addition, the non-availability of resources or the limited resources thereof place restraints and result in limited capacity for teachers to properly conduct laboratory food tests where security is a priority.

Laboratory facilities and infrastructures

Several authors remarked that without proper science laboratories, most schools would not be able to conduct practical lessons (Asheela, 2017; Shinana, 2019). The other challenge is that the low and high mixed cognitive abilities of the students also affect the knowledge gap. Despite the issues that other schools face such as challenges due to a lack of laboratories and equipment, the focus of this study was on schools that do have laboratory facilities and why teachers do not use them for hands-on experiences.

Knowledge, skills and attitudes of teachers

The teachers need to have the skills, knowledge and right attitudes to implement hands-on practical activities (Knoef, 2017). Additionally, the teachers who are positive about their teaching and the resources at their disposal have more opportunities to demonstrate the curriculum objectives by exposing learners to more hands-on practical activities. On the other hand, Knoef (2017) stated that the context of usage, learning regulations and (re-)design of curriculum materials add more value to the lessons in learners' practices in the laboratory or science classrooms. However, in some cases, teachers may not possess the kind of knowledge, skills and the right attitudes to handle specific practical activities that will ensure students have a better chance of coping with complex matters of the PEEOE approach.

In this regard, Ndevahoma (2019) says that if pupils are unable to reflect on their activities, they are more likely to reverse what they have learnt, as the teacher has not given them a clear indication of what to watch and measure for interpretation. A competent Biology teacher must be well versed in the strategy, incorporation and implementation of practical work as well as the assessment of learners' practical skills. Nonetheless, according to a recent study, learners' conducting of experiments is insufficient, and teachers are not successfully supervising them (Wang et al., 2021). One of the problems that may be central to these difficulties involved is the teacher's lack of competence to conduct practical work (Le et al., 2018). The concept of competence is gaining some traction in academic research. The expertise of teachers in teaching and learning is an important factor in determining graduation rates. Thus, according to research (e.g. Turner et al., 2017), teachers' expertise and knowledge in performing science experiments have a strong influence on students' active engagement in science classrooms. Consequently, teachers must be well prepared when they begin teaching and must continue to develop their knowledge and skills throughout their careers.

2.3.5 Affordances of hands-on practical activities

Hands-on practical activities have the potential to develop students' vast experiences, particularly in understanding the concept of food testing in the context of this study. In-depth studying of nutrients of certain food types can be enriched when the teachers utilise the resources at their disposal. It is against this background that this study focused mainly on why the teachers were reluctant to implement hands-on practical activities. Through hands-on practical activities, learners can formulate their hypotheses while busy experimenting (Ndevahoma, 2019). Apart from the hypothesis they formulate, students will be able to develop scientific skills which are necessary for their future choices in life, particularly those that want to pursue studies in the field of Biology. Practically, PCK (Shulman, 1986) has been proven to be the best approach to shaping the minds of students through piloting inquiry, practical scientific analysis and scientific explanation (Shinana, 2019).

According to Ottander and Grelsson (2006), hands-on practical activities contribute massively to how students learn to use analytical and critical skills and create interest in hands-on practical activities that enhance Biology understanding, particularly in food testing. A study conducted by Nghipandulwa (2011) in Namibia revealed that about 69.9% of teachers did not take hands-on practical activities very seriously. As a result, students' performance in Paper 3 was negatively affected. For students to improve in Biology, particularly in hands-on practical activities the teachers should address the domains prescribed by the assessment objectives of Biology in Namibia are outlined as follows:

A: Knowledge with understanding;

B: Handling information, application and solving problems; and

C: Practical (experimental and investigative) skills and abilities (MoEAC, 2016, p. 35).

More concern is on how teachers address assessment objective C which focuses on hands-on practical (experimental and investigative) skills and abilities. Henceforth, this study focused on how teachers ensure that hands-on practical activities in food testing reach the syllabi objectives and basic competencies to pass Paper 3 in the Otjozondjupa Region. Therefore, the hands-on practical activities have the following benefits – students gain experience on how to handle equipment and subsequently cope and learn better about food testing (Nghipandulwa, 2011). However, for this to be recognised, there is a need for the PD of teachers on how to do hands-on practical activities in their classrooms.

Professional development (PD) can be a way of improving teachers' practices particular in hands-on practical activities. The old traditional modes of teaching have locked in the potential of many learners to explore the learning outside what teachers subscribe to their students (Liswaniso, 2018). Henceforth, it is recommended that teachers should make use of the various modes of teaching that will explore their PD to existing knowledge they have such as group experiments, investigations, teachers' demonstrations, fieldwork, attending seminars, workshops and training on improving hands-on practical activities (Liswaniso, 2018).

According to Kennedy (2021), teachers can develop their professional growth through formal settings that include conferences, courses, seminars, retreats and workshops. The other opportunities for teachers to develop are informal PD, for example, independent research or investigation, peer learning initiatives or even just chatting with a colleague in the staff room (Kennedy, 2021). Similarly, Shinana (2019, p. 32) outlines the following: "The goal is for teachers to implement knowledge from these professional developments and to provide the students with enduring and applicable understanding of scientific concepts". Henceforth, professional development serves as mental development for teachers to rekindle the excellence in their work.

2.3.6 Insufficient preparation before conducting practical lessons

Preparation is the key to preparing people for a pleasant experience during science experiments. Materials, apparatus and equipment are commonly prepared in all schools with the assistance of laboratory assistants, who usually have extensive knowledge and experience assisting Biology teachers in the laboratory. Teachers also agreed that laboratory assistants play a significant role in ensuring that practical lessons are effective. It is extremely crucial to provide appropriate and adequate materials and apparatus for practical activities to avoid interruptions in teaching and learning. However, Awang et al. (2013) and Fadzil and Saat (2020) found that teachers must also master the scientific content and be familiar with the proper technique for handling apparatus and materials in the laboratory.

Biology teachers should be proficient in the handling and installation of laboratory apparatus, as this is part of their obligations in the laboratory. If teachers have difficulties managing scientific apparatus, they will have difficulties in teaching and evaluating students' practical work. According to previous research, a lack of equipment and materials in school laboratories can have a negative impact on students' practical skills (Chua & Karpudewan, 2017). In way of comparison to those findings, assertions made during data collection for this study demonstrated that most Biology laboratories are well-equipped but poorly managed and maintained.

2.3.7 Difficulty in designing and planning practical lessons effectively

One significant contributor to a lack of practical work in Biology is the teacher's lack of practical work experience. Biology teaching staff must always be particularly adept in the use of a variety of teaching methods, along with being cost-effective in organising all necessary equipment and ensuring the safety of students while performing practical work in the laboratory. Notwithstanding, studies conducted locally and internationally (e.g. Fadzil & Saat, 2017; Mohammad, 2007; Ng & Nguyen 2006) unearthed those in-service and preservice Biology teachers lack essential practical skills for effective laboratory work. As a direct consequence, teachers will find it difficult to effectively guide students across practical skills.

A study conducted by Mohammad (2007) concluded that preservice teachers are not very skilful in practical techniques. Awang et al. (2013) also found that teachers are incompetent in handling laboratory equipment and have not been able to perform systematic and efficient experiments. It may be because they do not plan and arrange the lessons effectively (Mahanani et al., 2020). Teachers still have a low level of competence to conduct practical or scientific experiments and, as a result, incompetent teachers have a significant influence on the level of interest of students in the subject (Awang et al., 2013). Failure of teachers to prepare their learning materials, insufficient preparation and inadequate science equipment would have detrimental consequences on the implementation of practical work.

2.4 Concepts Related to Learning

An ideal approach to concepts related to learning entails that teachers need to understand their conceptions and dispositions in their practical approach to hands-on practical activities.

2.4.1 Conceptions

According to Atallah et al. (2010), conceptions have two components, namely, knowledge and beliefs. In addition, Atallah et al. (2010) believe that conceptions are opinions that students hold about Biology, their beliefs and their expectation in learning the subject. Some procedures are part of the ideas, and they are both affective and cognitive. In other words, beliefs have to do with personal opinions, values and expectations (Vhurumuku & Mokeleche, 2009). Similarly, if teachers have views and beliefs that they think stimulate and influence teaching and learning, particularly in practice, it is likely to affect the outcomes of the hands-on practical activities.

As for Biology, there seem to be no conceptions developed by the teachers for students to believe or develop personal opinions, values and expectations when it comes to hands-on practical experiences in food testing. Consequently, Ndevahoma (2019) looked at two types of conceptions on hand, the deep approach and surface approach. These two approaches have different outcomes when students are thoroughly taught. For instance, if students during the food testing are given enough guided instructions, they develop the ability to construct meaning, re-count ideas as well as implement evidence in their explanation of the experiment. That is referred to as the deep approach to conception. While the surface approach could be that when students understand how procedures are carried out in food testing, they will replicate learning materials to better understand the way assessments are prepared. In a nutshell, the conception approach is significant for the development of hands-on practical experiences in Biology experiments.

2.4.2 Dispositions

Dispositions have to do with the abilities to reason and do things positively (Atallah et al., 2010). Atallah et al. (2010) argue that from a mathematical point of view, students' interests and competence determine their confidence (Agunbiade et al., 2017).

Moreover, dispositions have to do with students' own' interests, that is, how motivated they are to learn. Ndevahoma (2019) elaborates on the patterns of behaviours that can be developed for a particular context. If students are not motivated to try through experiments, particularly in preparation for Paper 3, it creates a sense of fear and doubt about the teachers' competencies. It is a fact that schools, particularly senior secondary schools in Otjozondjupa, have laboratories that hold teachers back from carrying out experiments as prescribed by subject policy, syllabi and Directorates of National Examination and Assessment (DNEA).

According to Gresalfi (2009), learning is considered to be a change in participation through which one 'becomes' a different person concerning the practices of that activity setting (Wortham, 2004). Thus, learning is a process of developing dispositions; that is, ways of being in the world that involve ideas about, perspectives on, and engagement with information that can be seen both in moments of interaction and in more enduring patterns over time (Gresalfi & Cobb, 2006). As Thomas and Brown (2007) note, dispositions involve attitudes toward the world, generated through a set of practices which can be seen to be interconnected in a general way. In my study, dispositions are viewed as attitudes towards hands-on practical activities in Biology: the way students feel about/how they act toward/how they take part in/whether they tend to like and enjoy or hate doing hands-on practical activities, as noted by Thomas and Brown (2007).

On the other hand, it is believed that students' dispositions are altered according to a certain level of exposure in a conditioned environment, yet, if students have little exposure their dispositions tend to decline in a thought-provoking environment (Ndevahoma, 2019). I believe that the school laboratory provides learners with the kinds of dispositions to challenge their minds to develop critical thinking skills and be able to analyse results or outcomes of their testing experiments given all the necessary help and appropriate lab equipment.

2.5 Theoretical and Analytical Framework

My study was guided by Shulman's (1986) PCK theory as my theoretical framework. Within PCK, I used Topic-Specific Pedagogical Content Knowledge (TSPCK) as the analytical framework (Mavhunga & Rollnick, 2013).

2.5.1 Pedagogical Content Knowledge

Shulman (1986) introduced the concept of PCK as a distinctive body of knowledge for teaching. Shulman (1986) posited that the development of PCK involves a dramatic shift in teachers' understanding. "From being able to comprehend subject matter for themselves, to becoming able to elucidate subject matter in new ways, reorganise and partition it, clothe it in activities and emotions, in metaphors and exercises, and examples and demonstrations, so that it can be grasped by students" (Shulman, p. 13). In light of this, Shulman's (1986) PCK is an acknowledgement of the importance of the transformation of SMK into SMK for teaching (van Driel et al., 1998). In other words, it refers to teachers' interpretations and transformation of SMK in the context of facilitating students' learning (van Driel et al., 1998). Essentially, Shulman was interested in how teachers cross-transfer the SMK they gain to students in the classroom setting. That is, how teachers deal with learners' difficulties.

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

Building on Shulman's PCK, Geddis and Wood (1997) introduced teacher transformation of subject matter using five components: learners' prior concepts, subject matter representations, instructional strategies, curriculum materials and curricular saliency. Mavhunga and Rollnick

(2013) extended on Geddis and Wood's (1997) seminal work, to introduce five Topic-Specific Pedagogical Content Knowledge (TSPCK) components and I used these as my analytical framework in this study.

2.5.2 Analytical framework: Topic-Specific Pedagogical Content Knowledge

Mavhunga and Rollnick (2013) state that PCK has a topic-specific nature through which one can analyse its importance. Furthermore, Mavhunga and Rollnick (2014, p.114) state that, "Topic Specific PCK (TSPCK) assists teachers to consider the specific information about the content knowledge of the topic concerning *prior learner knowledge, curricular salience, what is difficult to understand, representations including analogies and conceptual teaching strategies"*. The structure of the topic in terms of the most important core concepts distinguished subordinate concepts as well as pre-concepts needed to teach each of the core concepts on food tests. Essentially, the specific topic in this study was food tests.

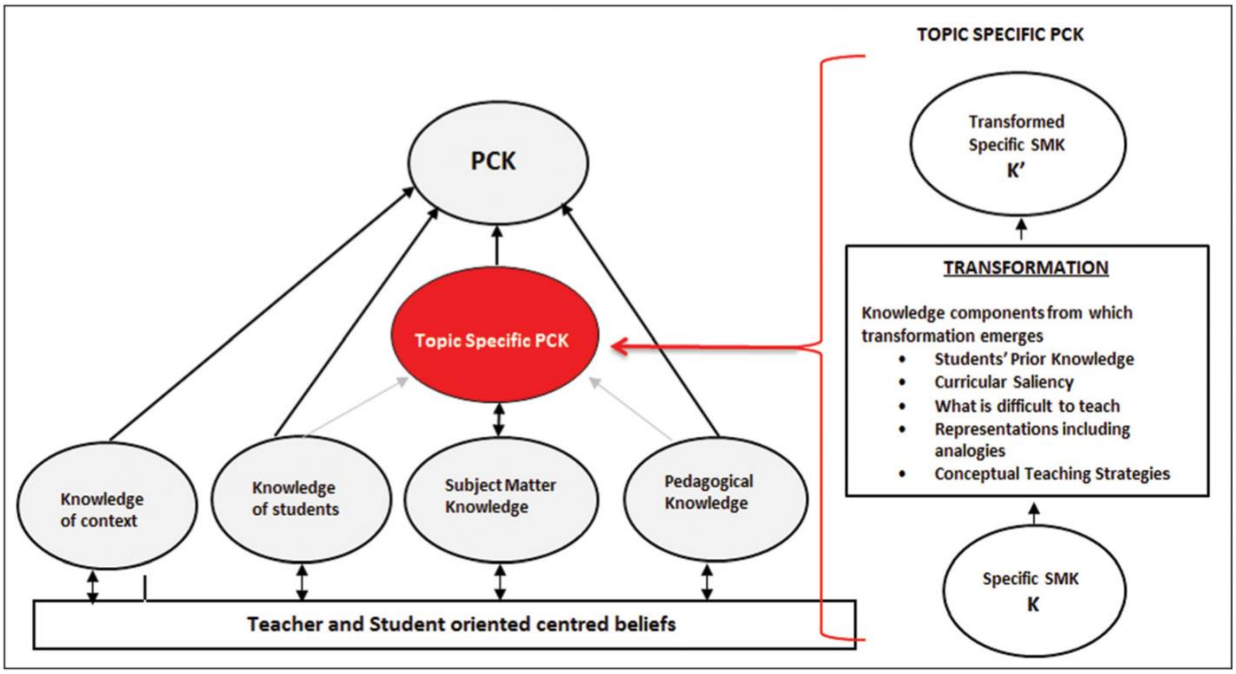

Figure 2.2: Showing the five components of TSPCK (adapted from Mavhunga & Rollnick, 2013, p. 115)

Teachers must elicit and build on students' prior knowledge as part of the prior knowledge component. Teachers must determine the major concepts of the topic that students must understand before the topic is offered to them as part of the curriculum saliency component. The methodology used by teachers to help pupils understand the material of that specific issue is outlined in the component of representation. Finally, conceptual teaching strategies examine the many strategies employed, bringing together all of the previously described elements. This includes considering how to cope with pupils' past knowledge which may be extensive, and how to use it to teach new material.

The analytical framework helps the teachers to spot a knowledge gap and understand what is at stake to comprehend students' prior knowledge. Sometimes the blind spot is that teachers tend to focus more on what they are supposed to teach, rather than focusing on the analytical needs of the learners. It is against this background that the study attempted to fill this knowledge gap and the mismatches in specific information about the content knowledge of the topic concerning what learners know or ought to learn considering the practical approach.

On the other hand, TSPCK is the teacher's transformation of subject matter and how teachers can handle the dilemmas. According to Geddis and Wood (1997), the main premise of the transformation of subject matter into forms accessible to the student has to do with contextualising the intellectualisation of the classroom whereby the teacher enables the engagement of the students to clarify, argue and justify.

It has to be done to increase aptitude for content delivery in areas where the students did not receive enough attention through the transformation of subject matter (Geddis & Wood, 1997). Hands-on practical activities appear to receive less focus in Biology classes, therefore, efforts to conduct experiments are hampered by a variety of problems. It has been observed that subject matter transformation merits specific principles of attention drawn where subject matter, learners and educational aims intertwine as well as interactions between all of these diverse kinds of teacher knowledge in the pedagogical engagement (Geddis & Wood, 1997) happening simultaneously.

The deliberate tactic is that at the end of the engagement, students should get the explicit context of achieving explicit educational objectives. To elaborate more details, the following figure is adapted from Shulman (1986, 1987) and Wilson et al. (1987) and illustrates how teaching as the transformation of subject matter happens.

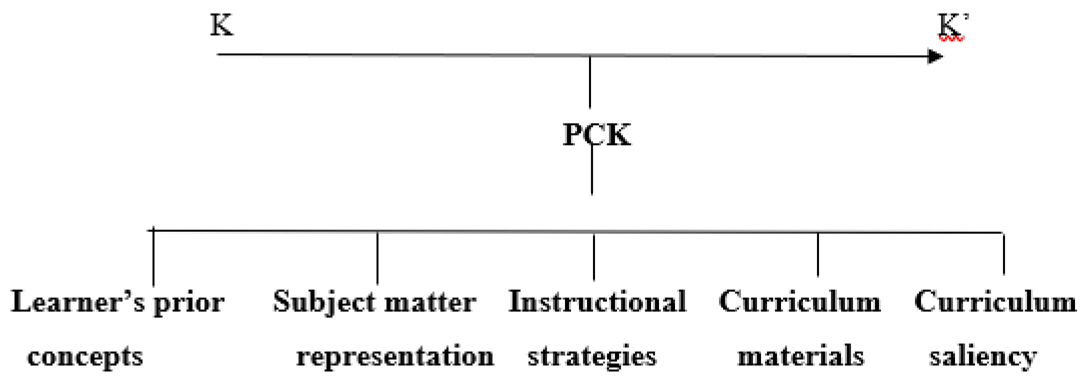

Figure 2.3: Teaching as the transformation of subject matter (adapted from Shulman, 1986, 1987; Wilson et al., 1987, p. 24)

The illustration above gives a sense of how teaching as a process of subject matter transformation can evolve. From students' prior knowledge, for instance, in food testing to subject matter representation which includes their conceptions and dispositions and then how they are linked to instructional strategies that the teachers will deploy practically to fill the void. Provided that curriculum materials support is available, the teacher will then be able to teach objectively to reach curriculum saliency.

2.5.3 Consensus Model of Pedagogical Content Knowledge

Shulman (1986, 1987) states that teachers possess Subject Matter Knowledge (SMK) which is required to transform learners' level of knowledge into reasoning in practical lessons. 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 Zone of Proximal Development[2] (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 learners do the task under the guidance of a more capable person. Thus, together with the teachers' pedagogical knowledge, the teacher needs to have rich conceptual understanding of the subject content that they teach (Loughran et al., 2006). The nature of PCK explained above represents PCK as a teaching theory.

Shulman's work on PCK led to scholars embarking on studies on the components and sources of PCK and how it is developed. It was concluded from these studies that there are several views regarding PCK, yet a common view was needed for a common understanding of PCK. Therefore, to come to a common understanding of PCK, a group of researchers met in 2012 in Colorado Springs and created an agreed-upon model, referred to as the Teacher Professional Knowledge Model (Consensus PCK Model) (Gess-Newsome, 2015, p. 31). This is shown in Figure 2.4 below.

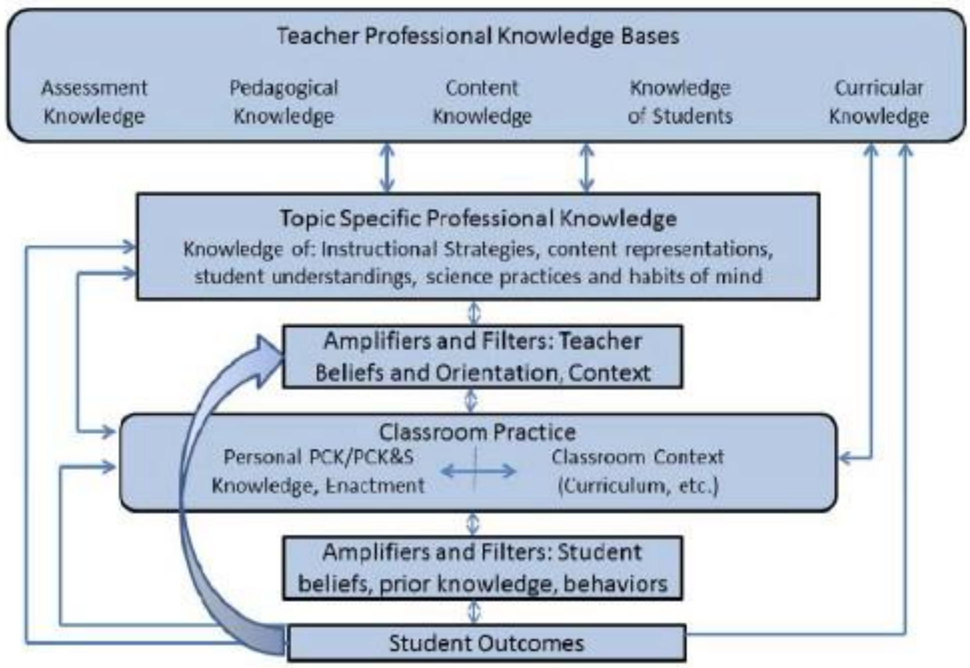

Figure 2.4: Consensus Model of PCK from PCK Summit 2012 (Gess-Newsome, 2015, p. 31)

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 pertaining to the place for knowledge is about instructional strategies, which is not accommodated in the model. Consequently, the model was 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 2.4 below (Carlson & Daehler, 2019).

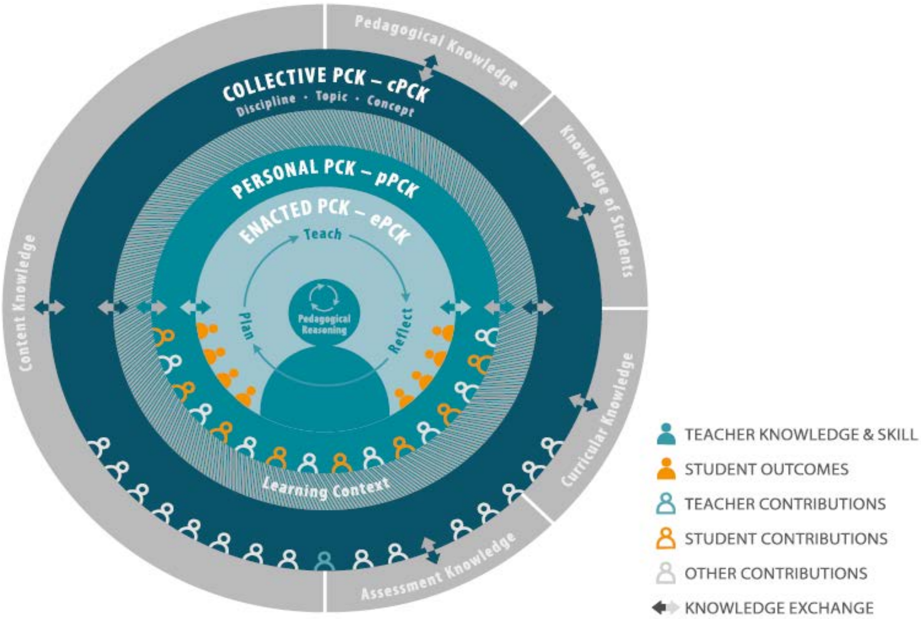

Figure 2.5: Refined Consensus Model of PCK (Carlson & Daehler, 2019, p. 83)

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 learnt 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, and they think and reason about it to find a way to show their PCK. As a result, the teachers show their PCK in a uniquely personal way which then makes up their personal PCK. Thus, personal PCK is the cumulative and dynamic PCK 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 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.

Teachers' pedagogical "knowledge base" includes all of the multiple intelligences necessary to manufacture effective teaching and learning environments. Thus, according to research, this knowledge can be studied. Identifying the content of this knowledge base, on the other hand, is a difficult process. The distinction between declarative ("knowing that") and procedural knowledge ("knowing how") from cognitive psychology serves as the underpinning theory for the majority of the studies. This approach is relevant because it focuses on understanding how knowledge is related to behaviour and attitude, or, quite primarily, the quality of teaching performance.

The first comprehensive study on teacher knowledge (Shulman, 1987) arranged teacher knowledge into seven categories, including the concepts of:

- general PCK (principles and strategies of classroom management and guidance and cross-curricular institutions); and
- knowledge of pedagogical content (the knowledge which integrates the content knowledge of a specific subject and the pedagogical knowledge for teaching that particular subject).

This latter was perceived as the most fundamental element of teachers' knowledge and has been widely investigated since. In contrast, even though much research shows that it is essential for developing quality teachers, general pedagogical knowledge has not been the subject of several research studies. Some models of general pedagogical knowledge combine pedagogical and psychological aspects, while others do not incorporate psychological aspects. Learning occurs in a social context, and learning success is completely reliant on the general cognitive and affective characteristics of individual students, thus according to psychological components.

Finally, this theory is significant to this study because teachers differ from scientists not in the quality and content of their subject area knowledge, but in the organisation and application of that information. To put it another way, theory assists a skilled science teacher's understanding of science arranged from a teaching standpoint and is used to help pupils understand certain ideas. The knowledge of a scientist, on the other hand, is arranged from a research standpoint and is utilised to produce new information in the field. In a study of the structure of SMK among groups of experienced science instructors, professional research scientists, inexperienced science teachers, subject area science majors and preservice science teachers, Hauslein et al. (1992) documented this theory in Biology as well.

2.6 Chapter Summary

In this chapter, I discussed various relevant literature that informed this study. Firstly, I discussed the Namibian Biology curriculum in which the goal of Biology is to provide students with scientific skills and knowledge through hands-on practical activities. I also explored literature on hands-on practical activities and visualisation. This was followed by the discussion of the aims and objectives of doing hands-on practical activities, types of hands-on practical activities and teachers' views and benefits of hands-on practical activities. Thereafter, constraints with hands-on practical activities and the potential of hands-on practical activities were also discussed. The chapter ended with a discussion of the theoretical framework of Shulman's (1986) PCK. In the next chapter, I discuss the research methodology that underpinned this study.

CHAPTER THREE: RESEARCH METHODOLOGY

3.1 Introduction

The main goal of this study was to explore enablers and/or constraints when Grade 10 Biology teachers carry out hands-on practical activities to mediate learning of food tests. To achieve this goal, the following research questions were addressed:

1. What are Grade 10 Biology teachers' perspectives and pedagogical insights on the use of hands-on practical activities when mediating learning of food tests?
2. How do Grade 10 Biology teachers mediate learning of food tests using hands-on practical activities?
3. How do discussions and reflections enable and/or constrain Grade 10 Biology teachers' understanding of carrying out hands-on practical activities to mediate learning of food tests?

In this chapter, I thus present the research methodology used in this study. I first present the paradigm informing this study followed by the research design employed in this study. Lastly, the chapter ends with a summary.

3.2 Research Paradigm

Creswell (2015) stated that the term "paradigm" originated from the Greek word "*paradeigma*" which means pattern. The term was first used by Thomas Kuhn in 1963 to denote a conceptual framework shared by a community of scientists which provided them with a convenient model for examining problems and finding solutions. According to Kuhn (1977), the term "paradigm" refers to a research culture with a set of beliefs, values and assumptions that a community of researchers has in common regarding the nature and conduct of research. Hence, a paradigm implies a pattern of scientific and academic ideas, values and assumptions. In line with this, David and Amey (2019) explained that a paradigm is a collection of assumptions or scientific beliefs about important aspects of reality. This suggests that a paradigm generates a brief guideline of how research is conducted and the strategy to select as well as selecting the appropriate data collection techniques and data analysis methods.

This study is underpinned by an interpretive paradigm. Bertram and Christiansen (2020) pointed out that those researchers grounded in the interpretivist paradigm aim to understand how people make sense of the world. Concurring, Merriam and Tisdell (2016) stated that qualitative research is based on a belief that knowledge is socially constructed by people in an outgoing fashion, as they engage in making meaning of an activity, experience or phenomenon. The aforementioned views entail that the interpretivist paradigm focuses on people's subjective experiences, how they construct their social world and how they interact with each other. This suggests that the interpretive paradigm aims at developing a greater understanding of how people make sense of the context in which they live or work, whereby the researcher engages the situation from the viewpoint of the participants (Bertram & Christiansen, 2015).

In other words, the interpretive paradigm rests, in part, on a subjectivist, interactionist, socially constructed ontology and epistemology that recognises multiple realities, agentic behaviours and the importance of understanding a situation through the eyes of the participants (Cohen et al., 2018). The interpretive paradigm was thus deemed most suitable because of its ability to capture the exact meaning of respondents' interpretation of the subject matter according to Burton (1962). However, I was mindful that one of the criticisms of the interpretive paradigm is that it focuses on descriptions at the expense of explanations. To address this limitation in my study, I used my third research question whose focus was on discussions and reflections to get in-depth explanations on the use of hands-on practical activities on the topic of food tests in particular.

3.3 Research Design

Merriam and Tisdell (2016) described research as a systematic inquiry. They further elaborated that engaging in a systematic inquiry involves choosing a study design that corresponds with the research questions, and the participants' worldview, personality and skills. In light of this, Creswell (2018) accentuated that a research design involves the most effective strategy for finding the information most appropriate to answer the research questions. Concurring, Cohen et al. (2018) explained 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. That is, the research determines the design of the research, which in turn informs the methodology (Cohen et al., 2018). In designing the research, the researcher has to consider the issues of how to choose a research project, how to plan it and how to ensure that the project is practicable (Cohen et al., 2018). In this next section, I discuss a case study, the research site and sampling, positionality and reflexivity, data gathering methods, research process, data analysis, validity and trustworthiness as well as ethical considerations take in the study.

3.3.1 Case study

I used a case study research design to explore how Grade 10 Biology teachers implement practical activities on food tests. Yin (2015) asserted that a case study is an empirical inquiry that explores a contemporary phenomenon in-depth and within its real world. I opted to use a case study because my unit of analysis was Grade 10 Biology teachers' perspectives and pedagogical insights on the use of hands-on practical activities, as well as how they mediate learning of food tests in their classrooms. Hence, consistent with the interpretive paradigm, a case study enabled me to understand real-world cases in practical terms, therefore enhancing my understanding of the important contextual conditions pertinent to the case being studied. Furthermore, a case study inquiry relies on multiple sources as evidence to converge needed data in a triangulating fashion. In line with this, Creswell (2018) referred to a case study as an empirical inquiry that investigates a contemporary phenomenon within its real-life context, when the boundaries between phenomenon and context are not clearly evident and in which multiple sources of evidence are used.

Fraenkel and Wallen (2012) stated that a case study can take either a qualitative or quantitative approach. In this case, a qualitative approach was used under a case study to explore how Grade 10 Biology teachers implement practical activities on food tests.

Mugenda and Mugenda (2015) emphasised that qualitative research is an approach that explores and understands the meaning that individuals or groups ascribe to a social or human problem. Agreeing, Creswell (2018) posited that the qualitative research approach is a research methodology which explores people's opinions, attitudes, beliefs or reflections on their experiences of things in the outer world. This suggested that a qualitative research design should be applied to this study. Further, Creswell (2018) stated that qualitative study is an inquiry process of understanding a social or human problem based on building a complex, holistic picture with words and reporting detailed views of informants conducted in a natural setting. Hence, qualitative researchers attempt to collect rich descriptive data in respect of a particular phenomenon or context to develop an understanding of what is being observed or studied.

3.3.1.1 Research site

The research was carried out in the Okahandja Circuit, which is part of the Otjozondjupa Directorate of Education, Arts and Culture in Namibia (see Figure 3.1 below). In Okahandja, three state schools offer Biology Grades 10-11. All three state schools have laboratories but are ill-equipped with apparatus and chemicals. The enrolment for the schools is about 800–900 students. The teacher ratio is 35–40 students per class. The buildings at the selected schools are deteriorating because of poor maintenance. Unfortunately, one of the three schools was downgraded because of poor performance and the Grade 10 and 11 phases were removed and the students distributed among the other two schools. As a result, l had to work with only two teachers instead of three.

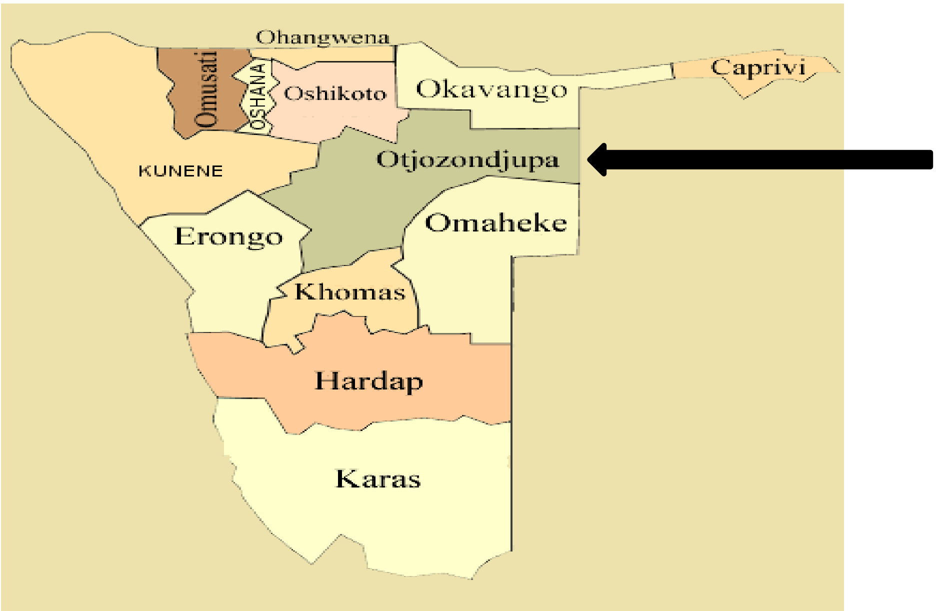

Figure 3.1: Shows the circuity in Namibia where the study took place

3.3.1.2 Research participants and sampling

Maree (2012) defined sampling as the process of selecting a smaller group of participants to tell us eventually what a larger population might tell us if one asked every member of the larger population the same questions. This suggests that sampling involves making decisions about who to include in a study. Thus, the participants of this study were selected using the purposive sampling technique.

According to Creswell (2018), purposive sampling is a non-probability sampling method and it occurs when elements/participants selected for the sample are chosen by the judgment of the researcher. In other words, purposive sampling also known as judgment, selective or subjective sampling is a technique in which the researcher relies on their own judgment when choosing members of the population to participate in the study. Hence, the decisions concerning the individuals to be included in the sample are taken by the researcher, based upon a variety of criteria which may include specialist knowledge of the research issue or capacity and willingness to participate in the research. Therefore, the purposive sampling technique allows the researcher to decide about the individual participants who would be most likely to contribute appropriate data, both in terms of relevance and depth.

Due to the nature of this study, participants were selected according to their availability and syllabus content knowledge, that is, the grade in which the topic of food tests is taught. Another reason why these teachers were selected was to allow them to be exposed to different PCK and how this could affect students' competencies in handling practical questions/papers.

Two Grade 10 Biology teachers from two senior secondary schools in the Okahandja Circuit were selected as the participants in this study. Both schools are in the same town, and they both offer Biology on the ordinary-level. These teachers were purposively sampled based on their experience (8 years) as well as their qualifications – bachelor's degree with honours in the science field and a master's degree in the science-related field in teaching Biology at the senior secondary level – as well as their willingness to participate in this study. The teachers had more than eight years of teaching experience and their higher-level students have always outperformed other ordinary-level students.

Table 3.1 below presents the teachers' profiles involved in this study – that is, their gender, teaching experience, qualifications and age group.

Table 3.1: Shows the biographical information of teachers

Biographical information	**Category**	**Teachers' codes**
Gender	Male	T1: Mr. Adams
	Female	T2: Ms. Idan
Teaching experience	3-10 years	T1, T2
Qualification	BEd Honours	T1, T2
Age	28-45	T1, T2
Grade(s) taught	10	T1
	10 and 11	T2
Number of learners	60	T1
	204	T2

3.4 My Positionality and Reflexivity

Rowe (2014) posited that positionality is the mechanism through which an individual views something, their general perspectives of the world or on a certain topic in particular, that are often shaped by their interests, circumstances, religious, political, gender, sex, personal attributes, race, ethnicity, geographical and historical perspectives (Grix, 2019). On the other hand, reflexivity refers to reflecting and acting throughout the research process. In other words, positionality is informed by reflexivity. Simply stated, reflexivity is the concept that researchers should acknowledge and disclose their selves in their research, seeking to understand their part in it, or influence on it (Cohen et al., 2011). Thomas (2013) was 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 suggested that the researcher must be explicit in their interest, personal circumstances, uncertainties and allegiances in the study undertaken.

Therefore, as alluded to earlier, I approached this study from an interpretive perspective. That is, "the social world in which we are interested as social scientists are 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).

Rhodes is a well-respected university, and as a master's scholar, I was mindful of the fact that this could contribute to power dynamics with my participants. To address this, I positioned myself as a new teacher in this phase (Senior Secondary phase), and with this, the participants were placed in a more experienced position than me. The teachers were more experienced than I was and were involved in setting and marking the Biology ordinary final examination. Furthermore, I established trust with the participants by explaining that I was researching to improve our day-to-day practices. In addition, an informed consent letter (see Appendix D) was used to outline the objectives of the study to the participants and also to sign for their permission to participate in the study.

3.5 Data Gathering Methods

Data gathering methods are the range of approaches used in educational research to gather data (Cohen et al., 2018). Researchers need to vary the methods used to gather research data for triangulation. In this study, questionnaires for teachers, SSIs, observation, SRIs, journal reflection discussions and group reflections were used to gather data from two Grade 10 Biology teachers.

3.5.1 Questionnaires

According to Bertram and Christiansen (2015), a questionnaire can contain either closed-ended questions, open-ended questions or a combination of both. In this study, I used a closed-ended and open-ended questionnaire to elicit teachers' perspectives and pedagogical insights on the use of hands-on practical activities when mediating learning of food tests (see Appendix G). The questionnaire was validated by my fellow master's scholars (three scholars took part) to ensure that all questions were unambiguous and that they could elicit appropriate data. In light of this, Bertram and Christiansen (2015) suggested that a good practice when administering a questionnaire is that it is piloted with a small sample before it is administered to a large sample. The participants were assured of confidentiality because of the sensitive nature of the study. I addressed informed consent, the right not to take part and to withdraw at any time, and addressed privacy, anonymity and non-traceability (Bertram & Christiansen, 2015). The data from the questionnaires subsequently informed the interview questions in the sense of clarification on certain aspects regarding the teachers' perspectives and pedagogical insights on the use of hands-on practical activities when mediating learning of food tests.

3.5.2 Interview schedule and semi-structured interviews

I applied the interview schedule (See Appendix H) by preparing the questions to ask further questions to get clarity on the type of hands-on practical activities they implement at school in their biological lab set-up. According to Pandey and Pandey (2021), an interview schedule is essentially a list of written questionnaires that have been prepared to act as a reference for interviewers, researchers and investigators in gathering information or data about a specific topic or issue.

An interview is a conversation between the researcher and the respondent or participants (Bertram & Christiansen, 2020). Semi-structured interviews (SSIs) helped the researcher to seek more clarification, as this was the instrument used to gather information for my first objective which was to explore the perspectives and dispositions of two Grade 10 Biology teachers on the use of practical activities when mediating learning of food tests. Although in each of these situations the respective roles of the interviewer and interviewee may vary and the motives for taking part may differ, a common denominator is a transaction that takes place between seeking information on the part of one and supplying information on the part of the other (Bertram & Christiansen, 2015). Due to the COVID-19 pandemic, SSI questions could not be validated.

Interviews were recorded with the permission of the participants. That was intended for data validity and rectification of errors. In addition, SSIs might allow for follow-up questions where necessary (Thomas, 2013) and for triangulation of the data gathered from the questionnaire. The one-on-one interviews allowed each teacher to express themselves and the interviews took about 30 minutes to one hour per teacher and conducted face-to-face. This was a form of triangulation whereby data gathered from the questionnaires were supported by data from the SSIs, where both participants were interviewed. Triangulation refers to the use of a combination of research methods and this can increase the trustworthiness of a study (Bertram & Christiansen, 2015).

3.5.3 Lesson observations

Maree (2012) defined observation as the systematic process of recording the behavioural patterns of participants, objects and occurrences without necessarily questioning or communicating with them. There are different types of observation as outlined by Maree (2012), namely being a participant or non-participant observer. In my case, I was a non-participant observer whereby I was not taking part in the research. Instead, I took some notes (See Appendix I) as these teachers were teaching. With observation, the researcher goes to the site of the study and observes what is taking place to obtain first-hand information (Bertram & Christiansen, 2015). This was done to establish first-hand how teachers mediate the teaching and learning of food tests. That is, whether they made use of hands-on practical activities as espoused by Asheela et al. (2021). I observed two lessons per teacher and they were about 40 minutes long.

3.5.4 Simulated recall interviews

Stimulated recall interviews (SRIs) were used to determine the reasoning and how decisions were made during the lessons, and this helped me to better understand the decisions made during the lessons. Hence, the SRIs helped me to rectify and follow up on some of the aspects that could not be well captured during the observations (Nguyane et al., 2013). Contrary to all the good that comes with SRIs, they further state that teachers' interactive cognitions are not always retrievable and therefore may be difficult, if not impossible to recall retrospectively (Reitano, 2005). This was not the case in my research as the SRI was carried out as soon as the lesson was done. This helped the two teachers to do introspection on their instructional strategies and behaviours towards the teaching process.

3.5.5 Discussions and group reflections

According to Maree (2012), discussions and group reflections (see Appendix J) are a good way to gather people from similar backgrounds or experiences to discuss a specific topic of interest. A moderator (or group facilitator) who introduces topics for discussion and helps the group to participate in a lively and natural discussion amongst themselves guides the group of participants. The strength of discussions and group reflections relies on allowing the participants to agree or disagree with each other so that it provides an insight into how a group thinks about an issue, the range of opinion and ideas and the inconsistencies and variation that exists in a particular community in terms of beliefs and their experiences and practices. Consequently, Creswell (2014) argues that the group's composition and the group discussion should be carefully planned to create a non-intimidating environment so that participants feel free to talk openly and give honest opinions. Similarly to Nhase (2019), I also used discussion and group reflections in my study to get more in-depth explanations of how the two Biology teachers used hands-on practical activities in their lessons. Additionally, as discussions and group reflections are structured and directed, but also expressive, they can yield a lot of information in a relatively short time. The discussions and group reflections were about one hour long and were tape-recorded with the permission of the participants.

3.6 Data Analysis Plan

Andrews (2012) argues that data analysis comprises breaking down the data gathered into handy themes, patterns, trends and relationships. Hence, the main purpose of data analysis in qualitative research is to comprehend different elements of one's data, established through an examination of the relationships between concepts, constructs or variables. Another reason for data analysis is to check if some patterns or trends can be identified and isolated or to institute themes in the data gathered (Taber, 2013). Concurring, Creswell (2018) defines data analysis as the process of inspecting, cleaning, transforming and modelling data to discover useful information, arrive at conclusions and support the decision-making process.

Mugenda and Mugenda (2015) state that such data should be coded and analysed immediately. It is from the marks of such analysis that researchers can make common sense of the data. Hence, data can be analysed quantitatively, qualitatively or mixed (both quantitatively and qualitatively). In this case, data was analysed qualitatively. According to Creswell (2018), qualitative data analysis is the classification and interpretation of linguistic (or visual) material to make statements about implicit and explicit dimensions and structures of meaning-making of the material and what was represented. The qualitative data was prearranged into themes corresponding to the study objectives. The data was then coded into descriptive codes and a descriptive data technique was used to analyse the data. Data analysis entails categorising, ordering, manipulating, summarising, accounting for as well as explaining the gathered data (Brink, 2007). The data collected from the questionnaires was transcribed and analysed in terms of emerging themes through the process of multiple readings and engagement. Data generated from teachers' perspectives was analysed using an analytical tool adapted from Atallah et al. (2010). Table 3.2 below shows the analytical tools for data analysis.

Table 3.2: Shows analytical tools for data analysis

Concepts	**Indicators**	**Research instruments**
Conceptions and experiences	• *Describing the term practical activities* • *Describing the purpose of practical activities in Biology* • *Describing with a broader understanding of food tests* • *Describing what is required to teach food tests* • *Describing the use of easily accessible resources when mediating learning of food tests* • *Describing what in-class activities help one to teach food tests*	Questionnaire and Semi-structured interviews
Dispositions	• *Describing one's feelings on incorporating hands-on practical activities in science teaching* • *Describing one's attitudes towards scientific inquiry in Biology teaching* • *Describing one's sentiment/feelings on teaching practical food tests in the resourced schools* • *Describing one's attitudes towards teaching food tests using easily accessible resources*	Discussions and Group reflections

	• *Describing the perceived value of using easily accessible resources when mediating learning of food tests* • *Describing the perceived value or relevance of the topic of food tests to the worldviews*	

Source: Adapted from Atallah et al. (2010, pp. 3-4)

Furthermore, data generated from lesson observations were analysed using the five components of TSPCK adapted from Mavhunga and Rollnick (2013) (see Appendix E). I used TSPCK to scrutinise how to make use of the perspectives of Grade 10 Biology teachers on the use of hands-on practical activities when mediating learning of food tests. My data analysis, therefore, was a continuous process until all data from the four approaches were analysed. Moreover, all data sets were labelled with codes and categorised into sub-themes and themes.

3.7 Validity and Trustworthiness

Validity is a term used to signify research integrity and deals with how real, how authentic and how truthful the research is (Pine, 2017). To address the validity of the study, I looked at data collection techniques and analysis (Bertram & Christiansen, 2020). I used a variety of data collection methods such as questionnaires, SSIs, lesson observations, SRIs, discussions and group reflections to ensure triangulation (Bertram & Christiansen, 2015). Triangulation reduces cases relating to bias as the data comes from different sources (Maxwell, 1996).

The interview was piloted during the master's contact session, as guided by my supervisor on how to go about conducting the interviews with our classmates using the interview schedule. This helped me to validate my research instruments. To improve the appropriateness of my research methods and techniques, I pilot-tested those interview questions before the data collection commenced. This led to me changing some of the questions on the interview guide so that they could be in line with the research questions.

In this study, the interviews and observations were videos recorded to allow for easy transcription, and for the participants to review and reflect on their lessons for validation purposes. After transcription, the transcripts were given back to the participants to check if they constituted the actual discussions which is known as member checking (Cohen et al., 2018). I made the research process transparent with enough details aiming to reach similar conclusions (Bertram & Christiansen, 2015).

3.8 Ethical Considerations

According to Creswell (2015), ethics are norms or standards of behaviour that guide moral choices about our behaviour and our relationship with others. The goal of ethics in research is to ensure that no one is harmed or suffers adverse consequences from research activities.

3.8.1 Respect and dignity

The rights, welfare, anonymity and privacy of the participants were respected and protected. During the signing of the informed consent letters, I explained to the participants 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 hence ensured that research activities were done in places and at times that were convenient. It was recognised, however, that since I would be doing research *with* these teachers, especially during the discussions and reflections 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 pseudonyms. 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.

3.8.2 Transparency and honesty

While planning for this study, I also considered the benefits and the risks that the study might have for the participants. For instance, 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. That knowledge may include how discussions and reflections enable and or constrain Grade 10 Biology teachers' understanding in carrying out hands-on practical activities to mediate learning of food tests.

3.8.3 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. 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, were communicated to my supervisors. My supervisor thus provided suggestions thereof.

3.8.4 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 other people could not access them. 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.

3.9 Chapter Summary

In this chapter, I described the research paradigm that informed this study which was the interpretive paradigm. Within the interpretive paradigm, a qualitative case study research design 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, I discussed the data gathering methods such as questionnaires, observations, SSIs, video SRIs, discussions and group reflections. The data analysis method employed was described. In the next chapter, I present, analyse and discuss the qualitative data gathered in this study.

CHAPTER FOUR: DATA PRESENTATION: QUESTIONNAIRES AND SEMI-STRUCTURED INTERVIEWS

4.1 Introduction

In the previous chapter, I discussed the research methodology I employed in this study. I explained how data were generated to answer the three research questions of this study. Questionnaires and SSIs were used to generate data. Thus, in this chapter, I present, analyse, and discuss the data generated from the questionnaire and SSIs. The questionnaire and SSIs aimed to gather data on teachers' perspectives and pedagogical insights on the use of hands-on practical activities when mediating learning of food tests. This was aimed at addressing these two research questions:

- What are Grade 10 Biology teachers' perspectives and pedagogical insights on the use of hands-on practical activities when mediating learning of food tests?
- How do Grade 10 Biology teachers mediate learning of food tests using hands-on practical activities?

First, I present, analyse and discuss data generated from the questionnaires and the data generated from SSIs together.

With the end goal of this research, the researcher used the Miles and Huberman model to break down information. Qualitative information analysis by Miles and Huberman (2014) is a far-reaching sourcebook depicting an examination which is aimed at following legal and stable connections among social phenomena, in light of the regularities and successions that interface or link these phenomena. I used the qualitative method in gathering data, however, I present the data using tables.

This sets out the outcomes or the findings that I got from the sample during the research on exploring how Grade 10 Biology teachers implement practical activities on food tests.

Two teachers who filled out the questionnaire were interviewed individually and tape-recorded with their permission. They were also given codes and pseudonyms that are used throughout this study. The codes used are shown in Table 4.1. T1 to T2 represent participant teachers 1 to 2. The gender of each participant F and M at the end of code example T1M represents F (female) and M (male). SSI is the code for the semi-structured interviews. The legends for the participants are as follows: T1: Teacher 1 – Mr Adams and T2: Teacher 2 – Ms Idan. This made it easy when presenting, interpreting and discussing the data obtained from the SSIs. This chapter is therefore outlined according to the themes developed from the data from Mr Adams and Ms Idan.

The research was conducted in the Okahandja Circuit, which is part of the Otjozondjupa Directorate of Education, Arts and Culture in Namibia. Two teachers participated in this study, that is, a female and a male. In terms of teaching experience, both teachers had the highest qualification which was a Bachelor of Education (BEd) Honours in Science Education. Further, the age of the participants ranged between 35 and 40 years. In addition, grades that were taught and the number of learners was indicated. Mr Adams taught Grade 10 and he taught 60 learners, while Ms Idan taught Grades 10 and 11 and her total number of learners was 204.

4.2 Development of Sub-themes and Themes

Data generated from the questionnaires and semi-structured interviews (SSI) were categorised according to the questions they were answering, and sub-themes were developed. These sub-themes were subsequently combined into themes. The participants' perspectives and pedagogical insights on the use of hands-on practical activities when mediating learning of food tests were not the same. As a result, three themes were developed and data generated from the questionnaire and SSIs are presented under those themes. The themes are teachers' understanding of hands-on practical activities; benefits of hands-on practical activities when mediating learning of food tests, and challenges experienced when teaching food tests using hands-on practical activities. When using participants' quotes, some may have been grammatically edited for clarity purposes. Table 4.1 shows the themes and sub-themes that emerged.

Table 4.1: Shows the themes and sub-themes that emerged from the questionnaires and semi-structured interviews

Themes	Sub-themes	Literature/theory
Teachers' understanding of hands-on practical activities	Understanding hands-on practical activities	Millar (2004); Asheela et al. (2021); Kibirige and Osodo (2014); Kandjeo-Marenga (2008).
	Views about using hands-on practical activities in Biology	
Benefits of hands-on practical activities when mediating learning of food tests	Understanding of concepts	Hodson (1990); Geddis and Wood (1997); Ndevahoma (2019); Shinana (2019); Asheela (2017); Gwekwerere (2016)
	Gives learners a real-life experience	
	Develop learners' investigative skills	
Challenges experienced when teaching food tests using hands-on practical activities	Large group to control learners	Shinana (2019); Asheela (2017); Knoef (2017); Millar (2004)
	Time to set up hands-on practical activities	
	Teachers' little knowledge	

I present the topics that emerged from the analysis in connection to theory and literature in this part. This allowed me to mix the data, theory and literature during interpretation and debate. Pedagogical Content Knowledge (PCK) components were used to interpret and discuss the findings. According to Shulman (1986), the creation of PCK necessitates a significant shift in instructors' understanding: "From being able to grasp subject matter for oneself to being able to explicate subject matter in new ways, reorganize and compartment it, clothe it in behaviours and emotions, metaphors and exercises, and examples and demonstrations, so that students can grasp it" (p. 13).

In light of this, Shulman (1986) claims that PCK is a recognition of the significance of transforming SMK into teaching topic matter knowledge (van Driel et al., 1998). In other words, it relates to teachers' interpretations and transformations of subject matter information to help pupils learn more effectively (van Driel et al., 1998). Specifically, Shulman was concerned about how teachers in the classroom cross-transfer subject matter information to pupils. That is, how teachers deal with the difficulties of their students. Thereafter, I go over each theme in greater depth, starting with the first: teachers' perceptions of hands-on practical activities. I now discuss each of the themes below.

4.2.1 Teachers' understanding of hands-on practical activities

The teachers involved in this study tried to make a meaningful definition of hands-on practical activities from different perspectives and the contexts they found themselves in. For instance, one teacher defined hands-on practical activities as follows:

> *One of the fundamental practicals that enable learners to learn scientific knowledge and how to do science. It also allows learners to experiment with trial and error, learn from their mistakes and understand the potential gaps between theory and practice.* (Mr Adams)

This definition resonates with definitions by scholars such as Asheela et al. (2021) and others. To elaborate, for instance, Asheela et al. (2021) accentuate that hands-on practical activities are experiments/practicals that provide additional experience by deepening the understanding of practical skills in science classrooms. This means that hands-on practical activities increase awareness of moving away from inductive reasoning to hypothetical-deductive reasoning to distinctively distinguish between data that will be collected and the explanations that students will derive from it. Henceforth, it will help students to differentiate between a theory and practice using the empirical view of learning by discovering new skills as they practice (Millar, 2010). That is, students use their senses while doing observation. As students are busy doing observations, they will then learn how to hypothesise to derive questions that will improve their generalisations as well as their approach to explanations.

Ms Idan seemed to have a better understanding of hands-on practical activities because she elaborated that hands-on practical activities include lectures, group experiments and teacher demonstrations where learners are involved in handling and observing real objects and materials. Teachers should therefore provide opportunities for learners to handle materials, observe events, handle observation results and draw conclusions. Further, she stated that the aims of practical work are often related to the nature of learning outcomes including investigative and practical skills. In this way, hands-on practical activities can be seen as a means of acquiring process skills to promote meaningful learning.

This finding seems to corroborate with Millar (2010) who argues that when observation and measurement are complemented with hands-on practical activities, they create information on real-world experiences among students (Gwekwerere, 2016). The real world provides further interpretation, which in most cases students cannot bring forth if they have not followed the correct steps. In addition, Millar (2010) explains that hands-on practical activities give a real worldview so that students can predict and compare information collected and sometimes through prediction, disagreements and agreements may arise. Moreover, if there are agreements, that means it increases confidence between match explanations and the real world, however, if disagreements occur, it means one may start to question the explanations given (Millar, 2010). This suggests that the information that is collected requires precise explanations, henceforth in Biology, the use of scientific hands-on practical experiences is useful when applying predictions.

4.2.2 Benefits of teaching practical work

In the questionnaire, the respondents were asked to list their answers from 1 to 10 with the most important being ranked '1' and the least ranked '10'. On the aspect of enhancing conceptual understanding, Mr Adams ranked it 3 and Ms Idan ranked it 2. This provided a clear explanation of the perception of Biology practical activities that teachers highly regard because they enhance conceptual understanding of the respective subject. In the literature review, Nakanyala (2015) alludes to this by mentioning that Biology learning might become meaningless to the learners if it is not done with the necessary practical activities to support the theoretical learning provided in class. Another aspect of teachers' perspectives was that Biology practical activities enhance investigative skills. However, regarding this aspect, Mr

Adams highlighted 4 and Ms Idan indicated 1. This can be attributed in part to the fact that the more frequently the teachers conduct the experiments, the more relevant they become. Similar sentiments were echoed during the interview by Mr Adams who mentioned that:

> *Basically, practicals on food tests actually enhance your teaching. It allows learners to master the required learning objective of food tests because I know that most of the time is just theoretical.*
>
> *Practicals are just to compensate those learners that are visual, they see and already know that theoretically if you do this it will turn purple and other learners see that.*

Ms Idan added that: "*even if scenario and scenario are big differences, they should always be able to think outside and use the materials that they are given to manipulate the situation depending on what they are given – not to just be narrow-minded".*

The excerpts above clarify the importance of hands-on practical activities from the participants' point of view, whose experiences have indeed proven to have an enormous impact if what they have been doing for the past years is anything to go on.

In this regard, Amoonga and Kasanda (2011) mention that the Biology curriculum is very clear on the reasons and purpose of the practical activities as being very beneficial to the learners in their endeavour to succeed in the subject. In light of the above, l would also add that as the teacher demonstrates to learners on the subject topic of food tests, this might also reflect on their understanding of the subject topic, as they will learn and discover new possibilities with the practical tests being done – some of which might have been overlooked during teacher training. This assists the teacher to be knowledgeable and to answer questions outside the realm of the syllabus.

For the aspect 'to enhance procedural knowledge about experiments', Mr Adams marked 5 and Ms Idan marked 1. The findings show the diverse views on this aspect with Mr Adams putting much weight on the procedural knowledge about experiments by marking 5. However, Ms Idan highly disregarded this aspect as witnessed by their marking 1 respectively.

Nevertheless, according to the perceptions of the three teachers, it remains a key aspect that Biology enhances procedural knowledge about experiments. The importance of procedural knowledge and experiments was further emphasised during the interview when it was mentioned:

> *The need for learners to understand because we all driven on the fact that, ok fine learners must understand and pass. We always want them to pass. The other things are that, because teaching, I'm now used to teaching practical Biology higher-level, and the challenge sometimes is the teachers themselves carrying out the practicals. Sometimes learners do not understand what the practical asks in what to do, because sometimes we have little knowledge on certain topics or how to conduct a practical.* (Mr Adams)

Mr Adams further elaborated:

> *I can go through the practical we do together for them to see and experience this practical in real life and then with the ordinary-level learners I actually would require them maybe once in the month to actually do hands-on practical activities which they are literally doing it by themselves – just to help with confidence on how to manipulate with this equipment in the lab.* (Mr Adams)

The above excerpts emphasise that a hands-on approach to learning or practical learning assists the learners as well as the teachers to have a better perception of the theoretical aspects of food science by providing a hands-on approach and answering PCK gaps that exist. For practical learning to be meaningful to learners, it must also be hands-on, and it should not be just the teacher demonstrating. Hence, a practical session must actually be learnercentred.

Hodson (1990) mentions that the Senior Secondary Biology curriculum is divided into four domains that are knowledge with understanding, handling information, application and solving problems and practical skills and abilities.

One of the advantages of the Biology test is that practical activities are said to motivate, stimulate and maintain interest in Biology. With regard to this perception, Mr Adams marked it 3 and Ms Idan marked it 3. In light of this, it seems the importance of hands-on practical activities in Biology is emphasised. During the interview, this was mentioned by Mr Adams who reasoned that "*basically, the two years before the national exams we need to expose the learners, so we need especially the practical suggestions, to prepare learners well".* Ms Idan stated that "*basically, I was just doing the demonstration to put the theory into reality".*

To buttress this point, the literature used in the study supports this notion. For instance, this view is shared by Gresalfi (2009) who mentions that learning is considered to be a change in participation through which one "becomes" a different person concerning the practices of that activity set. Gresalfi and Cobb (2006) weigh in and mention that learning is a process of developing dispositions; that is, ways of being in the world that involve ideas about, perspectives on, and engagement with information that can be seen both in moments of interaction and in more enduring patterns over time.

One of the identified benefits of Biology practical activities is to develop certain scientific attitudes and manipulative skills. Indications from the findings highlight that respondents' teachers viewed this aspect as important as Mr Adams rated it 2, Ms Idan rated it 1. During interviews, the importance of manipulative skills was raised by Ms Idan when she postulated: *"I actually would require them maybe once in the month to actually do hands-on practical activities which they are literally doing it by themselves – just to help with confidence on how to manipulate with this equipment in the lab*" (Ms Idan).

The most important advantage of practical activities in Biology can be seen as enhancing the learning of scientific knowledge. However, responses from these teachers differed on this aspect. For instance, Mr Adams rated 7 while Ms Idan rated it the highest by giving it a 1. The diverse views on this aspect by the teachers can be summed up as different views on the importance of each benefit derived from practical activities in Biology food tests in Grade 10. During the interview, Ms.Idan highlighted the following:

> *Usually, with the teaching, I would really separate the two, theoretically in the class, because even if you do hands-on practicals for the higher-level learners, the theory they should know, the theory of the strategies and procedures and how to carry out these results. Usually, I will just use the same approach to explain how to do the practical, the difference comes with the emphasis I put in with ordinary learners, where I just stop there with the theory, I explain to them.* (Ms Idan)

I agree with the participant in the excerpt that there must be a distinct difference when it comes to higher-level learners and ordinary-level learners on explanations and demonstrations.

Choudhary (2016) posits that the development of PCK involves a dramatic shift in teachers' understanding: "From being able to comprehend subject matter for themselves, to becoming able to elucidate subject matter in new ways, reorganise and partition it, clothe it in activities and emotions, in metaphors and exercises, and examples and demonstrations, so that it can be grasped by students" (p. 13).

4.2.3 Challenges experienced when teaching food tests using hands-on practical activities

One of the challenges highlighted in the study was overcrowded classrooms which meant less laboratory space to conduct practical lessons. Biology is demanding and it is taught best by involving learners. The lack of an equipped laboratory at these schools makes the provision of education difficult. As a result, some experiments involving simple apparatus are only taught using demonstrations. That is, learners do not have to do the experiments themselves but have to watch teachers conduct the practical experiments instead. In this regard, Mr Adams commented that: "*A complete class will consist of almost an average of 40 learners that is an average. Sometimes can be little more, can be little less*". Also, Ms Idan elaborated on this:

> *Because we are dealing with a large number of learners and the laboratory has limited space, that is why I preferred to bring the material or apparatus to the classroom so that they could have an opportunity to view, otherwise I could have selected certain learners to go to the laboratory.* (Ms Idan)

The insertion above is indistinguishable from Nghipandulwa et al. (2019) who claimed that 69.9% of Biology teachers did not have a laboratory explicitly for conducting Biology practicals and instead performed their practicals in a common laboratory used for both Physical Science and Biology or in their classrooms. Two out of nine teachers demonstrated that they did not bother with practical work and instead taught Biology as just a theoretical subject, which disadvantaged students on Paper 3 which was an alternative to the coursework paper. The findings also revealed that 66.6% of teachers in the Oshana Education Region did not conduct Biology practicals. In the same study, it revealed that there was not much practical work going on in those schools, as four of the six observed teachers were only doing demonstrations. The findings also revealed that the materials required for practical work were not available in Biology classrooms or laboratories. This was evidenced by the lack of practical manuals for both teachers and students which necessitated the use of teacher-created handouts. This is a clear demonstration that much needs to be done to ensure a continuous pattern of laboratory practical work is going on for the benefit of learners keen to perform better.

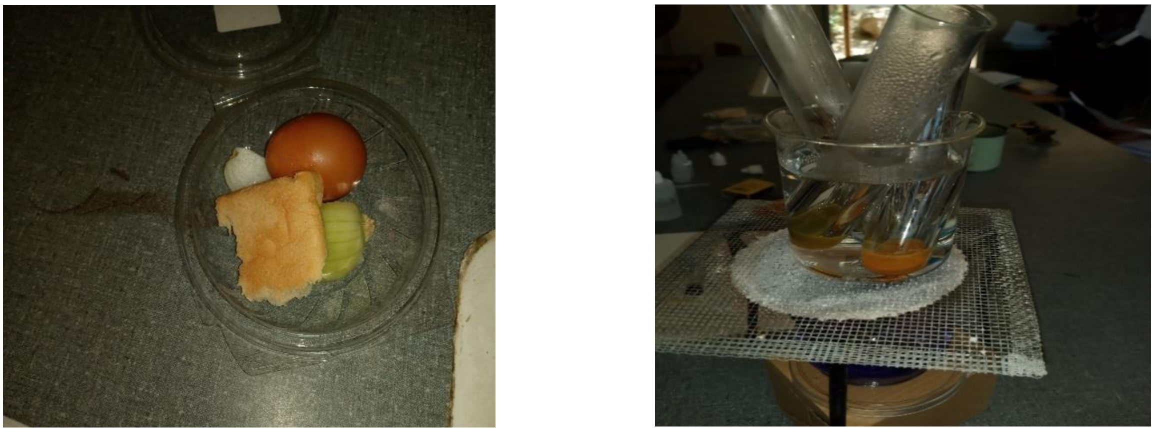

Figure 4A and 4B: A- shows the food that has been brought to the classroom by the learners, while B - shows crushed food samples put in a water bath

The figures 4A and 4B above shows the food that has been brought to the classroom by learners in preparation for the experiments. This means that learners were fully involved and well prepared for the experiments by sourcing for food samples. At the schools in this study, learners were exposed to investigations via demonstrations and in the other school, the learners were occasionally taken to the laboratory, which equipped them for the practical paper. However, in both schools, the practical activities were successful, and the experiments gave the desired results.

There seemed to be a challenge with regard to the time needed for the experiments, considering that there is limited time as learners also need to attend lessons. The timetable for learners gives them very little room to go through what has been learnt and as such, it is just lesson after lesson. This brings with it very little time to rest which means learners are studying under pressure and sometimes they fail to withstand the pressure which in return results in them failing to conduct the whole process of practical activities. This directly compromises how practical activities can be done since learners need to know the whole process from the actual set-up of apparatus to the testing and safety requirements that must be followed. In this regard, Mr Adams reflected that:

> *The greatest challenges on the practical now is that you won't have that same consistency throughout, you won't. You won't be able to carry out practical suggestions because you will burn out or be exhausted. In other words, it is really exhausting. So, the only recommendations, maybe we need learners inside on practicals, learners please do this and this, learners do not understand or the learners forgot, simply does not know how to manipulate the means of the apparatus. So then again you go back, do this and this. I think learners inside the lab will do*.

Lebata and Mudau (2014) support this view when they postulate that the learners' timetable is sometimes punishing if one looks at the number of subjects the learners are taking. It, therefore, makes it difficult for learners to continuously work under intense pressure doing so many subjects when they are given very little time to learn and are expected to have grasped everything in a very short period.

Teachers fulfil a crucial role when it comes to the teaching and learning of Biology in the classroom. It is, therefore, crucial that they not only know the Biology syllabus content well but know how to teach and conduct experiments. I believe that the lack of continuous training and skills development means teachers are still using skills and knowledge learnt in teachers' colleges two decades ago which might not be relevant in the 21st century as new methods of doing practical activities would have been invented.

Hofstein and Maalmlok-Naaman (2017) opine that teachers' academic preparation, certification type and years of teaching experience, among others, are often taken as indicators of teacher quality. Teachers play a crucial part when it comes to the teaching and learning of Biology in the classroom. It is, therefore, crucial that they not only know the Biology syllabus content very well but also know how to teach it.

All two participants who completed the questionnaires expressed the view that there was a lack of support from the subject advisors and the school management teams when it comes to practical activities in Biology, particularly from supervisors. The research findings revealed that the perceived lack of support from subject advisors and heads of department confused teachers on how to implement the Biology practical activities effectively. All participants stated that in most cases they felt stressed since there was no one to help them out when things became difficult. During the interviews, all the participants singled out the lack of support from subject advisors and heads of department as a challenge they experienced in the implementation of the Biology practical activities. When participants were asked to highlight the kind of support they experienced in the implementation of the Biology practical activities, they had the following to say. Ms Idan argued that "*Other challenges, sometimes maybe chemicals we are using might have expired. Sometimes it may not really show … truthful results".* Likewise, Mr Adams added that *"the reason why we store them together, I will just say, is the lack of organisational planning and usually we don't have time to separate the old and the new so that there can be a bit of order".*

In my own view, leadership remains one of the most critical components to making sure that learning institutions critically execute their mandate of educating learners. The support provided by school principals so that teachers have the necessary resources to execute their duties cannot be over-emphasised.

4.3 Chapter Summary

This chapter provided detailed views of the participants on the questions in the interviews and questionnaire. The views were contrasted and compared with the extracts from the literature reviewed. However, I similarly provided more detailed explanations and clarifications when necessary**.**

CHAPTER FIVE: DATA PRESETATION: STIMULATED RECALL INTERVIEWS, GROUP DISCUSSIONS AND REFLECTIONS

5.1 Introduction

My research question 3 sought to find out how discussions and reflections enable and/or constrain Grade 10 Biology teachers' understanding of carrying out hands-on practical activities to mediate learning of food tests.

In responding to this research question, l started by providing the enablers of carrying out hands-on practical activities to mediate learning of food tests.

5.2 Findings

Mr Adams mentioned that**:**

> *Basically, the two years before the national exams we need to expose the learners, so we need especially the practical suggestions, to prepare learners well. The other thing is most of the time you focus on Grade 12 and then you neglect the attention of the other classes. Especially the exam time, so I mean for higher-level national exams especially like two weeks before the exam, obviously that's the time you are allowed to open the question papers, so you can set up the lab, acquire the necessary equipment, materials, set up all that*.

Ms Idan commented that:

> *I believe that teaching food testing like theory, on the procedures how to do it is completely different from doing hands-on practicals because just saying it to them and then actually doing it, like brings another perspective to this food test. Usually, as teachers when you*

teach the learners about food tests, learners can basically accept what we say because we are the teachers and it is us who know. Even if I say that a positive test for Benedict solution the colour will change from blue to purple they just accept it. But sometimes they do not know if this is true or not. And then doing hands-on practicals actually brings it to another dimension where they actually see, this is actually possible and this true. What we are saying is that what we are talking about is actually proved and they can see by themselves. I just believe that it gives them a different understanding, different news, different perspective, generally on what science is by doing practicals.

The above insertions give the impression that the management of time on task is not effective, since Biology teachers feel overloaded to the extent that they sometimes neglect their laboratory practical tasks. On the other hand, it has also been proven that there is indeed a need for the theory to be understood before engaging learners in interpretations through hands-on practical activities.

In support of the above findings, Kandjeo-Marenga (2008) highlights that the aims and objectives of conducting hands-on practical activities are to explore teachers' abilities to apply Pedagogical Content Knowledgeable to give students a practical approach to carrying on activities. In light of that, the Biology curriculum's hands-on practical approach prepares students to learn with understanding rather than memorisation.

From these findings, it could be surmised that hands-on practical learning is meant to enhance and support the theoretical learning to make meaning from it, as most of the time, for learners, seeing is believing – hence the need to support the theory with the practical for them to have a better understanding of what is being taught. On the other hand, Muvhunga and Rollnick (2013) state that representations play a significant role as teaching aids that can help the learner make sense of what is being taught. This suggests that visual representations are important in how learners learn science concepts.

The study sought to find out how the summative assessments for the practical examinations (paper 3) affect the way the teachers teach the higher and ordinary-level learners during the year. Did they teach the learners differently because the summative assessments were different?

In addition, Ms Idan remarked that:

> *Biology level learners' ordinary-level, they do not do hands-on practical activities but then first they have alternative practical question papers. So that is how we conduct them. The question papers consist of a scenario of these experiments which are done, which are written on the papers and then they should just [give answers] from those scenarios given; there are follow-up questions which they should deduce answers from it. For higher-level Biology learners, they have paper 3 which is a practical paper not alternatives like ordinary which is hands-on practical. The teacher will prepare the lab, everything needed for each learner on the previous day or in the morning depending on the instructions of the examinations and then the learners will enter the lab. They have a question paper which often requires them to do a list of hands-on practical things in the lab and then they have to do it themselves. From the results – that is when they are asked questions regarding what they just did.*

Similar sentiments were shared during the literature review by the MEAC (2018, p. 1) who postulated that a practical hands-on approach provides, through well-designed studies of experimental and practical science, a worthwhile educational experience for all students whether they go to study science beyond this level. In particular, it enables them to acquire sufficient understanding and knowledge to become confident citizens in a technological world, to take or develop an informed interest in matters of scientific importance.

It was also highlighted that sometimes when using the hands-on practical approach, results might not come out as indicated in theory and this must be well explained to the learners. In this regard, Mr Adams claimed that:

> *I would like to say, usually when books are documented the strategies or procedures are written in the books, I would say this is the only way to carry out these practical because things, situations can be different and that is why as teachers, we shouldn't teach our kids to just focus on only this one thing because this scenario is given like this. They should also be told that situations can change. Therefore, the situation should be treated differently so*

then if in the textbook it was written use a puppet (sic) for example in the procedure documented in a textbook in the labs they come to find a syringe. Now I think we should instil this as a change of mindset. Even if scenario and scenario are big differences, they should always be able to think outside and use the materials that they are given to manipulate the situation depending on what they are given, not just be narrow-minded. Take what they have learnt and be able to think outside the box, be able to solve a problem when a situation is different.

Similar sentiments were expressed by Ms Idan:

The greatest challenges on the practical now is that you won't have that same consistency throughout, you won't. You won't be able to carry out practical suggestions because you will burn out or be exhausted, in other words it is really exhausting. So, the only recommendations, maybe we need learners inside on practicals, learners please do this and this, learners do not understand or they forget, simply do not know how to manipulate the means of the apparatus. So, then again you go back, do this and this. I think learners inside the lab will do.

The teachers need to have the skills, knowledge and right attitudes to implement aspects needed in hands-on practical activities. Additionally, the teachers who are positive about their teaching, the resources at their disposal and "the context handling, learning regulation, and (re-) design of curriculum materials" (Knoef, 2017, p. 45) will be able to explain to learners the reasons why certain experiments which have similar conditions and resources provide different results. In light of these assertions, it means that teachers must be knowledgeable enough to explain to learners the reasons why certain experiments which have similar conditions and resources provide different results.

Additionally, several challenges were also noted during the research study. For example, the large number of learners was a cause for concern and was viewed as affecting the effectiveness of hands-on practical approaches to teaching food tests.

Mr Adams claimed that a complete class will consist of an average of 40 learners; sometimes this can be a little more, can be a little less. "*With all of them can be tangible ordinary contents, higher-level just has extra contents. So, with higher-level, I usually select depending on their results. Usually for our learners to do higher-level, they need to at least have 70%*".

Shinana (2019) asserts that overcrowded classrooms overwhelm teachers to the extent that more scientific inquiry cannot be conducted properly. In my view, the challenge of overcrowding in public schools has been in existence for quite some time and there is no end in sight taking into consideration the continuing increase in the Namibian population. Teachers need to use the best possible means when teaching a large number of learners so that no learner is left behind. Learners could perhaps be grouped in such a way that all learners will get a chance to go to the laboratory, taking into consideration the groups and their sessions. In that way, the teacher can manage a large group.

Figure 5.1: Shows Ms Idan doing a practical demonstration with the help of a learner

The figure above shows Ms Idan doing a practical demonstration with the help of a teacher. The illustrations means that learners are actively involved during the practical demonstration. Instead of taking her overcrowded class to the lab, Ms Idan opted to do the demonstration. The learners looked on attentively. In the picture, one can also see how the test tube content is heated in the water bath to get the desired results.

Another notable challenge that has always existed when it comes to a practical hands-on approach to learning is the shortage of materials to conduct these practical food tests. In addition, the non-availability of resources or the limitations thereof limit teachers' capacity to properly conduct a laboratory food test where security is a priority.

> *Yes! I can say, our laboratory is up to standard. We have a lot of chemicals, but the problem is that some are old, and some are new, we store them together. We might not when these were purchased*. (Ms Idan)

Shinana (2019) mentions during the literature review the challenges associated with the lack of resources in laboratories in that some schools lack laboratories and infrastructure. This study focused on schools that have laboratories and why teachers are not using them for hands-on practical activities. As a researcher, I urge Biology teachers to be innovative in their approach to learning, even when there is a shortage of materials – they should work with the available resources and make the best use of them. Equally, in addition to the challenges that could hinder the use of hands-on practical activities and successful implementation of the NSSC Biology curriculum, teachers' conceptions, perceptions and attitudes are regarded as factors that similarly influence their practices (Shinana, 2019). As a result, in most secondary schools, hands-on practical activities are not consistently conducted because of the meagreness of the teachers' professional teaching skills and lack of resources and exposure (Choudhary, 2016). I agree with the two authors above that lack of practical activities in Biology has a detrimental effect on learners' learning process. Sometimes the skills of the teachers also contribute to the enhancement of learners' aptitude and attitudes of the learners towards the subject. All these efforts play a role in the performance and deliverance of the subject. Therefore, without teamwork, there is no real learning taking place in an induced lab. It also means that learners and teachers can work together to achieve the intended results as even if there are no adequate resources, there are many ways to improvise.

5.3 Chapter Summary

This chapter focused on the views of the participants' understanding of conducting practical work on food tests. The participants expressed the many challenges they faced while preparing for practical activities in the lab. The next chapter provides a summary of the findings, recommendations and the conclusion.

CHAPTER SIX: SUMMARY OF FINDINGS, RECOMMENDATIONS AND CONCLUSION

6.1 Introduction

This study was aimed at exploring how Grade 10 Biology teachers implement practical activities on food tests in their classrooms. It was triggered by the current state of teaching hands-on practical activities in Biology in Namibian secondary schools. The study sought to respond to the following research questions:

1. What are Grade 10 Biology teachers' perspectives and pedagogical insights on the use of hands-on practical activities when mediating learning of food tests?
2. How do Grade 10 Biology teachers mediate learning of food tests using hands-on practical activities?
3. How do discussions and reflections enable and or/constrain Grade 10 Biology teachers' understanding of carrying out hands-on practical activities to mediate learning of food tests?

In this chapter, I thus present a summary of my findings, recommendations from the study and the conclusion.

6.2 Summary of Findings

In this section, I discuss the summary of findings in relation to my research questions.

Research sub-question 1:

> What are Grade 10 Biology teachers' perspectives and pedagogical insights on the use of hands-on practical activities when mediating learning of food tests?

From the findings, teachers' views of practical hand-on activities corroborated those in the literature. For example, one teacher stated that the aim of hands-on experiments and hands-on practical work are often related to the nature of learning outcomes including investigative and practical skills. The development of these skills will be meaningful when teachers provide opportunities to learners to handle materials, observe events, handle observation results and be able to draw conclusions. Ms Idan expressed similar views. She indicated that there was a need to introduce the learner-centred approach. She was also determined to move around the classroom rather than being stationed in front of the classroom. Also, Ms Idan planned to make more use of the chalkboard to summarise main points as well as to give feedback to learners for assigned tasks.

Furthermore, the findings highlighted that when observation and measurement are complemented with hands-on practical activities they create information on real-world experiences among learners. The real world provides further interpretation, which in most cases learners cannot bring forth if they have not followed the correct steps. One teacher highlighted that one of the fundamental values of practical activities is that they enable learners to learn scientific knowledge and how to do science. They also allow learners to experiment through trial and error, learn from their mistakes and understand the potential gaps between theory and practice. Another teacher mentioned hands-on practical activities and elaborated that they include lectures, group experiments and teacher demonstrations where learners are involved in handling and observing real objects and materials.

Teachers should, therefore, provide opportunities for learners to handle materials, observe events, handle observation results and draw conclusions. In support of the respondent's perception of what hands-on practical activities are, the literature from Millar (2004) accentuates that hands-on practical activities are experiments/practicals that provide additional experience by deepening the understanding of practical skills in science classrooms. This means that hands-on practical activities increase the awareness of moving away from inductive reasoning to hypothetical-deductive reasoning to distinctively distinguish between data that will be collected and the explanations that students will derive.

The study also sought to identify the benefits associated with practical hands-on activities in Biology, one of which is being able to enhance the learning of scientific knowledge. The hands-on practical activities are said to benefit learners through being able to comprehend subject matter for themselves, to elucidate subject matter in new ways, reorganise and partition it, clothe it in activities, emotions, metaphors and exercises, examples and demonstrations, so that students can grasp it. Knowledge gaps can be filled during the food testing process and the experience of learners can similarly be enhanced. Scientific knowledge must be advanced by the theory of Shulman (1986) who stated that "from being able to comprehend subject matter for themselves, to becoming able to elucidate subject matter in new ways, reorganise and partition it, clothe it in activities and emotions, in metaphors and exercises, and examples and demonstrations, so that it can be grasped by students" (p. 13). In light of this, Shulman (1986) argues again that PCK is an acknowledgement of the importance of the transformation of SMK into SMK for teaching (van Driel et al., 1998). In other words, it refers to teachers' interpretations and transformation of SMK in the context of facilitating students' learning (van Driel et al., 1998). It is against this background, that learners should be given the optimum learning opportunities unveiled to them.

Another key and important aspect that emanated from the benefits derived from the hands-on practical activities was the ability to provide learners with opportunities to capture their real-life classroom experiences so that they have an appreciation of the theoretical aspects of scientific knowledge in practical means. This was said to be more important because theories have challenges in that they are not able to provide a clear and compact version of things but can only do so through practice, particularly within the subject of Biology.

Research sub-question 2:

> How do Grade 10 Biology teachers mediate learning of food tests using hands-on practical activities?

Practical activities were highlighted as capable of developing certain scientific attitudes and manipulative skills that are required in scientific studies. An open mind capable of thinking out of the box makes a great scientist for the future among learners. Hence, education tries to bring out the creativity of learners by showcasing the skills they have by allowing them the opportunity to practice hands-on what they learn in theory. By doing hands-on practical activities in the lab, learners might develop a passion for studying food nutrients contents and other related aspects which is a door opened for them to understand the activities from the perspective of scientific attitudes as well manipulative skills.

There was generally dislike and fear of Biology in the previous studies and learners were trying by all means to shun the subject. However, the real reason was a lack of understanding of certain scientific concepts. The hands-on practical activities motivate, stimulate and maintain interest in Biology. For learning to take place, there is a need to engage the learners with something that excites them and allows them to give their full attention. In light of that, practical hands-on experiments were identified as being capable of motivating, stimulating and maintaining focus and interest from learners during their education – a factor that was non-existent previously.

Experiments improve learners' conceptual understanding of Biology by allowing learners to be involved in the actual experiments not in theory but in practice. Under beliefs, there are "affective" and "cognitive" mechanisms. In other words, beliefs have to do with personal opinions, values and expectations that learners give to the subject topic when they have a better understanding between the knowledge being imparted to them and the learning taking place in class. This assertion is supported in the literature review by Atallah et al. (2010) who share the opinion that conceptions are opinions that students hold for Biology – their beliefs and expectations in learning the subject. Similarly, if teachers have views and beliefs that they think stimulate and influence teaching and learning, particularly in practice, it is likely to affect the outcomes of the hands-on practical activities.

The study sought to identify the constraints when Grade 10 Biology teachers carry out hands-on practical activities to mediate learning of food tests. The following were presented as the challenges. The study identified and found that a large number of learners results in overcrowded Biology classes and makes it difficult to control learners which affected teachers' ability to perform practical experiments and academic performance in Biology in the study area. The high number of learners makes it difficult for the teachers to accommodate learners in the laboratories and those laboratories themselves do not accommodate many learners. This resulted in only one of the teachers responding that they would do experiments in the laboratories when teaching higher-level learners because they are the ones with a lower level of learning conducted in Biology classes due to the nature of concentration required to be given to the learners to pass the subject. Similar sentiments were echoed by Namupala (2013) and Stephanus (2008) who mentioned that overcrowding in classrooms affects learners' academic performance. Classes that are overcrowded lead to teachers making use of teacher-centred approaches which do not actively engage the learners (Dabo, 2015). It has been reported that teachers' provision of individualised attention to weak learners influences academic achievement in secondary schools. This means that in less crowded classrooms, learners may receive individual attention and are more likely to perform better than in an overcrowded learning environment.

On the other hand, most schools had laboratories that were not in operation because they lacked proper equipment and chemicals. Biology as a scientific subject is learnt better by allowing learners to carry out the investigations on their own. However, in the absence of science laboratories, the teaching and learning of practical activities in Biology in most schools were indeed found to be problematic. Ambrose et al. (2000) support this by saying that most science laboratories in most high schools in Namibia were not in operation due to a lack of equipment.

The issue of time to conduct practical experiments for food tests was said to be insufficient. This ensure there is very little time to rest which means learners are studying under pressure and sometimes they do not perform well which in return results in them failing to conduct the whole process of practical activities. Teachers complained that the processes were exhausting and tiresome and leave their energy drained as they run around to try and implement the practical experiments. It works as a demotivating factor for the teachers. As a practical limitation, Farrell

(2004) argues that even if teachers are aware that they need to reflect on their teaching, there is continued pressure to get through the curriculum, and they are overburdened with other work outside the classroom. He went on to argue that, as a result, teachers have no room to entertain the idea of reflecting on their teaching. Most people assume that teachers know everything and therefore have all the details about Biology. However, the study did find that teachers do have information gaps from the time of their training in teachers' training institutions. As a result, in some aspects teachers have little knowledge about some biological aspects which the learners are supposed to learn.

Furthermore, the study revealed that there is a lack of commitment from the school management in assisting teachers with practical activities. As a result, this affects most practical activity lessons. In a study on the factors affecting Grade 11 learners' performance in Mathematics as perceived by learners, teachers and principals, Stephanus (2008) found that some of the supervisors fail to perform their duty of conducting class visits and when they do, they fail to give constructive feedback to the teachers which could help them to improve teaching and classroom management. Leithwood et al. (2004) notes that of all the factors that contribute to what learners learn at school, leadership is second in strength only to classroom instruction.

A **B**

Figures 6A & 6B: Shows how some laboratory taps have been broken which leads to a delay in the delivery of hands-on practical activities

Research questions 3:

> How do discussions and reflections enable and or/constrain Grade 10 Biology teachers' understanding of carrying out hands-on practical activities to mediate learning of food tests?

From the findings, the study revealed that the management of time on task is not effective, since Biology teachers felt overloaded to the extent that they sometimes neglected their laboratory practical tasks. On the other hand, it has also been proven that there is indeed a need for the theory to be understood from the theoretical point of view before engaging learners in interpretation through hands-on practical activities.

In support of the above findings, Kandjeo-Marenga (2008) highlights that the aims and objectives of conducting hands-on practical activities explore teachers' abilities to apply PCK and give students a practical approach to carrying on activities. In light of that, the Biology curriculum's hands-on practical approach prepares students to learn with understanding rather than memorisation.

From these findings, it could be surmised that hands-on practical learning is meant to enhance and support the theoretical learning, as in most cases, seeing is believing for learners, and to make meaning there is the need to support the theory with the practical for them to have a better understanding of what is being taught. On the other hand, Muvhunga and Rollnick (2013) state that representations play a significant role as teaching aids that can help the learners make sense of what is being taught. This suggests that visual representations are important in how learners learn and understand science concepts.

6.3 Recommendations

Teachers' refresher courses challenge teachers' lack of knowledge in some aspects, and so there is a need to have regular refresher courses. It is critical that the MEAC organise workshops where board members and principals could be trained and equipped with skills to be more knowledgeable about their subject areas. This can certainly go a long way in addressing the skills and knowledge gaps among Biology teachers.

Similarly, there is a need for CPD programmes to assist teachers who have challenges organising hands-on practical activities. This, however, can be done at the regional and circuit level so that all can receive adequate training. Responsible education officials should ensure that they reach out to school management to enhance the support and ensure that the necessary assistance is always available. Sometimes school management's hands are tied if they cannot do anything tangible to assist or render support to the teachers who do not have the equipment, for example in the lab. If regional CPD programmes can be set up even at the circuit level it will be of great assistance to the teachers in executing their duties.

Improvisation can be adopted to help with the shortage of experimental equipment and materials. These improvisations can be complemented with field trips to organisations that deal with biological aspects such as food and chemical manufacturers and hospitals as a means to allow learners to gain appreciation of the practical aspects of Biology in education which is limited within the school environment. Improvisations can also be done when there are too many learners and the teacher can choose to address a small group at a given time so that learners are given much-needed attention. Such improvisations make sure that the practical lesson activities that are done for learners improve their understanding of practical lessons.

Another measure is to put in place field trips to assist learners to experience most of the aspects of the theory that they learn in class as reality. Teachers should, however, be allowed to improvise with available materials if some laboratory materials are absent.

For experiments to be conducted meaningfully, there is a need to allocate enough time since it takes a lot of time to organise experiments. Having a double period for practical experiments makes more sense so that all the processes for the practical activities can be followed. On the same note, where time does not permit, using weekends and public holidays where they is no pressure from other subjects can result in the adequate coverage of practical activities.

The employment of a laboratory technician responsible for organising experimental activities, equipment, chemicals and other materials for the food tests will go a long way in reducing the time burden on teachers preparing and organising. It also reduces the use of expired chemicals in practical activities and makes sure that the laboratories are always in order when they are required for use. The laboratory technician can also aid in keeping the laboratory clean and help the teachers look out for learners that might be damaging the laboratory equipment.

6.4 Areas for Future Research

This study focused on exploring how Grade 10 Biology teachers implement practical activities on food tests. However, there is a need to broaden the study to include not only food tests but all the experiments which are done within the laboratory during science learning. Furthermore, in order to equally represent the whole of Namibia, the study should cover each education district in Namibia. The number of respondents should include both teachers and learners to get a balanced discussion with regard to the subject topic in Namibia. The study can further explore indigenous foods within the community and use them to do food tests.

6.5 Limitations of the Study

There are three limitations to this study. One of the limitations of this study is the size of the sample. The study only involved two teachers and this sample size is small and does not represent the whole population of Grade 10 Biology teachers in the Otjozondjupa region and the country at large. The smallness of the sample means that the findings of the study are not necessarily generalisable to all Biology teachers in Namibia. Similar research could be carried out that focuses on a larger sample of participants. Nevertheless, data from this study provided some insights on how Grade 10 Biology teachers carry out hands-on practical activities to mediate learning of food tests in their classrooms.

Another drawback would be that these individuals were all pursuing their BEd Honours while I was doing my master’s. It is possible that my academic seniority influenced them to participate, and that if I had been just another BEd Honours classmate, they would not have done so. Of course, it was made clear from the start that participation was entirely voluntary and that individuals may withdraw at any time.

In addition, the COVID-19 pandemic affected this research study in terms of time for data collection. During the peak of COVID-19, numerous lockdowns and restrictions were put in place by the Government of the Republic of Namibia. These lockdowns and restrictions resulted in the closure of schools in Namibia. When schools were closed it was impossible to gather data from the participants and also to carry out classroom observations. Thus, I had to wait for the schools to be opened to start data collection. However, when schools were opened, they were many restrictions that had to be adhered to such as wearing masks and maintaining social distancing. Therefore, I prepared an interview guide and lesson observation tool and maintained social distancing during the collection of data from the participants.

6.6 Personal Reflections

My research journey started during my college years although I did not have a good understanding of research. In 2107, I was introduced to Prof George Euvrard, a research lecturer at Rhodes University through the NIED programme. He made the research life seem so easy, but little did I know that it was just the theoretical part of everything. Then, the research was fun and interesting as he could practically show the differences in the research paradigms.

In 2018, I was introduced to my current supervisors Professor Ngcoza and Dr Nhase, who took us through different theories – some theories I was familiar with, and some were new. Of those theories, Shulman's (1986) PCK stood out for me, and this is how I came to choose it as my theoretical and analytical framework. In 2018, I had to submit a mini-research proposal for my final examination, not knowing that there was still a huge gap in the real research world.

At the end of 2018, I applied to Rhodes University for my master's, and I was accepted. With all this debt I decided to apply to Namibia Students Financial Assistance Fund. Firstly, I was not so confident, but in God I trusted; after some ups and downs I finally got awarded the funds. Although the money did not cover the first-year tuition, I could pay something to the university so that I could get my honours degree. In 2019 I had to do my proposal and in the same year, I was privileged to attend a workshop on introduction to research in South Africa – in Grahamstown at Rhodes University. That workshop was mind-blowing as it just triggered an eagerness in me to do this research project. At the workshop, for instance, there were scholars from all over Africa and it was interesting to see that it was doable, and I really learnt a lot. At the workshop, we were also taken through the ethics application process, which I found to be overwhelming.

Coming back from South Africa I had to continue with my proposal which needed to be submitted to the ethics committee for an ethical clearance certificate. The first response from the ethics committee was that major modifications were required for exploring how Grade 10 Biology teachers implement practical activities on food tests. This comment was not easy to digest, but I was well prepared because my supervisors had already prepared me and given me a template that I could use in case I would need to adjust and iron out those few errors. I followed my supervisors' advice and template that was adopted from Xolani Mayana and submitted and this time with better luck, I received approval from the ethics committee.

As a single mother of three 'little engineers' as Professor Ngcoza would refer to them, 2020 was not an easy year. The year started very well until finding a balance between my studies, work and parental obligations really started weighing down on me. Still, I managed to collect my data from the two schools although it was during the SARS-CoV-2 virus (COVID-19) with a lot of limitations as I could not do as many class visits as I would have liked. But even with all these challenges, I would always get feedback from Professor Ngcoza saying "Julia you are a star", or he would say "a star is always a star". This always put a smile on my face even though I was still being tormented by the many comments from his feedback.

I believe COVID-19 negatively affected the data collection process of my study as time was limited due to lockdowns and numerous strict restrictions. The time limitation was due to strict regulations such as lockdowns, curfews and restrictions of movement during the day. I remain indebted to my participants as they went that extra mile to help me collect my data, and they risked their lives for the love of education and the future of the Namibian child. The participants were excited when we had our group discussions, and I look forward to them taking part in my next research project. It was a welcoming community of practice as the participants accommodated me in their classes and their homes. In these COVID-19 difficult times, I learnt to be focused, persistent and resilient.

6.7 Conclusion

This study was aimed at exploring how Grade 10 Biology teachers implement practical activities on food tests in their classrooms. I gathered data to answer my three research questions to achieve this aim. I used questionnaires, SSIs, lesson observations, stimulated interview recalls, discussions and group reflections to gather my qualitative data. The study revealed that the Biology teachers involved in this study tried to make meaning of the definition and understanding of hands-on practical activities from different perspectives and the contexts they found themselves in. Their explanations were in line with Asheela et al. (2021) who states that hands-on practical activities increase awareness of moving away from inductive reasoning to hypothetical-deductive reasoning in order to distinctively distinguish between data that will be collected and the explanations that students will derive. The study further revealed that Biology teachers acknowledge the importance of hands-on practical activities. The study recognised that hands-on practical activities for learning or practical learning assist the learners as well as the teachers to have a better perception of the theoretical aspects of food science by providing a hands-on approach. This means that for practical learning to be meaningful to learners, it should be hands-on and not just demonstrated by the teacher. Hence, a practical session must actually be learner centred.

Additionally, the study also revealed that one of the challenges highlighted within the study is that there a large number of learners that have to fit in the school laboratory spaces where the practical lessons need to be conducted. Furthermore, there seemed to be a challenge with regard to the time for experiments, taking into consideration that there is limited time for lessons as teachers need to attend to the learners and shortage of experimental equipment. 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 can become fully aware of and also consistently practise, an inquiry-based approach in their classrooms.

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Appendices

Appendix A: Ethical clearance letter

RHODES UNIVERSITY
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Human Ethics subcommittee
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
NHREC Registration no. REC-241114-045

31/08/2020

Julia SHOOPALA

Email: g17s8163@campus.ru.ac.za

Review Reference: 2020-1186-3566

Dear Prof Kenneth Ngcoza

Title: Exploring what enables and/or constrains Grade 10 Biology teachers in carrying out hands-on practical activities to mediate the learning of food tests

Principal Investigator: Prof Kenneth Ngcoza

Collaborators: Ms. Julia Shoopala,

This letter confirms that the above research proposal has been reviewed and **APPROVED** by the Rhodes University Human Ethics Committee (RU-HEC). Your Approval number is: 2020-1186-3566

Approval has been granted for 1 year. An annual progress report will be required in order to renew approval for an additional period. You will receive an email notifying when the annual report is due.

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 the 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 cataloging number allocated.

Sincerely,

Arthur Webb

Prof Arthur Webb

Chair: Rhodes University Human Ethics Committee, RU-HEC

cc: Mr. Siyanda Manqele - Ethics Coordinator

Appendix B: Directorate Permission letter

REPUBLIC OF NAMIBIA
OTJOZONDJUPA REGIONAL COUNCIL

DIRECTORATE: EDUCATION, ARTS AND CULTURE
"Committed and Dedicated For Quality Education"

Tel no: 264 67 308000
Fax no: 264 67 304871
Enq: J. Sikeso
Email: jsikeso05@gmail.com

Private Bag 2618
Erf. 280, Sonweg Street
OTJIWARONGO
Namibia

20 August 2020

File No: 14/6/10

P.o.Box 94
Rhodes University
Grahamstown 6140
South Africa

Dear Ms. Julia Shoopala

SUBJECT: PERMISSION TO CONDUCT AN EDUCATIONAL RESEARCH WITH GRADE 10 BIOLOGY TEACHERS

Your letter dated 31 July 2020 bears reference and is hereby acknowledged.

Regarding the above mentioned subject, the Directorate of Education, Arts and Culture is pleased to inform you that permission is granted as per your request to conduct a research study at selected schools in Otjiwarongo Circuit. **NB: Please present this letter upon arrival at the school.**

You are kindly requested to make sure that, this research process should by no means whatsoever disrupt teaching and learning.

Your cooperation in this regard will be highly appreciated.

Yours faithfully

2020-08-21

....
MS. J.M. MUTENDA
REGIONAL DIRECTOR

All official correspondences must be addressed to The Regional Director

Appendix C: Principal permission letter

J.G. VAN DER WATH SECONDARY SCHOOL

P.O. BOX 40, OKAHANDJA
TEL: 062-501491 / FAX: 0886509158
E-Mail: jgvanderwath21@gmail.com
Cc: rowi5000@gmail.com

---

21 September 2020

TO WHOM IT MAY CONCERN

Dear Sir / Madam

RE: Permission granted to Ms Shoopala Julia to conduct a research study at JG van der Wath Secondary School.

This communique affirms that permission has been granted to Ms Shoopala Julia to conduct her research study at our school.

Thanking you in advance.

Yours sincerely

Mr R Williams
Principal

MINISTRY OF EDUCATION AND CULTURE
J. G. VAN DER WATH SECONDARY SCHOOL
2020 -09- 21
P. O. BOX 40 - OKAHANDJA
OTJOZONDJUPA REGION

Appendix D: Teacher consent letter

Dear Sir/ Madam

Re: Participation in research on Exploring what enables and or / constrains Grade 10 Biology teachers in carrying out hands-on practical activities to mediate the learning of food tests.

I am Julia Shoopala, a part-time student doing masters in science education at Rhodes University, South Africa. I hereby humbly request your permission to be a research participant in my research project. I plan to conduct the study for about four weeks in April/June 2020.

The focus of the study will be on *hands-on practical activities on food tests,* and it will be conducted in 2 phases. The first phase we will have a questionnaire and a semi-structured interview. The second phase includes a lesson observation and a stimulated recall interview.

Kindly be informed that your participation in this research study is completely voluntary and you can withdraw at any time you wish. I will ensure that your identity and views will be treated with high degree of confidentiality. It is recognised, however, that anonymity might be a challenge since we will be working together in this research project. Nonetheless, data that will be gathered will not be used for other purposes apart from this study. If you have any questions about the research, please feel free to contact me on 0812241626, shoopala2013@gmail.com or my supervisors Prof Ngcoza at k.ngcoza@ru.ac.za.

Your cooperation will be highly appreciated

Yours Sincerely

Julia Shoopala

DECLARATION BY PARTICIPANT

I agree to participate in the research, and I understand that I am free to withdraw at any time.

Name…………………………………………………………………………………….

Signature…………………………………………………………………………...

Contact number…………………………………………………………………

Appendix E: Parent informed consent declaration

RHODES UNIVERSITY
Where leaders learn

P.O. Box 1586

Okahandja

Shoopala2013@gmail.com

Dear parent / Guardian

Re: Request for your child to participate in the educational research.

I am Julia Nelago Shoopala, a part time student at Rhodes University with student number (17S8163). I have written a letter to the principal where your child is attending school to seek for permission to conduct an educational research. The focus of the research is to participation in research on exploring what enables and or / constrains Grade 10 Biology teachers in carrying out hands-on practical activities to mediate the learning of food tests. Should I be granted permission, I will be doing some video recordings of lesson presentations in which your child might appear. Therefore, I would like to seek permission from you to know if your child can take part in this educational research.

The research study will be under the supervision of Prof K. Ngcoza (k.ngcoza@ru.ac.za). My contact details are +264812241626 and email (shoopala2013@gmail.com). Should you have any concerns feel free to contact me, my supervisors and Mr. Siyanda Manqele the ethics coordinator at (ethics-committee@ru.ac.za) at any time.

I undertake to work with your child ethically and he/she will be free to choose whether to be part of this educational research or not.

Yours faithfully.

Julia Nelago Shoopala

……………………………………….

If you would give permission for your child to be part of this research study, please

complete the declaration below.

I.. (Full name of parent/ guardian)

hereby confirm that I understand the content of the letter and give permission for my

child to participate in the educational research.

....

Signature of parent Date

....

Signature of learner Date

Appendix F: Learner assent form

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CHILD PARTICIPANT'S ASSENT FORM

INFORMED CONSENT DECLARATION

(Child participant)

Project Title: *Exploring what enables and or / constrains Grade 10 Biology teachers in carrying out hands-on practical activities to mediate the learning of food tests.*

Researcher's name: *Julia Nelago Shoopala*

Name of participant: ……………………………………………………………………………………

1. Has the researcher explained what s/he will be doing and wants you to do?

YES	NO

2. Has the researcher explained why s/he wants you to take part?

YES	NO

3. Do you understand what the research wants to do?

YES	NO

4. Do you know if anything good or bad can happen to you during the research?

YES	NO

5. Do you know that your name and what you say will be kept a secret from other people?

YES	NO

6. Did you ask the researcher any questions about the research?

YES	NO

7. Has the researcher answered all your questions?

YES	NO

8. Do you understand that you can refuse to participate if you do not want to take part and that nothing will happen to you if you refuse?

YES NO

9. Do you understand that you may pull out of the study at any time if you no longer want to continue?

YES NO

10. Do you know who to talk to if you are worried or have any other questions to ask?

YES NO

11. Has anyone forced or put pressure on you to take part in this research?

YES NO

12. Are you willing to take part in the research?

YES	NO

______________________________ ________________________

Signature of Child **Date**

Rhodes University, Research Office, Ethics

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Appendix G: Questionnaire

Questionnaire

Adapted from Liswaniso, 2018.

Please check /tick (√) or fill in the description that mostly applies to you.

Section A

Please write your personal details in the following

1. Gender:

Male	Female

2. Age: …….

3. Teaching experience in Biology (years):

1-2	3-4	5 and more

4. Qualification:

BETD	
B. ED	
HED	

M.ED	
Other (specify)	

5. Grade you are teaching:

10	11

6. Number of learners: ……………………………….

Section B

This section asks you about how Biology practical activities are taught by the subject teachers in senior secondary schools.

1. Do you use practical activities in your teaching of Biology?

Yes	
No	

2. How often do you teach practical activities in your Biology subjects?

Once a week	
Once every lesson	
Once in two weeks	

Rarely	
Never	
Others (specify)	

3. What teaching time is allocated to practical lessons in Biology?

40 min	
80 min	
Other (specify)	

4. Does your school have a science laboratory?

Yes	
No	

5. Do you make use of the science laboratory or a classroom?

Classroom	
Science Laboratory	

6. What is your aim of teaching practical work to your learners? Please rank these in order of importance from 1 to 10. The most important should be ranked '1' and '10' the least aim should be ranked '10'.

Aim of teaching practical work	Rank
1. To enhance conceptual understanding	
2. To enhance investigative skills	
3. To enhance procedural knowledge about experiments	
4. To motivate, stimulate and maintain interest in Biology	
5. To develop certain scientific attitudes and manipulative skills	
6. To enhance the learning of scientific knowledge	
7. To encourage accurate observations and descriptions of objects	
8. To promote a logical scientific reasoning method of in solving problems	
To verify or clarify facts and principles taught in theoretical lessons	
To make biological phenomena more real through actual experience	

7. Do you have enough materials and equipment to teach Biology hands-on practical activities on food tests?

Yes	
No	

8. What type of practical work do you teach to your learners to achieve the development of practical skills?

Investigations	
Experiments	
Fieldwork	
Problem-solving activities	
Projects	
Exercise	
Excursion	
Demonstration	

Section C

1. What are your views about using hands-on Biology practical activities in your lessons? ………………………………………………………………………………………………
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2. What encourages you to teach food tests using hands-on practical activities? ………………………………………………………………………………………………
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3. What challenges do you experience when teaching food tests using hands-on practical activities on food tests to your learners? ………………………………………………………………………………………………
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4. How does these problems affect the teaching of hands-on practical activities on food tests? ………………………………………………………………………………………………
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5. How are summative practical examinations conducted for O/H level learners? ……………………………………………………………………………………………

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6. How does the conduct of the Summative practical assessment affect your way of teaching practical activities to O/H level learners? ……………………………………………………………………………………………

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7. Any other information or recommendations. ……………………………………………………………………………………………

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Thank you very much for your time and contribution!

Appendix H: Semi-structured interview schedule

1. Could you briefly share with me your views on hands-on practical activities when mediating learning of food tests?

2. Could you please tell me what encourages or challenges you to make use of hands-on practical activities?

3. Can you briefly explain to me how the Summative Practical assessment is conducted for Ordinary /Higher-level learners?

4. Could you please tell me how the conduct of Summative Practical examination affects your teaching using hands-on practical activities?

5. Is there perhaps any other information you would like to share with me or any recommendations for this study.

Appendix I: Classroom observation tool

Classroom Observation Schedule Form

Adapted from Simasiku, 2017.

Name of School: ________________________ Observation Date: __________________

Name of Teacher: _______________________ Grade: ___________________________

Subject: _____________________________ Number of Learners: _______________

Lesson Topic: __________________________ Observer: ________________________

Ratings:

1 (weak) = Extensive weaknesses

2 (Fair) = More weaknesses than strengths

3 (Good) = More strengths than weaknesses

4 (Excellent)= Strong in all aspects

ORGANISATION					
1	**2**	**3**	**4**	**Measure**	**Explanation**
				Teacher and learners are well prepared for class	

				Teacher and learners use class time efficiently	
				Teacher relates this to previous class(es), or provides learners with opportunities to do so	
				Teacher provides and follows an outline or organisation for the class session	
				Teacher has all necessary materials and equipment readily available	
				Teacher uses effective transitions between class topics	
				Teacher conveys the purpose of each class activity or assignment	
				Teacher completes the scheduled topics	
				Teacher summarises periodically throughout and at end of class or prompts learners to do so	

INSTRUCTIONAL METHOD					
1	**2**	**3**	**4**	**Measure**	**Explanation**
				uses a variety of instructional methods	

				the learning materials demonstrate a logical progression with learners' prior experience and knowledge	
				allows adequate wait time when asking questions	
				responds to wrong answers constructively	
				teacher draws non-participating students into activities/discussion	
				prevents specific students from dominating activities/discussion	
				asks probing questions when student answers are incomplete	
				teacher responds to questions clearly and promptly	
				guides the direction of the discussion	
				refrains from answering own questions	

				mediates conflict or differences of pinions	
				uses active learning strategies (group work, paired discussion, polling)	
				allows sufficient time to complete in-class assignments	
				specifies how learning tasks will be evaluated (if appropriate)	
				provides opportunities for students to practice what they have learnt	
				demonstrating experiments	
				teacher uses teaching technique(s) appropriate to the instructional goals for this class	
				teacher proceeds at an effective pace	
				teacher uses appropriate technology (e.g.., multimedia, electronic grade book, etc.	
				teacher provides clear directions for group work/labs/exercises	
				teacher assesses learners' learning	

				materials and equipment provide a wide range of experiences	
				decoration on walls (posters, flip charts, learners' works, etc.)	
				teacher makes material interesting to learners	

SENSE MAKING					
1	**2**	**3**	**4**	**Measure**	**Explanation**
				Learners making predictions	
				Learners choosing appropriate strategies	
				Learners drawing conclusions	
				Learner's reciting/recalling facts	
				Creating/formulating patterns/equations	
				Interpreting and analysing data	
				Making observations	

				Learners every day to scientific ways of reasoning	
				Learners' explanations	
				Learners' questioning	
				Learners arguing and presentation of information	
				Learners taking actions	
				Learner's interpretations	
				Learners exploring concepts and ideas	

LEARNERS ENGAGEMENT					
1	**2**	**3**	**4**	**Measure**	**Explanation**
				Learners involved in active learning task	
				Learners "talk and act" more than "sit and listen"	
				Learners share information in groups/pairs/individually	

				Learner-teacher, learner-learner, learner-material	
				All learners have the opportunity to participate in questions and activities	
				Specific learners' responses are elicited by the teacher	
				Learners respond in an appropriate manner (no shouting out, etc.)	
				Learners communicate openly and shows genuine interest in teacher	
				Learners are involved in doing practical work	
				Learners answer teacher's questions	
				Learners talking with other learners	
				Learner's writing, drawing and reading	

Observer's Name: __________________ Signature: __________ Date: ___________________

Teacher's Name: ___________________ Signature: __________ Date: ___________________

Appendix J: Transcribed group discussion and reflections

Mr. Participants partake during the interviews with one being the interviewee and two being respondents. In keeping with the anonymous principle of the teachers interviewed within the group discussion, respondents were identified as T1 as the first respondent and T2 as second respondent.

What do you understand by the term hands-on practical?

T1: "This is hands-on approach to teaching and learning which involves investigating skills".

T2: "This is where we draw the line between ordinary-level and higher-level education whereby in ordinary-level, they are basically given theoretical scenarios of experiments, whilst in higher-level they get to carry out practical experiment themselves".

Why carry out hands-on practical?

T1: "Basically it enhances learners understanding of some difficult theoretical concepts. It creates some believes hence compliments the vision of education".

T2: "Practical experiments helps prove theories and the learners get to see the reality of what they are taught in class".

How do you link the pedagogy to the content?

T1: "I am more of a drilling teacher. That will emphasise on assessment activities like tests and classroom exercises until satisfied that learners have grasped the taught concept"

T2: "Sometimes like the case in Biology, your view and understanding are not accepted. As a result, my pedagogy is to motivate learners to have a photographic memory of what is written in the textbook. My role will therefore help them make sense of what they are memorising"

What are food tests?

T2: "In my understanding food test are experiments done to test different types of food. For example, to prove that bread contains carbohydrates, proteins and fats in what percentage. When we undertaking these practical experiments not knowing what is contained in the food staff and these experiments assists us in proving what certain foods properties have".

T1: "These are some of the experiments that learners found fascinating where they discover new things from the food, they it every day and have an appreciation on the benefits and effects of the food they consume every day. Learners find it interesting particularly when colour changes during experiments as it appears magical to them.

What is required in these practical experiments?

T2: "First of all you need chemicals, solutions or regents. For example, in the Benedict solution, equipment and materials like bicker, experiment stand, benson burner are a must.

T1: "After having all the necessary equipment available, one requires to have a heart for it. It only means that both the teacher and the learners need to be willing to give their best for the learning process to remain interesting and exciting"

Can one have alternative chemicals to conduct experiments?

T1: "Like what my colleague has explained previously, the processes and procedures are laid down, hence one cannot have alternatives when conducting them as we risk of confusing learners of what is written in text and the practical, we are conducting"

Who brings the food you test to the classroom?

T1: "As teachers, we are just facilitators of education to learners hence we only tell them what is required for a certain experiment and the learners they can bring the food items. We do it as a way of involving learners in their own learning.

T2: "I often list down the food items required for a certain experiment, and ask the learners who can bring eggs, cooking oil and any other food staff in order to conduct the experiment. As a result, the learners do bring in the food items.

Do you often investigate indigenous foods since learners are from different backgrounds?

T2: “Indigenous foods brings an interesting dimension to food experiments but as a teacher, l has my own vision of what needs to be achieved with each lesson, hence l will only request for what is required for a lesson. Most Biology lessons are based on modern food. However, this is not to say that indigenous foods have no room in Biology. To accommodate indigenous foods in education, l would just explain to the learners what ingredients are contained in them and their benefits and disadvantages to their health.

T1: “Indigenous food experiments can be problematic but that does not mean they cannot be studied. We often discuss about them during lesson, but we have not conducted experiments on indigenous foods.

What is your idea of easily accessible resources?

T1: “Freely available and cheap”

T2: “What is cheap is usually readily available”

What do you think is the way we treat indigenous food compared to modern food when teaching learners?

T2: “Most of our textbooks had not put into consideration indigenous foods staff but they are now being highly considered since they are regarded as health as compared to modern foods. To accommodate them into our education, for example, l would just explain to learners what is contained in the mopane worms rather than conducting experiments on them. We obtain such knowledge through our own research using internet and from our teacher training and secondary school education.”

T1: “It all comes down to the issue of availability since most times, indigenous foods are scarce and expensive, whilst modern foods are cheap and readily available. This does not by anywhere means that indigenous foods cannot be experimented with”

What happens when they are no chemicals to carry out experiments?

T2: “As a time, improvisation is important, l can use a project to show learners video of the experiment so that they can have a first-hand appreciation of what lam explaining in theory. Alternatively, l can ask for chemicals from other schools who do have, and, in some instances, we do assist each other when other schools do not have the materials to conduct lessons with learners.

Can video be efficient in place of experiments?

T1: “These are scenarios we often come across every day in our lives as teachers, but we have to think on our feet and come up with solutions so that learners can actually learn. For example, in dip rural school where you cannot have access to internet, you must use even the environment around you teach experiment. Sometimes you are left with no option but to only teach theoretically with emphasise being made to learners to put it down as written in the textbooks.

Can you explain the value of using accessible resources?

T2: “Accessible resources are those materials that are readily available when required and, in most instances, they include those materials that can be reused”

T1: “These are learning materials that are easy to get and are often required to conduct experiments within laboratories”

What is the relevance of food tests?

T1: “The relevance of these food experiments is based on how creative you can be and how far you can go with each of the food tests and the value it brings to the lesson.

T2: “To me the relevance cannot be over-emphasised. It can be used to identify ingredients and components obtained in food staff. People can then identify those time of food they are allergic to and know what type of food to consume and not to consume in line with their health needs”