Exploring how the use of a mini-ecosystem enables and/or constrains grade 5 learners to make sense of scientific inquiry

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By

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Declaration of Originality

I, Tobias Ruusa Taimi (17T8183), hereby declare that this study entitled **"Exploring how the use of a mini-ecosystem enables and/or constrains grade 5 learners to make sense of scientific inquiry"** is my own unassisted work. This study was never submitted in any form of assessment or for any study to any higher institution. Ideas from other scholars used in the study were acknowledged using APA style of referencing and Rhodes University Education Department Guidelines.

	30 June 2022
Signature	**Date**

Abstract

The Namibian Science curriculum clearly states that learning of science should be promoted through using inquiry-based approaches. However, it does not state how teachers should go about promoting inquiry-based approaches in their classrooms, especially in under-resourced rural schools. This is exacerbated in part by the fact that there is inadequate or lack of professional development for science teachers which focus in particular on promotion of inquiry-based approaches. As a result, science teachers tend to ignore inquiry-based approaches in their classrooms. It is against this background that my study sought to explore how the use of a 'mini-ecosystem' enables and/or constrains grade 5 learners from an under-resourced rural school to make sense of scientific inquiry.

The study is underpinned by an interpretive paradigm. Within the interpretive paradigm, a qualitative case study approach, using the Predict-Explain-Explore-Observe-Explain (PEEOE) framework was adopted. This case study was carried out in an under-resourced rural Namibian school and the participants were grade 5 Natural Science and Health Education learners. I also invited a teacher from the school to be my critical friend and a participant observer. Data were generated using the Views About Scientific Inquiry **(**VASI) questionnaire, observations, focus group interviews and learners' reflections. Vygotsky's socio-cultural theory was my theoretical framework, and within this theory, I used mediation of learning, social interactions, the zone of proximal development and self-regulation as lenses to analyse my data. A thematic approach to data analysis was adopted. That is, qualitative data were analysed inductively to come up with sub-themes and thereafter common sub-themes were combined to form themes.

The findings of the study revealed that the observation of mini-ecosystems enabled learners to interact and participate with each other in their respective groups. Moreover, learners were able to identify some scientific concepts such as evaporation, condensation, water cycle and rainfall. These findings are in contrast with the fact that they seemed to struggle to answer the VASI questionnaire that was conducted prior to observation. The study thus recommends that science teachers should make efforts to use easily accessible resources such as a 'mini-ecosystem' to promote scientific inquiry amongst their learners.

Key words: Natural Science and Health Education, Mini-Ecosystem, Scientific Inquiry, ESD, Sense-making, VASI, Socio-Cultural Theory

Dedication

This thesis is dedicated to my exquisite children Sabina, Ndiitodino, Sindano and to all my family members and friends who played a role during this journey. I would also like to dedicate this thesis to my late mother 'Gwakasino' who was praying for me in her sick bed until she passed on in October 2020 during the COVID-19 pandemic. I thank you mom and please be our guardian angel!

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I would like to thank the school management of Rose Combined School (pseudonym) and its entire staff members for permitting me to carry out the study at their school. Thanks for allowing learners to observe their 'mini-ecosystems' which were placed on the window seals in your staff room to avoid being vandalised by other learners.

I would like to sincerely acknowledge learners who willingly agreed to take part in this study after teaching hours. Dear learners, you made this study a reality, and without your participation I would not be able to complete this thesis. I appreciate your participation, invaluable contributions and responses.

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I would like to thank my family and my late mother Kristofina Andenge (May her soul rest in peace!). You were a strongest woman ever during the 16 years being in sick bed. You raised us to fear God, love others and share a little we have with others. You always put us in our prayers. I miss going behind your room and listen to how you prayed for us since you liked praying in our absence. I also believe that you became our guardian angel. I am praying through Jesus Christ to give our guardian angel spiritual power to protect us from the merciless COVID-19 pandemic. Thanks to my brother and sisters for understanding my situation as sometimes I could not avail myself when you needed me most.

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Finally, I would like to extend my sincere words of gratitude to Ms Nikki Watkins for professionally formatting and editing my thesis.

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List of Abbreviations and/or Acronyms

AAAS	American Association for the Advancement of Science
ESD	Education for Sustainable Development
IBA	Inquiry-Based Approach
LCE	Learner-Centred Education
MEC	Ministry of Education and Culture
MOE	Ministry of Education
NIED	National Institute of Educational Development
MEAC	Ministry of Education Art and Culture
NOS	Nature of Science
NOSI	Nature of Scientific Inquiry
NRC	National Research Council
NSHE	Natural Science and Health Education
NSTA	National Science Teaching Association
PEEOE	Predict-Explore-Explain-Observe-Evaluate
SDG	Sustainable Development Goals
SI	Scientific Inquiry
STEM	Science, Technology, Engineering and Mathematics
UN	United Nation
UNESCO	United Nation Educational Scientific and Cultural Organisation
VASI	Views About Scientific Inquiry
ZPD	Zone of Proximal Development

CHAPTER ONE: SITUATING THE STUDY

1.1 Introduction

The Namibian Science curriculum clearly states that learning of science should be promoted by using inquiry-based approaches. However, it does not state how teachers should go about promoting inquiry-based approaches in their classrooms, especially in under-resourced rural schools. The main aim of this study was therefore to explore how the use of a [1]mini-ecosystem enables and/or constrains grade 5 learners from an under-resourced rural school to make sense of scientific inquiry.

In this chapter, I describe the background of the study. This is followed by my personal experience, the statement of the problem, purpose and significance of the study. The research goal, research questions and theoretical and analytical frameworks of the study are presented, followed by the description of the key concepts used in the study. Finally, the chapter ends with a chapter summary.

1.2 Background of the Study

The South African science education documents and policies seem to advocate for the inclusion of scientific inquiry in the K-12 school curriculum (National Research Council [NRC], 1996) in Natural Sciences. This implies that inquiry-based approaches to science learning should be developed from early childhood. Lederman et al. (2013) also supports these ideas, who posit that the ability to use scientific knowledge to make informed personal and societal decisions is the essence of what science educators and reform documents define as scientific literacy. Literacy can be described as the basic education that allows learners to read and write from the

[1] A mini-ecosystem is made out of small plants and wet soil that is put in a closed bottle.

onset of the education system. The whole idea is to support science teaching by promoting learning through inquiry (Department of Education [DoE], 2012).

Essentially, inquiry-based approaches are central to learner-centred education (LCE) (Asheela et al., 2021; CDR, 2015; Mccombs & Whisler, 1997). In light of this, Mccombs and Whisler (1997) suggest that learner-centred approaches guide the design of the educational system that supports learners' learning and achievement. Concurring, Nyambe (2015) posits that a learner-centred approach is a process that allows knowledge to be constructed in learners' minds as opposed to being constructed in teachers' minds.

The National Curriculum for Basic Education (NCBE) (MEAC, 2016), a Namibian document, looks at a learner-centred approach as knowledge-based learning. Knowledge-based learning moves learners from a literate society to a knowledge-based society. Hence, knowledge-based learning is when the knowledge created is being transformed and used for innovation to improve quality of life and to develop lifelong learning. Put differently, it is a way of using wisely the existing knowledge and creating new knowledge (MEAC, 2016).

Notably, knowledge-based learning resonates with Vygotsky's (1978) socio-cultural theory (SCT) because both these theories focus on knowledge that is constructed from a societal point of view or perspective. That is, through social interactions, ideas are learned and skills are developed. Knowledge-based learning and SCT have the potential to promote scientific inquiry during the teaching and learning of science. It is against this backdrop that in this study I sought to support learners with sense-making of the scientific skills and scientific processes that would hopefully lead to scientific reasoning and inquiry.

Similarly, in the Namibian context, the National Institute for Educational Development (NIED), through the Natural Science and Health Education syllabus (MoE, 2015), supports the use of scientific inquiry since it is critical for LCE. For instance, the syllabus states that learning experience in Natural Science should promote teaching and learning for understanding in order to provide scientific background. Science teachers are thus required to promote learning by using scientific inquiry teaching to help learners acquire scientific skills and knowledge by understanding, analysing and synthesising it in their own ways. To achieve this ideal, I consulted, analysed and interpreted different curriculum documents to gain deeper meanings in relation to scientific inquiry (Strydom & Delport, 2011). To Nhase (2019), scientific skills grow when learners are able to develop the Nature of Scientific Inquiry (NOSI) within their classrooms and in their community.

However, I have noticed that learners in grade 5 that are at rural schools, in particular, seem to have difficulty in understanding scientific meanings and terms in Natural Science and Health Education. I assume that this could be due in part to the fact that such terms are not part of learners' socio-cultural background (Mavuru & Ramnarain, 2017). Concurring, Maselwa and Ngcoza (2003) stated that taking learners' everyday experiences into consideration enhances their conceptual understanding. Moreover, another challenge could be attributed to the fact that teachers might not receive quality training that is the same as what they are expected to practice through an inquiry-based approach in their classes. As a result, some teachers use only theory without hands-on and mind-on practical activities in their lessons (Asheela et al., 2021; Mavuru & Dudu, 2021). To address some barriers to learner-centred learning, I explored how the use of a mini-ecosystem enables and/or constrains the sense-making of scientific inquiry.

1.3 My Personal Experience – Situating Myself in the Study

I attended a combined school in a rural area and there were not enough textbooks. Teachers used to write notes, drawing apparatus and pictures on the chalkboard. On the other hand, one had to wonder how best a teacher could accurately draw and/or how best every learner could draw at an early age. It was thus not easy to acquire and make sense of content knowledge because the whole teaching was theoretical.

Additionally, teachers found it difficult to teach science subjects during our time because the curriculum was more in a colonial language. Many science concepts could not be translated to the vernacular language for understanding and this resulted in some of us knowing terms without knowing their meanings. I assume that this could be because teachers were not trained in the way they were expected to practice scientific inquiry-based approaches in their classrooms (Shinana et al., 2021). On the contrary, teachers might not get the support they require to enhance inquiry-based approaches or perhaps they are not empowered to do so at all. That resulted in some teachers not being comfortable with the curriculum and they would get angry when asked to explain in detail something they did not understand. I can still remember my grade 6 environmental education teacher ignoring a question I had asked and starting to talk badly about me. She was like, "some people think they know better than teachers" and she pretended as if we both knew the answer. I was very disappointed and disturbed. From that day I stopped asking questions in class.

Another experience I encountered during school was teachers' assessment methods. In most cases, teachers informed us about the examination date so that we could prepare ourselves in advance. We used to pass well because everyone studied seriously. However, the reality was that we were only studying for examination purposes and that does not promote education sustainable development. That is, we just memorised specific concepts without understanding how we can relate them to our everyday activities and that led to rote learning (Nyamakuti, 2021). Teachers were either not sure of what teaching or learning methods to use instead of chalkboard and textbooks or they were reluctant because they did not receive enough training on how to improvise teaching resources.

I, therefore, learned that it is challenging to teach at a school with not enough teaching materials. At times, the situation forced teachers to write activities and tests on the chalkboard because there was neither photocopy paper nor ink. Correspondingly, if the activity consisted of pictures to be drawn on the chalkboard and the teacher was not an expert in drawing, they might replace it with a simple activity that consisted of words only.

Admittedly, prior knowledge elicited in schools should be related to everyday practices such that a teacher who is trained to use accessible resources may teach better through an inquiry-based approach than those who do not know anything about it. Despite the fact that I was taught methodology in my college education, I was not clear on how to probe learners to explore certain topics until I joined Rhodes University in 2017.

During my time at Rhodes University, doing an honours degree, I discovered teaching and learning through scientific inquiries as effective. I found that it is crucial to consider scientific inquiry during the teaching of science subjects because it allows learners to know how scientists reach conclusions (Akerson & Abd-El Khalick, 2005). During our contact sessions, for instance, I learned that it is significant for science teachers to include teaching materials in class. I learned also that if teaching materials are not clearly stated in the syllabus, teachers should try to improvise materials for better understanding.

For example, during our contact sessions at Okahandja, Eva who was a teacher by profession demonstrated the preparation of the traditional Namibian non-alcoholic beverage (*oshikundu*) and aimed at demonstrating the formation of carbon dioxide. I was so impressed to see the fermentation part and through the process, the gas of carbon dioxide was produced. Another practical demonstration was that of making *umqombothi*, a South African alcoholic beverage conducted at Rhodes University, Grahamstown, by an expert community member. The demonstrator presented in her home language isiXhosa while a master's student translated into English because the class was multicultural, attended by both South African and Namibian students. In her demonstration, I discovered so many scientific skills that are embedded in traditional practice.

Through this discovery, a lot of scientific concepts entrenched in traditional practice helps the understanding of scientific concepts through home language instruction rather than use of Western science, with all pictures and figures are unfami.

So, from all these presentations, I learned that it is possible to teach science using the learners' home language and easily accessible resources. I also learned that home language improves learners' class participation and understanding because they speak freely without any fear of language barriers. Hence, the more the learners participate in class, the more they might improve their scientific knowledge. The notion of the home language in science was also supported by Msimanga and Lelliot (2014) who stipulated that the use of home language with difficult concepts may be a legitimate source for science teachers to create opportunities for learners' conceptual understanding. Hence, all these findings and presentations motivated me to explore whether the use of a mini-ecosystem enables and/or constrains the sense-making of scientific inquiry of the topic of the ecosystem.

To conclude, the knowledge I gained from my supervisors and the two presenters opened my eyes to answer my long-awaited question on whether learners are capable of making sense of scientific inquiry when observing a mini-ecosystem brought to class as teaching materials. I discovered that if teaching tools are used with full knowledge, learners could make sense of the science concepts and if not used correctly, they might constrain the sense-making of scientific inquiry. Hence, I experienced through my everyday teaching that going to class without any teaching tools hinders the enhancement of scientific inquiry.

1.4 Statement of the Problem

The National Curriculum for Basic Education (MEAC, 2016) and the grade 5 Natural Science and Health Education syllabus emphasises the importance of promoting the teaching of science through inquiry. However, it is not clearly stated how teachers should use the approach to mediate learning of science. As a result, science teachers tend to be reluctant to teach using problem-based ways that require learners to work together to investigate phenomena (Gillies, 2019).

To ameliorate this problem, some studies related to the scientific inquiry have been conducted in Namibia and South Africa (e.g., Nhase, 2019; Shinana, 2019). In her study conducted in South Africa, for instance, Nhase (2019) explored how grade 3 Foundation Phase teachers promoted scientific process skills in their classrooms using learners' home language isiXhosa. Her findings revealed that the teachers involved in her study were able to use learners' home language as a resource to promote scientific process skills.

On the other hand, in her study conducted in Namibia, Shinana (2019) mobilised the indigenous practice of making *oshikundu*[2] to promote inquiry-based approaches. Her findings revealed that easily accessible resources, which could be in the form of indigenous practices, can be useful to promote scientific inquiry. However, I could not find any study focusing on the promotion of scientific inquiry in primary schools in Namibia using a mini-ecosystem as an easily accessible resource as reiterated by Asheela (2017) in her study. It is against this backdrop that my study sought to close this gap by exploring the use of a mini-ecosystem in promoting scientific inquiry.

1.5 Purpose and Significance of the Study

The purpose of this study was to explore how the use of a mini-ecosystem enables and/or constrains grade 5 learners in an under-resourced rural school to make sense of scientific

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[2] *Oshikundu* is a non-alcoholic beverage made by Oshiwambo people in Namibia and it is very rich in nutrients (Nikodemus, 2018; Shinana, 2019).

inquiry. That is, the investigation involved a mini-ecosystem which is an example of an easily accessible resource (Asheela et al., 2021; Ndevahoma, 2019; Shinana, 2019) to enable learners to reason scientifically. Moreover, and in addition to scientific inquiry, the mini-ecosystem was intended to allow learners to discover scientific concepts such as transplant, respiration, photosynthesis, energy, evaporation, condensation, water cycles and so forth. The monitoring of the mini-ecosystem contributed to the sense-making of these concepts. On a personal level, by engaging in this study I had hoped to improve my practices in terms of using easily accessible resources to promote inquiry-based approaches in under-resourced rural schools.

1.6 Research Goal and Research Questions

In this section, I present my research goal and research questions.

1.6.1 Research goal

The main goal of this study was to explore how the use of a mini-ecosystem enables and/or constrains the grade 5 learners from an under-resourced rural school to make sense of scientific inquiry.

To achieve this goal, the following research questions were addressed.

1.6.2 Research questions

1. What are grade 5 Natural Science and Health Education learners' views towards scientific inquiry?
2. How does using a mini-ecosystem enable and/or constrain shifts in grade 5 Natural Science and Heajhnlth Education learners' views towards scientific inquiry?
3. How does using a mini-ecosystem enable and/or constrain grade 5 Natural Science and Health Education learners to make sense of scientific inquiry?

1.7 Theoretical Framework

Vygotsky's (1978) Socio-Cultural Theory (SCT) of learning informed the study. Vygotsky (1978) believes that learning is a social process and it is the origin of human intelligence in society. He further elaborates that everything is learned at two levels; by interacting with one another and then by integrating knowledge into the individual's mental structure. Vygotsky emphasises that effective learning happens by social interaction between peers. Concurring, McRobbie and Tobin (1997) accentuate that the social plane complements the individual plane.

1.8 Data Gathering Techniques

- VASI questionnaire
- Observation
- Focus group interview
- Learners' reflections

1.9 Definition of Key Concepts

Natural Science and Health Education: Natural Science and Health Education is within the natural scientific area of learning in the national curriculum, which has a link to other subjects across the curriculum, making it interdisciplinary.

Mini-ecosystem: A closed-up bottle with small plants inside.

Sense-making: To figure something out.

Scientific Inquiry: These are methods and activities that lead to the development of scientific knowledge.

VASI: It is a paper and pencil assessment that measures learners' understanding of scientific inquiry.

Socio-cultural theory: A theory that looks at how learning and knowledge are constructed and obtained through social interaction within the community (Vygotsky, 1978).

1.10 Thesis Outline

This thesis consists of six chapters and I discuss what is contained in each chapter below.

Chapter One: Situating the Study

In this chapter, I explained the context of the study. I further explained the statement of the problem, purpose and the significance of the study. Furthermore, the research goal, research questions and theoretical framework were discussed. The data gathering techniques and the definition of concepts used in the thesis were defined.

Chapter Two: Literature Review and Theoretical Framework

Chapter two of the study presents the literature relevant to the study. The teaching and learning of science in primary schools and the Namibian curriculum are explained. The concepts of the ecosystem, mini-ecosystem, scientific inquiry and sense-making of scientific inquiry are explained. Educational for Sustainable Development (ESD) and challenges associated with ESD are discussed. The theoretical and analytical frameworks that underpinned the study are discussed.

Chapter Three: Research Methodology

Chapter three of the study provides the research methodology employed in this study. That is, the research paradigm and research design are presented. Additionally, the research goal, research sites, sampling and participants and data analysis are explained. Lastly, validity and trustworthiness are discussed.

Chapter Four: Learners' Views About Scientific Inquiry

The chapter gives a narrative description of data analysis developed from the VASI questionnaire that aimed to answer research questionnaire one. Research question one asks "What are the grade 5 Natural Science and Health Education learners' attitudes towards scientific inquiry?" I presented, analysed and discuss data from learners that focused on eight aspects related to knowledge of the scientific inquiry. The chapter ended with a conclusion.

Chapter Five: Observation, Focus Group Interview and Learners' Reflections

The chapter consists of three parts that answer research questions two and three. The first part presented data from observation. The second part presented data from the focus group interview. The third part presented learners' reflections. These parts aimed to ascertain whether a mini-ecosystem enabled and/or constrained the grade 5 Natural Science and Health Education learners from an under-resourced rural school to make sense of scientific inquiry.

Chapter Six: Summary of findings, recommendations and conclusions

The sixth chapter consists of a summary of findings, implications and recommendations from findings and personal reflections on this research journey.

1.11 Chapter Summary

In this chapter, the context of the study, research goal, research questions and key concepts were discussed. In the next chapter, literature related to the study and the theoretical framework that underpinned the study are discussed.

CHAPTER TWO: LITERATURE REVIEW AND THEORETICAL FRAMEWORK

2.1 Introduction

The purpose of the study was to work with grade 5 Natural Science and Health Education (NSHE) learners on how the use of a mini-ecosystem enables and/or constrains the sense-making of scientific inquiry in the topic of the ecosystem. The study was triggered and motivated by the need for the promotion of scientific inquiry in under-resourced rural schools in Namibia. I, therefore, chose to use a mini-ecosystem model as it exemplifies easily accessible resources as reiterated by Asheela et al. (2021).

In this chapter, I discuss literature relevant to the study. Firstly, I discussed literature on the teaching of science and NSHE as per the requirement of the Namibian curriculum. I also discuss the concept of an ecosystem and also literature about learners' attitudes toward science. The concepts of scientific inquiry, inquiry-based approach, nature of science inquiry and sense-making of scientific inquiry are also discussed. I also discuss literature on ESD in general, ESD in the Namibian context and challenges associated with its enactment or implementation. The theoretical framework underpinning my study, that is, Vygotsky's (1978) SCT is also discussed.

2.2 Current Science Teaching and Learning in Primary Schools

The Namibian Ministry of Education (NMoE, 2016) suggests that the teaching of science subjects should be emphasised from the primary level. This implies that learners need to develop scientific knowledge as early as possible because it can help them to acquire scientific reasoning at a tender age. The scientific knowledge gained by learners is believed to help them to engage in public discourse and debate about important issues that involve science and technology (Worth, 2010). Therefore, the teaching of science develops a greater appreciation and understanding of the real world if learners are curious to learn and when learners are exposed to hands-on practical activities during teaching (Asheela et al., 2021; Mavuru & Dudu, 2021).

However, the United Nations Educational Scientific and Cultural Organisation (UNESCO, 2013) identified that there is insufficient science exposure at the primary level and that needs to be improved. Namibia is no exception. UNESCO (2013) cited the teachers' lack of Science, Technology, Engineering and Mathematics (STEM) subject matter knowledge and educational resources. I assume that this might be caused in part by poor educational training from higher education institutions (HEIs). Moreover, some primary science teachers obtained their qualifications through part-time studies. As a result, it seems that they did not get full exposure to the subject matter knowledge and pedagogical content knowledge (Shulman, 1986). As a result, they cannot make sense of scientific issues, concepts and processes as required in the NSHE syllabus (MEAC, 2016). Concurring, Duarte et al. (2018) posit that there is low availability of resources that restrict science primary education in Namibia. This means that there is still more to be done in teaching primary science education in Namibia.

Yet, the expectation of the Namibian NCBE (MEAC, 2016) is to see learners use simple scientific models, methods and skills to make sense of the natural environment. That is, learners need to relate the implications of scientific understanding to their personal and social health and the sustainable use of all-natural resources for future generations (MEAC, 2016). Hence, there is a need for learners' exposure to science subjects.

Additionally, the NCBE (2016) and MEAC (2016) emphasise that upon completion of the junior phase, learners should use methods and skills to increase variables in existing scientific models for models to reflect real-life situations. Real-life situations enable learners to see the application of science in their everyday life (Gwekwerere, 2016). Furthermore, the NCBE (2016) indicates that the aim of teaching using real-life situations is to develop individual understanding, creativity and the ability to construct alternative solutions to problems. It is believed that real-life examples help learners realise the value of the natural environment and factors affecting it, and have the skills and knowledge to maintain a safe and healthy lifestyle.

It is recognised, however, that learners might not reflect scientific skills in real-life situations because teachers might not use scientific models in their classrooms. Hence, it is against this background that a model of a 'mini-ecosystem' that was used as a principle of Education for Sustainable Development (ESD) in the study improved the quality of learning by developing sustainable competencies such as collaboration, self awareness, communication and critical thinking (UNESCO, 2014) (see Section 2.5 for detailed information).

2.2.1 The Namibian curriculum and teaching of Natural Science and Health Education

The Namibia National Education for Basic Education (MEAC, 2016, p. 11) states that:

> Scientific literacy - understanding scientific processes and being able to apply scientific thinking and skills - is crucial today. The natural sciences area of learning contributes to the foundation of a knowledge-based society by empowering learners with the scientific knowledge, skills and attitudes to formulate hypotheses and to investigate, observe, make deductions and understand the physical world in a rational, scientific way.

This implies that curriculum developers need to consider the inclusivity of scientific processes that lead to scientific thinking and inquiry. Hence, for the teaching of science to be effective, teachers should play a great role in the implementation of curriculum reform in the classroom (Ottevanger, 2001). This scholar added that teachers need to learn new roles in teaching and use new or revised materials to master new skills. Conversely, according to Ottevanger (2001), the Namibian curriculum goals are difficult to implement since resources such as textbooks are not readily available or enough for every learner. This contributes to rote learning that limits economic transformation and socio-cultural dynamics of a society (Josua et al., 2022), particularly in the context of this study, Namibian society.

In Namibia, specifically in primary schools, Natural Science is a subject combined with Health Education and is called NSHE. Natural Science and Health Education (NSHE) is within the natural scientific area of learning in the national curriculum, which has a link to other subjects across the curriculum, making it interdisciplinary in nature. Essentially, learning experiences in the natural scientific area aim at increasing learners' knowledge and understanding of the physical and biological world of which they are part – their lived world (Ottevanger, 2001). Moreover, the NSHE syllabus integrates Natural Science, social, economic, physical, mathematical and technological learning areas of the curriculum, aimed at motivating learners to effect changes in behaviour which promote good health (MEAC, 2015). Therefore, there is a need for a continuum and meaningful flow in subjects and specific topics from one grade to the other. Mavhunga and Rollnick (2013) refer to this as curricular saliency. That is, how the curriculum progresses from one topic to another or from grade to grade.

Regarding the subject allocation, the NCBE (MEAC, 2016) indicates that the Natural Science learning area comprises the following subjects: Environmental Learning (Pre-Primary); Environmental Studies (Grades 1-3); Natural Science and Health Education (Grades 4-7);

Elementary Agriculture (Grades 5-7); Life Science (Grades 8-9); Physical Science (Grades 8-9); Agricultural Science (Grades 8-12); Biology (Grades 10-12); Physics (Grades 10-12); and Chemistry (Grades 10-12). For instance, the Namibian Ministry of Education (MoE, 2009) states that the curriculum for Junior Secondary Life Science and Senior Secondary Biology syllabi express the importance of continuum in the subject, in particular, the topic of ecosystems. The topic of ecosystems runs from grade 4 up to grade 12; this gives a logical flow of meaning from simple to complex.

This continuum and progression help learners relate prior knowledge to new knowledge (Kuhlane, 2011; Roschelle, 1995). In light of this, scholars such as Kuhlane (2011) propose that teachers should always use learners' prior knowledge when teaching every topic of the new grade; this is also a requirement for the NSHE syllabus. In this regard, the NSHE syllabus' objectives are:

- Convey the content directly;
- Let learners discover or explore information for themselves;
- Learners need directed learning;
- Learners need remedial and enrichment teaching and support; and
- Learners can be allowed to find their own way through a topic or area of content.

In such cases, tasks should be designed so that pairs or group work are needed to complete learning, and teachers are urged to use local examples to illustrate scientific issues, concepts and processes (MEAC, 2015). As a result, NSHE is divided into five components, namely Health Education, Scientific Processes, Matter and Environment, Living Organisms and Energy. Of the five components, however, my study focused on the concept of ecosystems, a topic under the component 'Matter and Environment'.

However, if the teaching and learning process is not done through an inquiry-based approach, learners will continue to struggle mastering scientific skills (Penn, 2019), which then results in poor science reasoning. Hence, I believe that a mini-ecosystem is a useful model to demonstrate the process of investigating and comparing it to a real ecosystem. Likewise, the mini-ecosystem was useful in harnessing scientific inquiry skills amongst my learners.

2.2.2 An ecosystem

According to Elphick and Mackernzie (2015), an ecosystem is an area that involves a deep understanding of the existence of animals and plants. That is, plants and animals in an ecosystem need each other for survival. However, it seems there is confusion between ecosystem and ecology. Magntorn and Hellden (2005) define the difference between ecology and ecosystem, stating that ecology is a large component of biology, while an ecosystem is a central concept in ecology. This suggests that ecology is an umbrella term, whereas ecosystem is a concept within ecology.

Notably, there are many types of ecosystems, but the NSHE syllabus only looks at three main ecosystems that are common in Namibia, namely, the Coast and Sea, Desert and Savannah ecosystems (Elphick & Mackenzie, 2015). These scholars aver that there is a need to identify the importance of an ecosystem for human existence and advocate for environmental awareness of how to maintain the ecosystem.

For instance, Figure 2.1 below reveals that this ecosystem was not maintained as people were cutting down trees and this should be prevented. Even though cutting down trees is not good as it has negative effects like deforestation and soil degradation, it made life easy for other living organisms. The photograph was taken by Clopton (2013) a science teacher who was preparing for the lesson on types of ecosystems in her grade 5 classes. Under the dry wooden tree, Clopton found ants, spiders, roaches and roly-poly. All these animals were surviving well in the dried woods. This implies that there is life under a dead tree. However, in the African context, dried wood is used for fire, building houses and so forth. So, if one has to take the wood without knowing the negative impact on living and non-living organisms, they might affect the ecosystem under the dried wood. Notably, a concern raised by Fisher et al (2013) that This suggests that a science teacher could take their class to this spot to teach about an ecosystem.

Figure 2.1: Shows an example of an ecosystem (www.nps.gov>learn>upload)

For instance, in most rural areas in Africa, people depend on their ecosystem for survival through getting natural resources directly or indirectly (Egoh et al., 2012). Concurring, Wangai et al. (2016) add that the African context promotes cultural ecosystem services because it enhances the economic and socio-cultures of many countries through agriculture. Agricultural practices that help in ecosystem services are maintaining water quality, pollination, nutrition, soil retention, carbon sequestration and biodiversity (Davari et al., 2010). The study, therefore, was intended to enable learners to understand the importance of an ecosystem and how to maintain it through mobilising a mini-ecosystem.

2.2.3 Mini-ecosystem

According to Bruner (2012), a mini-ecosystem is when you put soil and plants in a closed glass bottle. Hence, creating a mini-ecosystem allowed us to investigate the ecosystem in the form of simple hands-on practical activities (Asheela et al., 2021; Finnerty, 2020).

Nevertheless, not all models act as enabler to the research questions. If a model used without proper consultations, it would not deduce to the expectations. Hence.in the study, there was a discussion amongst groups about whether or not the mini-ecosystem would survive in the bottle. In light of this, the model of a mini-ecosystem gave learners a living demonstration which enabled them to reach deeper understanding (Bruner, 2012)

Figure 2.2: Shows a mini-ecosystem (www.sumcoco.com)

My study participants understood that the mini-ecosystems that we designed were made up of producers as reiterated by Ginn (2014). Ginn further explains that producers are organisms that create their own food through the processes of photosynthesis and chemosynthesis. Further, that photosynthesis is when food is created by green plants, while chemosynthesis is when food is created by anaerobic bacteria. However, a mini-ecosystem is made up of consumers (organisms that feed on other organisms) and decomposers (organisms that feed on dead organisms) (Ginn, 2014). Hence, through a mini-ecosystem, new concepts were developed and were translated from general terms to scientific terms which is a significant component of scientific literacy (Lederman et al., 2018).

2.3 Learners' Attitudes Toward Science

Attitudes are evaluative judgements formed by a person (Aijzen, 2001). Aijzen adds that evaluation and the subsequent decisions depend upon personal knowledge, feelings and experiences. Another definition is that attitudes are the combination of emotional or affective components (liking or disliking), a cognitive component (beliefs) and a behavioural component (tendencies to act towards these items in various ways) (Baron, 2001; Reid, 2006). Osborne et al. (2003) describe attitudes about a subject as encompassing feelings, beliefs and values toward the subject. Concurring, Agunbiade et al. (2017) claim that attitudes toward learning science could be positive or negative depending on science activities/studies, interest in science or science-related careers and perceived usefulness of science.

Attitudes are recognised as a second indicator (D2) out of the other six disposition indicators by Atallah et al. (2010) and these scholars used the second indicator (attitudes) to address learners' attitudes toward Mathematics. However, regarding negative attitudes, literature by Kihwele (2014) disclosed that most learners believe that science is difficult and is not for all but only for a few individuals. Experiencing such negative beliefs about science, Kihwele (2014) argued that learners become reluctant, resulting in poor performance. Adding to Kihwele's arguments, Agunbiade (2017) in her study hypothesised that some learners believe that science is difficult even before they study it, resulting in poor effort and ultimately poor achievement.

In contrast, in this study, I used Atallah et al.'s (2010) second indicator to address learners' attitudes towards learning scientific inquiry. Additionally, I was interested to establish whether there were shifts (or not) in learners' attitudes from the beginning of the study until the end. Figure 2.3 below shows six modified dispositions indicators by Atallah et al. (2010).

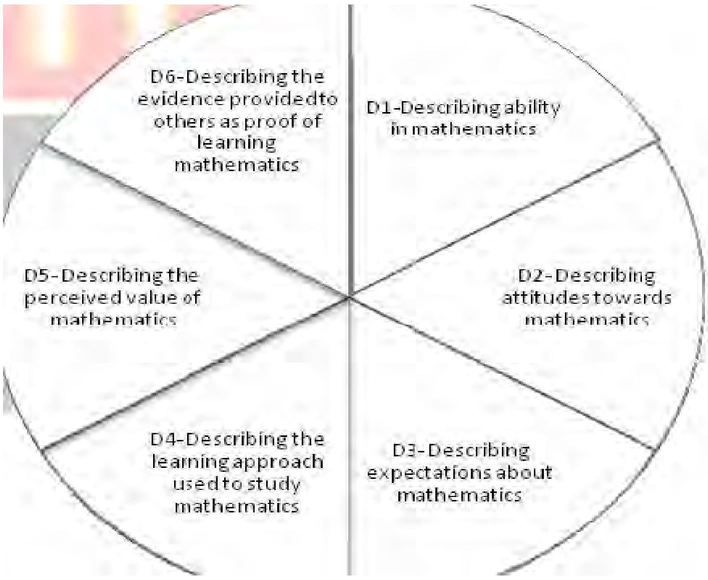


Figure 2.3: Atallah et al.'s (2010, p. 8) disposition indicators

Ekawati (2017, p. 4) indicates that:

> The habit of thought associated with scientific thinking deserved more careful consideration. To be scientific means that one has such attitudes as curiosity, rationality, willingness to suspend judgement, open mindedness, critical mindedness, objectivity, honesty and humility etc. attitude regulate behaviour that is directed towards or away from some object or situation group of objects or situation.

As articulated earlier by Osborne et al. (2003), learners' attitudes toward science vary depending on the subject and topics. Extending on Osborne et al.'s ideas, Ainley and Ainley (2011) and Bybee and McCrae (2011) accentuate that a positive attitude towards science ultimately influences learners' continuing engagement in science activities. They highlighted that learners have positive attitudes toward the learning of human science, health and diseases in Biology. However, Osborne et al. (2003) further point out that learners develop negative attitudes toward the subject because they are being forced to memorise topics rather than find a sense of the topic. Memorising could also be caused by a lack of using models and tools that enhance learning of science. That then contributes to rote learning. Rote learning methods are mostly found in under-resourced schools where teachers seem to teach without teaching and have a lack of learning materials, overloaded classes and/or no laboratories (Kibirige & Hodi, 2016).

2.4 Scientific Inquiry

According to the National Science Education Standards as stipulated by the National Research Council (NRC, 1996, p. 23),

> [Inquiry] involves making observations; posing questions; examining books and other source of information to see what is already known; planning investigations; reviewing what is already known in light of experimental evidence; using tools to gather, analyse, and interpret data; proposing answers, explanations, and predictions; and communicating the results. Inquiry requires identification of assumptions, use of critical and logical thinking and consideration of alternative explanations.

Scientific inquiry is defined by Schwartz et al. (2003) as characteristics of the scientific enterprise and processes through which scientific knowledge is acquired. That includes the conventions and ethics involved in the development, acceptance and utility of scientific knowledge. Schwartz et al. (2003) further explain that scientific inquiries are methods and activities that lead to the development of scientific knowledge.

Lending support, Lederman (2009) refers to scientific knowledge as a systematic approach used by scientists in an effort to answer their questions of interest. Lederman (2010) further looks at scientific inquiry as general science process skills with traditional science content, creativity and critical thinking to develop scientific knowledge. Agreeing, Worth (2010) also adds value to scientific inquiry, as he specified that inquiry develops learners' scientific skills either explicitly or implicitly. Scientific inquiry within the parameters of the school is discussed as a learning activity that can equip learners with skills to investigate the natural world and engage in critical and analytical thinking resulting in solving problems in an authentic scientific context (Meyer & Crawford, 2015). This is supported by Naude and Meier (2016) who define inquiry as a cluster of learning and teaching approaches in which learners' inquiry or research drives the learning experience. Recently, scholars such as Gaigher et al. (2014) believe that scientific inquiries are views and perceptions of learners towards scientific reasoning. Also, Kambeyo (2018) concurs that scientific inquiry represents the systematic process of investigating questions about the natural world, resulting in the discovery of new scientific knowledge. Hence, science investigations are guided by teaching through inquiry.

Similarly, Friesen (2017) stipulates that learners engage in inquiries through asking questions and seeking clear answers; hence, teaching through scientific inquiry is central to a learner-centred approach (Nyambe, 2008; Nyambe & Wilmot, 2012). The approach allows learners to engage actively in inquiry processes and meaningful construction of knowledge, with teacher guidance to achieve a meaningful understanding of scientifically accepted ideas (Krajcik et al., 1994; Minstrell & van Zee, 2000; NRC, 1996; Roth & Roychoudhury, 1993). In learner-centred approaches, learners are expected to raise questions, predict answers, investigate and provide explanations (Bosman, 2016) and teachers facilitate the learning process (MEAC, 2016). Adding to learning through inquiry, Shinana et al. (2021) states that learners authentically learn science concepts when afforded an opportunity to explore (Nhase 2019).

Nonetheless, if teachers lack scientific inquiry, then they would not be informed on how to foster scientific inquiry among learners (Penn, 2019). Penn (2019) in her study concludes that poor inquiry-based pedagogies are unable to scaffold learners' understanding of NOSI. It seems like some teachers do not know how to improvise in the case of a lack of resources. In that regard, some teachers tend to ignore teaching by an inquiry-based approach and instead stick to rote learning.

Teachers are thus advised by Penn (2019) to nurture learners' understanding of the nature of the scientific inquiry to help them improve their understanding of science. Therefore, this study afforded my learners an opportunity to understand how scientists develop knowledge and how they critique things (Lederman et al., 2013). Also, learners' sense-making of science concepts was enhanced as they emerged from the mini-ecosystem. Notably, learners discovered some of these concepts by themselves and developed a deeper understanding by asking each other questions in their groups. Hence, inquiry-based approaches are useful in promoting learner talk and discussions in science classrooms (Lemke, 2001; Sedlacek & Sedova, 2017).

2.4.1 Nature of Scientific Inquiry

The National Science Education Standards (National Research Council [NRC], 1996) and Benchmarks for Science Literacy (American Association for the Advancement of Science [AAAS], 1993) recommend that elementary learners develop an understanding of how scientists go about their work in terms of understanding science as inquiry as well as the nature of science (NOS). From the earliest grades (K-2), the Benchmarks recommend that learners not only "gain lots of experience doing science" but they should also be taught about "how the science community arrived at those conclusions" (Akerson & Abd-El-Khalick, 2005, p.4).

Lederman (2007) defines NOS as the epistemology of science, science as a way of knowing or the values and beliefs inherent to the development of scientific knowledge. Most countries regard the understanding of NOS as a primary goal of science education, which arouses the question of what exactly NOS is (McCain, 2016). In this regard, Settlage and Southerland (2012) describe NOS as an unspoken assumption that guides the actions of scientists. Another definition by the National Science Teaching Association (NSTA) is that NOS is a critical component of scientific literacy that enhances learners' understanding of science concepts and enables them to make informed decisions about scientifically based personal and societal issues.

Explaining NOS, the NSTA, 2020) stipulates that learners need to know that scientific knowledge is reliable. This is supported by the AAS (1993) as they state that scientific knowledge is simultaneously reliable and subject to change. These two associations believe that scientific knowledge is subject to changes. That is, old ideas can be replaced or supplemented by new ideas. Learners should then try to make sense of contemporary scientific knowledge and keep in mind that scientific methods can change. That is, science is dynamic and not static. Scientists believe that science needs to be delivered through inquiry using science practicals (NRC, 2012).

Scientific inquiry hence provides a viable context for discussion and reflection within which learners can develop NOS conceptions (Carey & Smith, 1993; NRC, 1996). The teacher then must engage learners in meaningful scientific inquiry (Akerson & Abd-El-Khalick, 2005) to find meanings in whatever they are practicing in class as well as to help them adopt such scientific methods. However, Bansal and Ramnarian (2021) stipulate that implementation of inquiry-based teaching has been silent due to intrinsic factors such as lack of professional science knowledge that contributes to teachers' uncertainty in the inquiry-based approach. Moreover, these scholars also state that extrinsic factors such as school ethos, professional support, resources, class size and others serve as significant barriers in the implementation of an inquiry-based approach. Hence, policymakers and institutions of higher learning need to work together and include inquiry-based teaching strategies in primary education in order to advance learners' conceptual understanding to adopt an inquiry-based pedagogy (Bansal & Ramnarain, 2021).

According to Lederman et al. (2020) students should be able to understand how scientists do their work and how scientific knowledge is developed, critiqued and eventually accepted by the scientific community. Adding on to these, Lederman et al. (2019) argue that teachers should not only engage learners in investigations but also provide them with explicit/reflective instruction on the rationale for every inquiry action. Such instruction develops learners with the knowledge and skills of doing scientific inquiry as well as the understanding of the nature of scientific evidence and knowledge, which they can use long after leaving school (Lederman et al., 2019).

Bantwini (2017) found that in most schools, poor infrastructure and resources limited learners' engagement in inquiry-based activities and by extension the opportunity to understand the NOSI. Of notable importance to the current study is that most South African primary school teachers are poorly qualified to teach science because they did not major in science during their teacher development process (Penn et al., 2020).

Moreover, Penn (2019) in her study conducted in South Africa further states that science education researchers have carried out several studies and the findings have indicated that there is still a gap between policy and implementation of inquiry in school science. She indicates that fewer studies have been conducted to elicit learners' understandings about inquiry in South African schools. In this regard, it could be hypothesised that few educators consider teaching science through inquiry in South Africa. Such a gap is also reflected in the Namibian science subject policy and guide in the sense that educators are not literary trained to teach through inquiry (learner-centred approach). De Kock (2005) says that it is doubtful that teachers will be able to identify, analyse and extend learners' scientific interests if they are not comfortable with imparting the scientific knowledge. Such a challenge has made educators reluctant since there is no concrete guidance to follow.

2.4.2 Scientific inquiry-based approach in science classroom

An inquiry-based approach is a way of teaching that is intended to eliminate rote learning to a more constructivist view of learning (Harlen, 2015; Ramnarain & Hluatswayo, 2018). As stated by Shinana et al. (2021), the inquiry-based approach is aligned with the learner-centred approach since learners are at the centre of learning while teachers facilitate the learning process. That is, inquiry-based learning affords learners an opportunity to ask questions, suggest a way of answering such questions, predict, propose explanations, collect evidence and interpret information in relation to the questions being investigated (Asheela et al., 2021; Harlen & Qualter, 2014). Penn (2019) also adds that learners should be able to make their own observations, classifications, predictions, measurements, hypothesise, ask questions, and collect, analyse and interpret data. This was indeed the intention of this study.

In the case of my study, therefore, the Predict-Explore-Explain-Observe-Explain (PEEOE) approach (Asheela et al., 2021) played a great role as it enhanced the learner-centred approach that promotes discussions and social interactions (McRobbie & Tobin, 1997; Vygotsky, 1978). Learners monitored the plants that they had put in closed bottles (mini-ecosystem). Prior to putting plants in the bottles, learners were asked to predict what would happen to the seedlings. Learners also explored by putting the seedlings in the bottles, observing the mini-ecosystem for about five days and explaining the outcomes. All these steps are a combination of hands-on and mind-on activities that involve the PEEOE approach (Asheela et al., 2021). Hence, the PEEOE approach was crucial because it allowed learning through inquiry (Capps & Crawford, 2013).

According to the NSES (NRC, 2000) as seen in Penn (2018, p. 31), the essential aspects of knowledge about inquiry are:

- "Scientific investigations all begin with a question, but do not necessarily test a hypothesis;
- There is no single set and sequence of steps followed in all investigations (i.e., there is no single scientific method);

- Inquiry procedures are guided by the question asked;
- All scientists performing the same procedures may not get the same results;
- Inquiry procedures can influence the results;
- Research conclusions must be consistent with the data collected;
- Scientific data are not the same as scientific evidence; and
- Explanations are developed from a combination of collected data and what is already known".

Additionally, an inquiry-based approach's emphasis is that learners discover information by themselves as stated earlier by Shinana (2019). Hence, inquiry learning is important because, in this way, knowledge is not discovered through memorisation but through construction. Hereafter, this implies that learners discover knowledge that they cannot easily forget (Lamm, 2017) and they gain such knowledge through active learning rather than passively receiving information from the teacher (Mkimbili et al., 2017; Sedlacek & Sedova, 2017; Vygotsky, 1978). Based on the ideas of Schrudel (2017), active learning is an interactive assessment of prior learning, experience and community knowledge to enable learners to focus on problems in meaningful ways, and assess the learners' insights and competence for making better environmental management and lifestyle choices. In this regard, Mkimbili et al (2017) and Sedlacek and Sedova (2017) believe that learners would remember such knowledge and subsequently use it in their everyday interpretations. Essentially, scientific inquiry affords learners an opportunity to explore resources and materials they are using during the learning process. For instance, in the case of this study, learners predicted what would happen when a seedling was put in a closed bottle. Furthermore, learners explored, investigated and monitored closed bottles (mini-ecosystem) and herein lies the importance of self-regulated learning (Vygotsky, 1978).

2.4.3 Learners' sense-making of scientific inquiry

Sense-making, according to Nikodemus (2017), is retrospective in nature and occurs during socialisation. Additionally, sense-making is defined by Hogan (2019) as a conceptual process in which learners engage with the natural or designed world, wonder about it and develop, test and refine ideas. Hogan elaborates that in most cases people use the phrase 'figure something out'. So, to figure something out is to make sense of something. To Fitzgerald and Palincsar (2019), sense-making is an activity that is always situated within the cultural and historical contexts where people interact with each other and with the aid of cultural tools including language (Vygotsky, 1978). According to Ndevahoma (2019), sense-making is when learners relate a particular situation to what they know or experience from their environment. Also, Weick et al. (2005) argue that sense-making involves turning circumstances into a situation that is comprehended explicitly in words and that serves as a springboard into action.

Nikodemus (2017), relating to the study by Ash (2004), stipulates that physical activity and dialogic processes increase learners' understanding and sense-making of science. In the classroom, a science teacher who seeks to support sense-making must recognise sense-making in their learners' science talk (Lemke, 2001). In her study, Ndevahoma stipulates that she observed the learners' sense-making by finding their "aha" moments, their moments of sudden discovery and insight. As explained by Walker (2013), an "aha" moment is when a person realises something new that has the potential to change the story. Henceforth, Ford (2012) proposes that for learners to engage in sense-making, they need to focus on attaining a 'grasp' of scientific practice, that is, an ability to participate in key forms of discourse and activity that form the epistemic basis of scientific claims.

Yet, there are factors that affect learners' sense making of scientific inquiry; one is that some learners are too shy to carry out practical activities, regardless of the mode of instruction. Shyness could be as a result of learners' poor motivation from teachers, parents and society in particular. To address this dilemma, this study was conducted in the vernacular language *Oshiwambo* to help learners gain confidence (Mavuru & Ramnarain, 2017) and make sense of scientific inquiry (Nikodemus, 2017). The sense-making of scientific concepts helps learners sustain their scientific knowledge and hence the promotion of ESD (Noguchi, 2018).

2.5 Educational Sustainable Development

According to Haan (2006), ESD aims to develop the motivational drive we will need to lead a fulfilled and responsible life amid the complex conditions of a world rapidly undergoing globalisation. Also, Arbuthnott (2008) views ESD as an educational programme that helps in achieving sustainable development that requires attention to the mediating factors of knowledge generation and attitude change. Moreover, Chikamori et al. (2016) contend that ESD is an educational activity that aims at raising good adults or citizens who have the will, attitude and skills to contribute to building a sustainable society. These explanations of ESD accord with the fact that ESD integrates the principles and practices of sustainable development into all aspects of education and learning, to encourage changes in knowledge, values and attitudes with the vision of enabling a more sustainable and just society for all (Laurie et al., 2016).

To support ESD, schools should set learning principles that enable quality teaching and learning that might produce capable learners who would be responsible for taking care of the world's socio-economic wellbeing. Due to this reason, the national governments and experts must provide legal frameworks, economic incentives and technologies, which may facilitate and mobilise local communities (Noguchi, 2018).

Figure 2.4: The Sustainable Development Goals (SDGs) (www.un.org)

Education SDG four, is one of the recently proclaimed global goals, focusing on the provision of quality lifelong learning and education for all (United Nations [UN], 2015). Goal 4 promotes quality education and aims to ensure inclusive and equitable quality education and promotes lifelong learning opportunities for all. The SDG is concerned with enhancing access to education and equality of access, and ensuring that there is quality education at all levels to deliver the knowledge and skills for a sustainable future.

SDG 4.7 thus should ensure that by 2030, all learners acquire the knowledge and skills needed to promote sustainable development, including, among others, through education for sustainable development and sustainable lifestyles, human rights, gender equality, promotion of a culture of peace and non-violence, global citizenship and appreciation of cultural diversity and culture's contribution to sustainable development. Giangrande et al. (2019) state that ESD should educate the whole person and support sustainable habits of mind and enables dispositions such as systems thinking.

Pavey and Donoghue (2003) suggest that role-play pedagogy is useful to get learners to apply their knowledge to a given problem, reflect on issues and the views of others, to illustrate the relevance of theoretical ideas by placing them in a real-world context (Gwekwerere, 2016), and to illustrate the complexity of decision-making. Additionally, Fatima and Carolina (2017) are certain that, in addition to tutor-led discussions, several role-play scenarios should be employed to take the theoretical frameworks off the page and into the workplace. However, UNESCO (2014) posits that assessing both the outcomes of ESD and efforts that seek to reorient education systems is a challenge to be addressed. As a result, this study sought to bridge easily accessible resources and prior knowledge to improve learners' scientific reasoning as a way of promoting sustainability competencies that prepare learners for the 21st century. Despite ESD merits, however, many challenges are encountered.

2.5.1 Challenges associated with Education for Sustainable Development in schools

Some ESD challenges face schools globally. Laurie et al. (2016) identified three challenges of ESD in the world. The first challenge noted is the integration of ESD across the primary and secondary curricula. Primary and secondary education is expected to ensure that all learners acquire the knowledge, skills and values necessary for the exercise of responsible citizenship (UNESCO, 2004).

Teachers lack skills for the implementation of ESD because they have not been equipped with proper training from HEIs. In this regard, Kanyimba et al. (2014) accentuate that the lack of incorporation of ESD training challenges lecturers since they also do not understand its practicality. These scholars indicate that failure to sustain education may cause deviation from already existing priorities. Hence, Laurie et al. (2016) detail that it is important to fully integrate ESD in curricula across all subjects and within a clear framework.

The second challenge of ESD detected by Laurie et al. (2016) is the lack of professional development for teachers to ensure ESD policy implementation: They said that:

> Student learning suffers if teachers fail to understand ESD. ESD involves knowledge in several disciplines, often beyond teachers' areas of specialization. Some teachers may reduce ESD to recycling and green projects and may not emphasize sustainability in broader contexts. Others understand its complexity and the need for systems thinking,

> but they view ESD as an overwhelming challenge and responsibility. (Laurie et al., 2016, p. 240)

These ESD challenges can be observed through access and retention in basic quality education, reorienting existing education to address sustainable development, increasing public awareness of sustainability and providing training for all sectors of the workforce (McKeown, 2000). In light of this argument, there is a great need for teacher education and training in ESD, the appointment of ESD coordinators in schools, ESD policies for schools, interdisciplinary collaboration and fieldwork (Kanyimba et al., 2014).

The third challenge regarding the implementation of ESD, according to Laurie et al. (2016), is that school leaders lack adaptation of ESD management practices to complement and support ESD in the curriculum. To have teacher education and training opportunities in place, there is also a need for strong educational leadership of principals and teachers, including high expectations of teachers and management support. Hereafter, school administrators also need to adopt new management practices and structures, such as different time schedules in schools (Laurie et al., 2016).

To conclude on ESD, it is crucial to reorient the existing education programmes to include more aspects related to sustainability and its three pillars: society, environment and economy (Haan, 2006; UNESCO, 2005). Since no one discipline can claim education for sustainable development on its own, instead all disciplines have to contribute (UNSECO, 2005). The ESD programmes according to Arbuthnott (2008) help to achieve sustainable development that requires attention to the mediating factors as well as knowledge generation and attitude change. Moreover, Arbuthnott (2008) proffers that the more personal and specific our intentions are, the more likely they are to influence our behaviour. This is because we are more likely to act consistently with attitudes about our own needs than attitudes about the needs of others. Framing our attitudes and intentions specifically and concretely improves the likelihood of acting on our intentions (Arbuthnott, 2008). It was hoped in my study that through observing their mini-ecosystems, learners would appreciate the importance of the ecological, social and economic interests.

2.5.2 Education for Sustainable Development in the Namibian context

Namibia is a signatory to numerous international agreements on sustainable development (Shiningayamwe, 2011). Shiningayamwe (2011) further states that such treaties have helped Namibia by giving prominence to the promotion of environmental literacy in its constitution, development plans and educational policies.

Kanyimba et al. (2014) point out that the role, status and scope of ESD are contained in the Namibian Constitution (Ministry of Information and Broadcasting, 1990), the Namibia Vision 2030 (Government of the Republic of Namibia, 2004), the National Curriculum for Basic Education (2016), Education for Sustainable Development policy (Ministry of Education, 2009) and other key Namibian national curriculum documents.

The aims and objectives of ESD in Namibian curricula according to SEEN (2005) are:

- interdependence of all living things and their environment;
- to promote a sense of responsibility towards restoring and maintaining ecological balances through the sustainable management of natural resources; and
- to encourage involvement in practical activities to preserve and sustain the natural environment.

According to Shiningayamwe (2017), in Namibia, teaching methods have shifted from early positivist approaches towards participatory methods based on social constructivism. Hence, the implementation of ESD through teaching and learning promotes progressive constructivist pedagogy, integration of disciplines and use of everyday knowledge related to disciplinary knowledge and structure (Kanyimba, 2002). Shiningayamwe further posits that more new methods are emerging which are ontologically situated, for example, the inquiry-based methods aiming toward the *Education for All* policy (Ministry of Education and Culture [MEC], 1993).

There are methods suggested to implement ESD in classrooms, namely investigation and problem solving, demonstrations, cooperative group work and experimental methods (Dreyer & Loubser, 2005; O'Donoghue, 2015). These include among others teaching strategies such as group work, project work, eliciting prior knowledge, excursions, drama and role-play (MoE, 2009).

However, Haindongo (2013) cautions that some teachers are unaware of the purpose of these components in the curriculum as they appear without any special distinction being made between them and other components. Admittedly, to implement ESD, teachers require not only curriculum policy changes, strategies and plans but also a deeper understanding of what is required and what and how to implement them in particular contexts (Shulman, 2004; UNESCO, 2012).

The major challenge of ESD in Namibia is thus to meet the training needs of teachers with the view to effect profound changes in their ways of thinking, attitudes and behaviours for sustainable development (Kanyimba et al., 2014). These scholars added such a challenge affects teachers' practices as they seek to implement ESD pedagogies in their teaching. The University of Namibia (UNAM) is responsible for training teachers who are expected to implement ESD, however, UNAM seems to have failed to prepare teachers adequately for ESD (Kanyimba et al., 2014). This has resulted in little attention paid to ESD in the school curriculum, resulting from teachers not being able to convince learners about the importance of ESD (Haindongo, 2013; Tshiningayamwe, 2011). As a result, active approaches to teaching and learning are highly recommended for ESD (UNESCO, 2012). This implies that for ESD to be successful, learners should be active participants in knowledge construction (Sedlacek & Sedova, 2017) rather than receivers of others' knowledge (Wood, 2007). In the context of this study, a mini-ecosystem was used to promote active participation by learners.

Other factors that hamper the delivery of sustainable knowledge in the Namibian curriculum are higher learner-teacher ratios, lack of qualified teachers, lack of education facilities in schools, inadequate lesson preparations, poor school management and administration and lack of motivation among teachers (Enviroteach, 1998; Hoabes, 2004; Tshiningayamwe, 2011). It is for these reasons that in this study I experimented with using a mini-ecosystem to promote scientific inquiry amongst learners from an under-resourced rural school.

2.6 Theoretical Framework: Vygotsky's Socio-cultural Theory

A theoretical framework is an important component of a research study. It grounds the study and guides the methodological design. Goos (2003) views a framework as a way of capturing and interpreting data in order to deduce meaningful results and make sense of them. It forms a reference point for the interpretation of the research findings (Mpofu et al., 2013). On the hand, the term analysis means the separation of problems into their constituent elements to help make complex issues simpler (Mpofu et al., 2013). Hence, an analytical approach is the use of an appropriate process to break a problem into small pieces. This study was informed by Vygotsky's (1978) SCT.

Vygotsky (1978) believed that learning is a social process and it is the origin of human intelligence in society. He further elaborates that everything is learned at two levels; by interacting with one another and then by integrating knowledge into the individual's mental structure. Vygotsky emphasises that effective learning happens in the nature of social interaction between peers. Concurring, McRobbie and Tobin (1997) accentuate that the social plane complements the individual plane.

In consequence, Vygotskian scholars support that knowledge is constructed through social interactions between less knowledgeable others and more knowledgeable others (Lantolf, 2008). More social interactions lead to mastery of the activities. Shabani (2016) also writes about SCT and says that learning is a result of the transition from controlled to uncontrolled process via practice. This implies that through social interaction, new knowledge and ideas are learned and developed with the community. Within Vygotsky's SCT, I used the following concepts as lenses to analyse my data: mediation of learning, social interactions, zone of proximal development and self-regulation. I now discuss each of these below and explain how they related to my study.

2.6.1 Mediation of learning

Vygotsky (1978) defines mediation of learning as a process of constructing symbolic tools for learning to be meaningful. He further states that mediation is a process whereby teachers and learners critically show science knowledge and skills. Expanding on Vygotsky's seminal work, Donato and McCormick (1994) regard mediation as the instruction of cognitive change that takes place in the form of textbooks, visual materials, classroom discourse patterns, opportunity for second language interactions (Mavuru & Ramnarain, 2019; Msimanga & Lelliot, 2014; Nhase, 2019) and types of direct instruction or various kinds of teacher assistance.

Vygotsky (1978) believes that human mental activities are mediated by symbolic cultural tools (including language) or signs that are used in most science subjects. Cultural tools are the instruments that give signals to the internalisation of ideas. Vygotsky further describes cultural tools as "mediating function of some object or means of activity" (1997b, p. 60). Vygotsky avers that cultural tools and signs correlate because they all support mediation activities. Extending Vygotsky's ideas, Shabani (2016) stresses that human relations with the world are not direct, but are mediated by physical and symbolic tools. In this case, the tool or artefact that I used to mediate learning in this study was the mini-ecosystem. As alluded to earlier, it was intended to help learners to 'figure something out' – the processes happening inside their closed bottles. During this study, it was also hoped that the mini-ecosystem would promote social interactions amongst the learners as espoused by Vygotsky (1978) and his disciples.

2.6.2 Social interactions

Vygotsky (1978) posits that learning occurs in a social environment. For example, Ellis (2000) states that learners can finish a task when helped to learn it by others who are able to do the same task alone. In this way, Ellis defines social interaction as a process of helping learners to finish their new tasks. Similarly, Shabani (2016) defines social interactions as the basis of learning and development, whereby learning is a process of apprenticeship and internalisation in which skills and knowledge are transformed from the social into the cognitive plane (McRobbie & Tobin, 1997). Also, extending on Vygotsky's seminal work, Penn (2019) adds that social interactions can be mediated and facilitated by more knowledgeable others. This implies that learners who know better help others to do better, be it at school or in the social environment. In this study, learners were encouraged to learn from one another and ask each other when they did not understand. Learners were also encouraged to have discussions or arguments (Ogunniyi, 2007a), and do group work and homework together. By doing so, it was hoped that they would develop meanings relating to scientific inquiry and henceforth shifted in their zones of proximal development.

2.6.3 The Zone of Proximal Development

Vygotsky (1978) defines the zone of proximal development (ZPD) as "a distance between the actual development level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers" (p. 238). In simple terms, Vygotsky describes the ZPD as the distance between what a person is able to do on their own and what a person is able to achieve through the support of more knowledgeable others. The ZPD helps the development of potential learning through discussions, and through the process, critical thinking is involved and developed. Vygotsky (1978) believes that learning takes place within the ZPD as a result of social interactions and collaboration with others. In support of Vygotsky (1978), Stott (2016) also avers that ZPD is based on a more knowledgeable other, usually an adult, who scaffolds a child through to increased performance or development.

Building on Vygotsky's seminal work, Chaiklin (2003) defines the ZPD as an interaction between the competent person and the less competent person on a task so that the less competent person becomes independently proficient at what was initially a jointly-accomplished task. Three aspects of ZPD were discovered by Chaiklin (2003), namely the generality assumption, the assistance assumption and the potential assumption. According to Chaiklin, the generality assumption means that the ZPD applies to the learning of all kinds of subject matter and the assistance assumption involves dependent learning through intervention by more competent others. To continue, the potential assumption is when learners reach a certain maturity that enables them to learn easily (Chaiklin, 2003; Vygotsky, 1978).

In his elaboration, Shabani (2016) describes the ZPD as the current or the actual level of development of the learners and the next level that can be attained through the help of environmental tools and the help of capable others. Shabani (2016) concurs with Vygotsky (1978), that collaboration and group work activities enable learners to achieve a complete understanding of an activity. Notwithstanding, self-regulation is critical in the learning process.

2.6.4 Self-regulation

Vygotsky (1978) points out that self-regulation can be achieved through social interaction that begins with children's exploration of their inner potential to imitate elders. According to Kavoc (2005), adults play a role in the child's ability to develop self-regulation as they present attitudes toward learning, providing stimulating objectives that motivate learners to be active in class. Agreeing, Harrison and Muthivhi (2013) explain that self-regulation is a deep internal mechanism that underlies the intentional thoughts of a learner. Concurring, Ndevahoma (2019) regards self-regulation as a way of controlling one's impulses to stop or start something. Hence, self-regulation can be observed in different ways depending on the grade. For example, self-regulation in preschoolers was observed through role-play and class activities. In the context of this study, self-regulation was observed through the development and monitoring of a mini-ecosystem where participants were interacting well with the members of their groups.

The SCT assisted me to analyse whether (or not) learners acquired and developed scientific inquiry in this study. Using Vygotsky's concepts of social interactions, mediation of learning, ZPD and self-regulation as a lens to analyse data gave me signals on whether learners make sense of scientific inquiry (or not) from questionnaires to the development of mini-ecosystems and the monitoring of them. As for ZPD, it helped to analyse learners' seriousness, commitment and curiosity during group interactions. The social interaction lens helped me find whether social interactions resulted in sense-making of the scientific inquiry.

2.7 Chapter Summary

In this chapter, I discussed literature relevant to the study. I firstly discussed literature on the teaching of NSHE and the concept ecosystem. Learners' attitudes toward science, scientific inquiry, inquiry-based approach and sense-making of scientific inquiry were discussed. I also discussed literature on ESD and its challenges towards its implementation in schools. Lastly, I discussed the theoretical framework that underpinned this study, that is, Vygotsky's SCT.

CHAPTER THREE: RESEARCH METHODOLOGY

3.1 Introduction

The main goal of my study was to explore how the use of a mini-ecosystem enables and/or constrains grade 5 learners in an under-resourced rural school to make sense of scientific inquiry. In this chapter, I thus discuss the research methodology informing this study. I start by discussing the research paradigm followed by the research design employed in this study. Essentially, this study adopted a qualitative case study research design and the data generation methods were VASI questionnaires, observation, focus group interviews and learners' reflections. Lastly, I discuss the validity, trustworthiness and ethical issues with regard to the study.

The research methodology is a systematic way of solving problems that shows the procedure of how research is going to be carried out (Rajasekar et al., 2003). These scholars further refer to research methodology as a study of methods by which knowledge is gained. Concurring, Wagyuni (2012) describes methodology as a way of conducting research under a certain paradigm. This study is, therefore, underpinned by a research paradigm.

3.2 Research Paradigm

Paradigms are ways in which researchers view the world in order to get meaning and interpret reality (Maree & van der Westhuizen, 2009). These authors further state that research paradigms reflect researchers' beliefs about the world and how they interpret and act in the same world. It is thus assumed that reality is socially constructed by every unique individual from within their own unique interpretation (Kumar et al., 2011). In the same vein, Bertram and Christiansen (2015) specify that a research paradigm defines the views that a researcher holds, what is acceptable to research and how it should be done. To add to this idea, Nhase (2020) stipulates that a paradigm allows a researcher to build on a coherent and well-developed approach to research. In light of these foregoing arguments, this study is underpinned by an interpretative paradigm that sought to develop a deeper understanding of how people make sense within their context.

According to Maree and van der Westhuizen (2009), the interpretive paradigm acts as a lens that the researcher uses to examine the practice of the research from a socio-culturist's point of view. Concurring, Cohen et al. (2018) state that the interpretive paradigm views the social world as an emergent social process that allows people to understand experiences from individual behaviours and actions. These scholars elaborate that individual behaviours can only be understood by the researcher who understands the individual's own interpretations of the world around them. As a result, these individuals' interpretations are subjective and vary (Merriam & Tisdell, 2016).

Referring to interpretive points of view, the exploration of a mini-ecosystem allowed me to understand the following. Firstly, the discussion during the process of developing a min-ecosystem in the class helped me to find out whether learners were able to interact with each other and ask science-related questions. Secondly, the monitoring of a mini-ecosystem aided in establishing whether learners were discovering new science concepts. Thirdly, the focus group interview that I conducted helped me to find out whether a mini-ecosystem enabled and/or constrained the sense-making of scientific inquiry among the grade 5 learners of an under-resourced school. Within the interpretive paradigm, a qualitative case study research design was employed.

3.3 Research Design

A research design acts as a guide for activities or specifications of procedures and strategies to follow in order to obtain the most valuable answers to research questions (Jongbo, 2014). That is, a research design deals with a logical problem and not a logistical problem as it provides scientists with a detailed outline or plan for the collection and analysis of data. Agreeing, Bertram and Christiansen (2015) point out that the research design is a systematic way of planning how to gather and analyse data. Moreover, Creswell et al. (2016) define the research design as a plan or a strategy that moves underlying philosophical assumptions to specify the selection of respondents, and what data techniques and analysis to be used. In this study, I thus employed a case study research design.

3.3.1 Case study

Cohen et al. (2011) define a case study as a unique example of real people in a real situation. Bertram and Christiansen (2015) are of the view that a case study is a way of looking at what is likely to be in that particular situation. In this regard, a case study allows much information to be collected and at the same time, the data collected is adequate, rich and of great depth (Cohen et al., 2018). It also has the ability to answer the 'why' and 'how' questions rather than the 'what' questions (Yin, 2009). Hence, the case study has the potential to evaluate and explain why a particular phenomenon works or does not work (Hashondili, 2020).

A case study was deemed appropriate in this study to get some insights into learners' attitudes towards scientific inquiry. My case was grade 5 learners from an under-resourced rural school in the Oshana region. My unit of analysis was how the use of a mini-ecosystem enabled and/or constrained grade 5 learners' sense-making of scientific inquiry.

3.4 Research goal, Questions and Research Process

In this section, I discuss the research goal, research questions and research process.

3.4.1 Research goal

The main goal of this study was to explore how the use of a mini-ecosystem enables and/or constrains the grade 5 learners to make sense of scientific inquiry. To achieve this goal, the following research questions were addressed.

3.4.2 Research questions

1. What are grade 5 NSHE learners' views towards scientific inquiry before observing the mini-ecosystem?
2. How does using a mini-ecosystem enable and/or constrain shifts in grade 5 NSHE learners' views towards scientific inquiry?
3. How does using a mini-ecosystem enable and/or constrain grade 5 NSHE learners in their sense-making of scientific inquiry in a rural school?

3.3.3 Research process

Phase one: Orientation

This was the first day of introducing the study to the grade 5 learners. I gave my learners consent letters to take to parents/guardians so that they could give their permission for the learners to take part in the study. Parent consents were written in the vernacular language in order to help parents/guardians understand our achivements clearly at the end of the study. Parents/guardians had the right to enquire if they did not understand study goals. However, considering power relations, parents were required to indicate with a tick if they supported going ahead with the study or with a cross if they were not willing for their children to participate in the study.

I explained to the learners that the importance of the study was to enrich their understanding of scientific inquiry in science and in particular, the topic of the ecosystem. I asked learners to return the consent letters the next day and I also set a schedule for the study. For example, the schedule included types of data techniques and when to complete them. Each technique was explained prior to its presentation.

VASI questionnaire

I gave VASI questionnaires to 21 learners that constituted the whole class of grade 5(a). I intervened by reading the Oshiwambo version questions since learners found some sentences difficult to understand. I monitored learners' progress and I found that they were completing the questionnaires at a slow pace. Since learners were not allowed to write their names, I followed the class list and gave every learner a number corresponding to their name, which is the number they wrote on top of their VASI questionnaires cover. Thereafter, I collected the incomplete questionnaires which they completed the next day. The aim was that the next day I would just call out numbers instead of learners' real names.

Phase three: Observation

On that day, I brought small plants, bottles and scissors to class and engaged learners in discussions on what they thought the aim of bringing such tools to class was. After some group discussions, I guided the learners on how to develop their mini-ecosystems. I gave them monitoring sheets (see Appendix 5.3) to record their group findings for two weeks. The observation outcome of the monitoring of the mini-ecosystem was discussed during the focus group interview.

Phase four: Focus group interview

The focus group interview was conducted with only five learners who were purposively selected by a group representative with the help of their group members. These learners were chosen because they were trusted by their groups to represent them. Learners were allowed to bring in their mini-ecosystems to the interview and were encouraged to use their experience from the VASI questionnaire and observation to answer focus group interview questions (see Appendix F (i) for the Oshiwambo version and Appendix F(ii) for the English version).

Phase five: Learners' reflections

All five groups formed during observation of the mini-ecosystem and focus group interview were asked to write group reflections. The aim was to encourage learners to reflect on their mini-ecosystem experiences and to establish whether the study helped them to make sense of scientific inquiry. Another aim of group reflection was to enhance collaboration as it allowed all learners to provide support and encouragement to one another in their learning process (Yaacob et al., 2021). Learners were guided before they reflected. I also read questions with them and I recapped what transpired during the questionnaires, observation and the focus group interview (see Appendix F for more information). The correlation of these ideas is given by Hemmati and Soltanpour (2012) who agreed that reflection with the support of a collaborator has the potential to affect learners' improvement positively. Data that emerged from learners' reflections are found in section 5.5. The summary of data from learners' reflections is coded as Group AR, Group BR, Group CR, Group DR and Group ER which is the group name i.e. GA and R for reflections.

3.3.3 Research site

This study was conducted with grade 5 NSHE learners from a rural under-resourced school in the Oshana region. The Oshana region is one of the regions found in the Northern part of Namibia (see Figure 3.1 below).

The arrow shows the Oshana region where the study took place

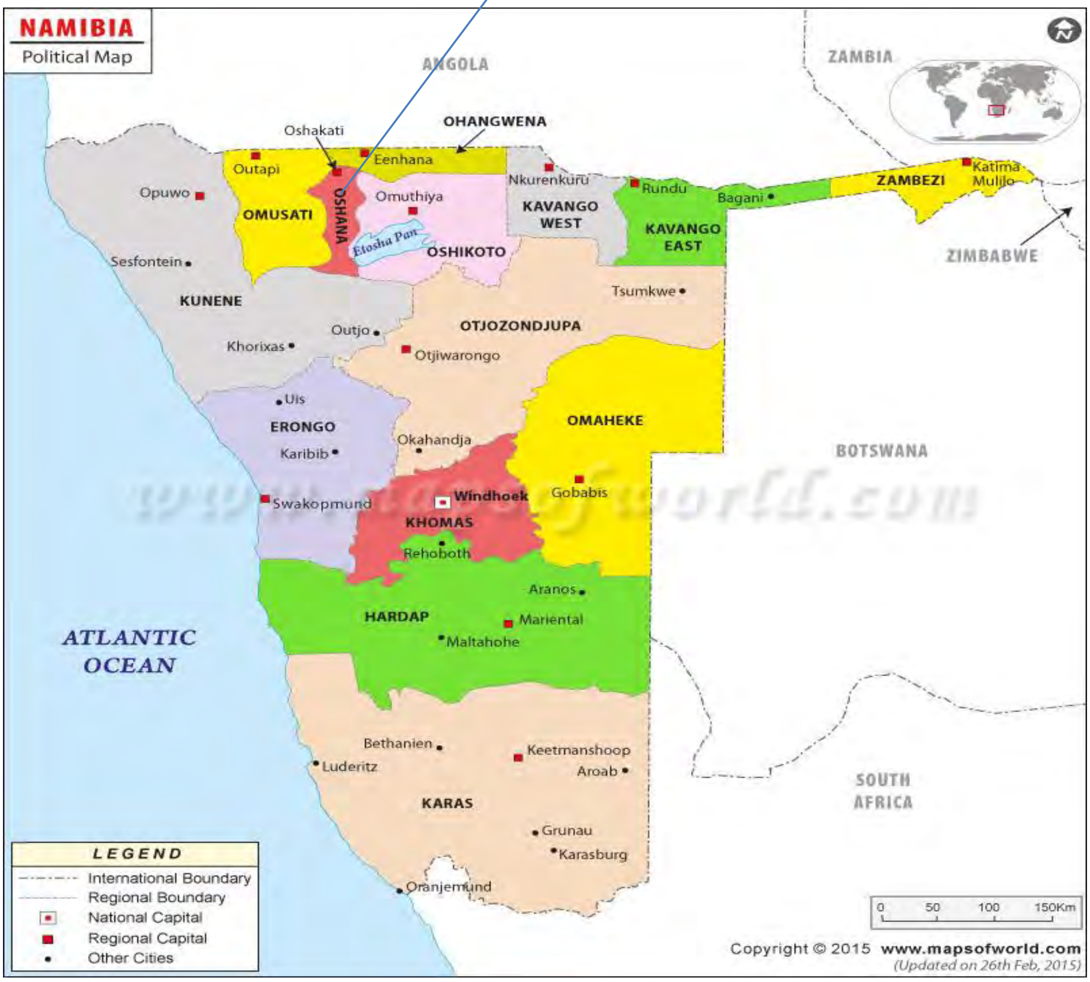


Figure 3.1: Shows Namibia political map with different regions (www.mapsofworld.com)

The school is a combined school that comprises grade 1 to grade 9 learners. The school is about 50 km from the nearby town of Oshakati and about 20 km from a tarred road. At the time of this study in 2020, the school had an enrolment of 520 learners, 269 boys and 251 girls. The school had 22 staff members and three institutional workers. As a result, the teacher-learner ratio was at 1:21 during the COVID-19 pandemic. If it was not for the pandemic that forced the school to have at most twenty-five learners in each class, the school was supposed to have only one grade 5 class of 42 learners.

The school infrastructure is not decent at all. Because the school is in a rural area, community members often take advantage of the fact that many teachers go home on the weekends and some teachers stay in the village far from the school, and the school always loses chairs and tables which are stolen by learners or community members. Every year the school always tries to repair chairs and desks since the government cannot provide enough chairs. But still, the school is forever short of chairs and desks. Added to this, the school does not have a science laboratory, hence, teachers do not have laboratory resources to teach. Also, there are not enough textbooks at the school and in some subjects, five or more learners share one textbook.

At the time of this study, there were 42 learners, 21 boys and 21 girls in the grade 5 class. However, due to the covid-19 pandemic, classes were halved in compliance with the social distancing of one metre and other regulations put in place by the Namibian Ministry of Education Art and Culture (MEAC). The MEAC cautioned schools to amend the school operational mode of teaching, whereby the school opted for time-based cohorts. Such cohorts were allowed a day off for each group. In such a case, the class was split into two classes – grade 5a and grade 5b, with 21 learners in each class.

At the time of this study, the school had an acting principal after a long-serving principal retired earlier in 2020 and later passed on in May 2021. The school also had four heads of departments for languages, lower primary, science and social science. My critical friend was a grade 5 Agricultural Science teacher from the school. The reason for choosing this teacher is because she replaced my first critical friend who was hospitalised during the study and later was on one-week sick leave.

3.5 Sampling and Participants

Bertram and Christiansen (2015) define purposive sampling as a method that allows a researcher to choose a specific sample for a particular purpose. The study was carried out with 21 grade 5a learners, whom I purposively selected due to the teaching programme I explained earlier. That class was the one attending class the day I started this study. I purposively created five groups; four groups each consisting of four learners, while the fifth group consisted of five learners. They participated in developing and monitoring a mini-ecosystem. Every group was instructed on how to develop a mini-ecosystem after I had provided them with some seedlings. This was after I had asked them to provide some small plants and they said it was difficult for them to get small plants because it was a dry season. As a result, they could not find small plants around their vicinity. The learners were allowed to give themselves some names and were subsequently coded as follows: group A- apple, group b- banana, Group C- carrot, group D-*eembe* (dry berries) and group E-*eenyandi* (jackal berries) respectively.

Every group selected a representative who made sure every participant within their respective group was present for the study. These group representatives had an opportunity to make sure their everyday activity was well attended to. Another duty of the representative was to bring to my attention participants who were no longer interested so that we could agree on whether they should continue or end the agreement. All participants and I monitored the mini-ecosystems for five days in two weeks and recorded results in the monitoring form I provided them with. Even though the monitoring of the mini-ecosystem was for two weeks, the total number of days participants attended the study was just five due to the teaching slots the school chose to follow because of the covid-19 pandemic. That is, my participants (5a) came to school on Tuesday, Thursday and Monday while the other class (5b) came on Wednesday, Friday and Tuesday respectively.

Additionally, I gave authority to group representatives to select one representative, whom they felt could represent their group in the focus group interview. When I asked the five participants why they thought they were selected, they responded that the other participants trusted them. The reason for selecting only a few participants was to avoid large numbers. According to Dilshad and Latif (2013), focus group discussions produce rich qualitative data since they allow participants to interact with one another.

3.6 My Positionality and Reflexivity

According to Thomas (2013), interpretive researchers have an undeniable position in the research process and this position affects the nature of the observation and the interpretations that they make. As a result, the position of the researcher might negatively affect the nature of the observations, which might affect the data interpretation. Since I conducted the study with the grade 5a class, I dealt with the issue of positionality and power relations in the following ways. I informed my participants that the study was an introduction to the topic of the ecosystem and it was not a normal lesson. Therefore, if any learner did not feel like taking part in the study, they were welcome to withdraw. I explained to them, however, that the process of developing and monitoring a mini-ecosystem would subsequently be repeated during normal teaching. Denscombe (2014) notes that a researcher does not commence the research with a clean sheet, but uses conceptual tools which derive from several sources, including culture and values (Cohen et al., 2018). Culturally, if learners are told that either the tests or exercises they are busy with are for assessment purposes, they tend to be reluctant or not pay serious attention to it. Hence, four learners in this study chose not to return their VASI questionnaires because they felt they were not worth being returned.

I also positioned myself as a co-learner and we all monitored the mini-ecosystems. I also informed my participants that since we were all learning from each other, there were no right or wrong answers. All answers were regarded as relevant and so the learners felt free to participate.

3.7 Research Methods

Research methods show how the researcher conducted the study. In this study, data were collected using four methods, namely the VASI questionnaire, observations, a focus group interview and learners' reflections. The use of different data gathering methods allowed me to collect a variety of data and also helped with data triangulation.

Triangulation, according to Carolyn (2019), is a process of using contrasting data sources to enable rich data. Concurring, Gurbiel (2018) defines triangulation as a procedure in which only one occurrence is analysed regarding one research question. This scholar adds that triangulation is a methodological procedure which aims to verify acquired data. I now discuss each of these data collection methods below.

3.7.1 The VASI questionnaire

According to Lederman et al. (2013), the VASI questionnaire is a paper and pencil assessment that measures learners' understanding of scientific inquiry. These scholars explain that scientific investigations begin with an open-ended question, but do not measure the hypothesis. It is important, therefore, since it uses unrestricted open-ended questions that allow participants to provide information without constraints (Creswell, 2015).

The VASI questionnaire tests eight aspects of scientific inquiry. These aspects are measured through three categories; more naïve views, mixed views and more informed views (Lederman et al., 2018). To elaborate, more naïve views are considered when a specific response and the understanding are inaccurate. The mixed views are when learners' responses consist of an accurate response and inaccurate understanding. Lastly, more informed views are considered when the learners' responses and understanding are complete. Table 3.1 below shows Lederman et al.'s (2014) aspects of scientific inquiry. The VASI item number that appears in the table refers to the labelling structure of questions in the questionnaire.

Table 3.1: Aspects of scientific inquiry and corresponding items on VASI questionnaire

Aspect of Scientific Inquiry	VASI Item#
1. Scientific investigations all begin with a question but do not necessarily test a hypothesis	1a, 1b, 2
2. There is no single set and sequence of steps followed in all scientific investigations (i.e., there is no single scientific method)	1b, 1c
3. Inquiry procedures are guided by the question asked	5
4. All scientists performing the same procedures may not get the same conclusions	3a
5. Inquiry procedures can influence the conclusions	3b
6. Research conclusions must be consistent with the data collected	6
7. Scientific data are not the same as scientific evidence	4
8. Explanations are developed from a combination of collected data and what is already known	7

Source: Lederman et al. (2014, p. 75)

However, Lederman et al. (2014) stipulate that the VASI questionnaire is suitable for grade 6 learners and upwards due to issues of language proficiency. That is, the possibility for learners to misconstrue the questions could be high. To address this and for quality data in this study, the VASI questionnaire was translated into Oshiwambo (learners' home language). The translation was done next to each question (see Appendix C). Another reason for the questionnaire to have two versions was to avoid losing the core meanings of the questions during the process of answering (Nhase, 2019). However, I have to say that the quality of translation was slightly compromised because it was not easy to form scientific concepts from learners' generalised answers. In her study conducted in South Africa, Nhase (2019) also noted that questionnaires helped to formulate the context of the study and understand views on the use of an inquiry-based approach. In my study, the VASI questionnaire was administered to 21 grade 5a learners. Prior to the questionnaire answer time, I explained the purpose of the questionnaire (Penn, 2017).

3.7.2 Observation

Maree (2010) defines observation as a systematic process of recording the behavioural patterns of participants without communicating or questioning them. Observations allow a researcher to have first-hand information by visiting the site of the study to see or watch carefully for themselves the way things happen or events unfold (Bertram & Christiansen, 2015). This implies that the observation technique allows the researcher to gather data in a social situation (Cohen et al., 2018). Cohen et al. (2018) mention that observations are inescapably theory-laden in terms of what to look at, what not to look at, how to look and how to interpret what we see. Cohen et al. (2018) add that observation research findings are strong in validity because the researcher conducts observation.

Hence, during observation, learners were confident because they were curious to see plants growing in a closed bottle. The main aim was to see their group responses to 'what they think will happen to the plant in the bottle'. I conducted the observations as follows:

Phase 1 - Background to observation

I brought seedlings and empty bottles to the class and allowed learners to predict the use of all tools that I was carrying. I gave a seedling and an empty bottle to each group. That was the time learners started their discussions without my intervention. I informed learners to question each other in their groups about what my aim was in bringing seedlings and bottles to class. The findings of the class discussions are presented in chapter five (Section 5.5) of the study.

Phase 2 - Background to observation

I asked learners to predict what they thought would happen when small plants with wet soil were put in a closed bottle and then placed on the windowsill to get sunlight. I intervened in the process of developing a mini-ecosystem and learners were very interested to explore and curious to know how seedlings survive inside the bottles. I facilitated the placing of seedlings into the bottles. A critical friend videotaped and recorded the entire process. Additionally, my critical friend was responsible for completing the observation schedule adapted from Nikodemus (2017) (see Appendix I).

Phase 3 - Observation

In this phase, learners had to observe a mini-ecosystem for five days over two weeks. The study was conducted during the covid-19 (SARS-Cov-2 virus) outbreak. Schools were closed due to covid-19, and schools were advised to divide classes for a minimum of 20 learners per class out of the total 40 learners. As a result, classes had to alternate coming to school. However, participants who lived nearby the school came to school and monitored their mini-ecosystems every day for two weeks. Throughout this process, learners had to write their findings in the monitoring sheets everytime they observed their mini-ecosystems. Learners were able to record their results and share them with other groups.

In conclusion, Cohen et al (2018) state that observational data comments on the physical environment, and should then be followed up with interview material to discover participants' responses to, perceptions of, messages contained in and attitudes to, the physical environment. Hence, below I discuss the focus group interview.

3.7.3 Focus group interview

Powell and Single (1996) posit that a focus group is a group of individuals selected and assembled by researchers to discuss and comment on a topic that is the subject of the research. To add to this definition, Kaplowitz and Hoehn (2001) point out that focus group interviews are groups of discussions designed to learn about subjects' perceptions of a defined area of interest. Manqele (2017) indicates that a focus group is a carefully planned discussion designed to obtain perceptions on a defined area of interest in a permissive, non-threatening environment. Concurring, Bertram and Christiansen (2015) define an interview as a conversation between the researcher and the respondent. Adding to these definitions, Cohen et al. (2018) state that a focus group interview is economical on researcher time, encourages interaction between the group and foresees less intimidation for children than individual interviews. Hence, for the focus group interview to be effective, researchers should consider the questions they wish to ask (Doody et al., 2013).

The following aims helped me to analyse the focus group interview. Firstly, the aim was to discover learners' attitudes towards scientific inquiry. The second aim was to establish whether the creation of a mini-ecosystem resulted in any shifts in learners' attitudes toward scientific inquiry. The third aim was to establish whether the creation of a mini-ecosystem enabled and/or constrained the grade 5 learners from rural under-resourced school to make sense of scientific inquiry. I asked every group to choose a representative for the focus group interview. The participants were happy to hear that the interview was going to be conducted in Oshiwambo. These learners were very happy because they found out that the researcher had just created a relaxed environment and they were able to give the information freely (Chrispen,2016).

In this regard, the learners claimed that they participated well and freely because the study was conducted in their own language. They further claimed that they expressed themselves openly and gave their views without translating them into English which sometimes caused them to keep quiet because they were not fluent in English. The use of home language is supported by Mavuru and Ramnarain (2019) who postulate that using home language has the potential to pave the way for knowledge construction and making sense of science concepts. Also, Nhase (2019) added to the use of home language by stipulating that it helps promote scientific inquiry in classrooms. Hence, the five participants chosen did not hesitate to take part in the interview.

In their groups, learners discussed and reflected on their experiences of observing mini-ecosystems. Therefore, the focus group interview aimed to test whether learners had any shift in their views about scientific inquiry, learners' interactions and assessed quality answers that led to sense making of scientific reasoning. The focus group interview took about 27 minutes, and the interview was videotaped and recorded with the help of my critical friend.

3.7.4 Learners' reflections

Reflections are ways of creating an understanding of learning experiences (Schumacher, 2014). Also, Nyamakuti (2021) adds to the definition by stipulating that reflections present changes in learners' conceptions, dispositions and sense-making toward science concepts. Additionally, Kudumo (2021) said that learners' reflections give a researcher an overview of how learners have a conceptual understanding of the presentation through their interactions, attitudes and sense-making. I learned how to take journal reflections when I was doing my Honour Degree at Rhodes University and I introduced the method in my class and learners liked it. Learners wrote a once-off reflection about their whole study experience using the local language – from the orientation process, questionnaire, monitoring of a mini-ecosystem to the the focus group interview. I read through the reflection questions (see Appendix F) with learners, guiding them on how they should reflect (Kudumo, 2021). However, with the help from the critical friend, we translated all work to English in order to do final assessment in English.

Table 3.2: Shows a summary of the data gathering techniques used in the study

Technique	Purpose	Research question
VASI questionnaire	Measure learners' attitudes and understanding of scientific inquiry	1
Observation	How learners explore a mini-ecosystem to make sense of scientific inquiry. A shift in learners' attitudes and sense-making of scientific inquiry	2
Focus group interview	Encourage interactions between learners in their groups. Find if there were shifts in learners' attitudes between the VASI questionnaire and observation of the mini-ecosystem	3
Learners' reflection	Understand learners' experiences and sense-making of scientific inquiry	1, 2, 3

Figure 3.3: Summary of the research processes in the study

3.8 Data Analysis

Data analysis, according to Graziano and Rauln (2010), is a process of analysing and interpreting data to make meaning of it. Agreeing, Wahyuni (2012) also says that data analysis involves drawing inferences from raw data. Moreover, Cohen et al. (2018) justify that data analysis focuses on the meanings from in-depth, context-specific, rich, subjective data from participants in a certain situation, with the researchers themselves as principal research instruments. In this study, a thematic approach to data analysis was adapted and qualitative data were analysed inductively to come up with sub-themes and themes (Saldaña, 2009) (see Tables 5.4 and 5.5).

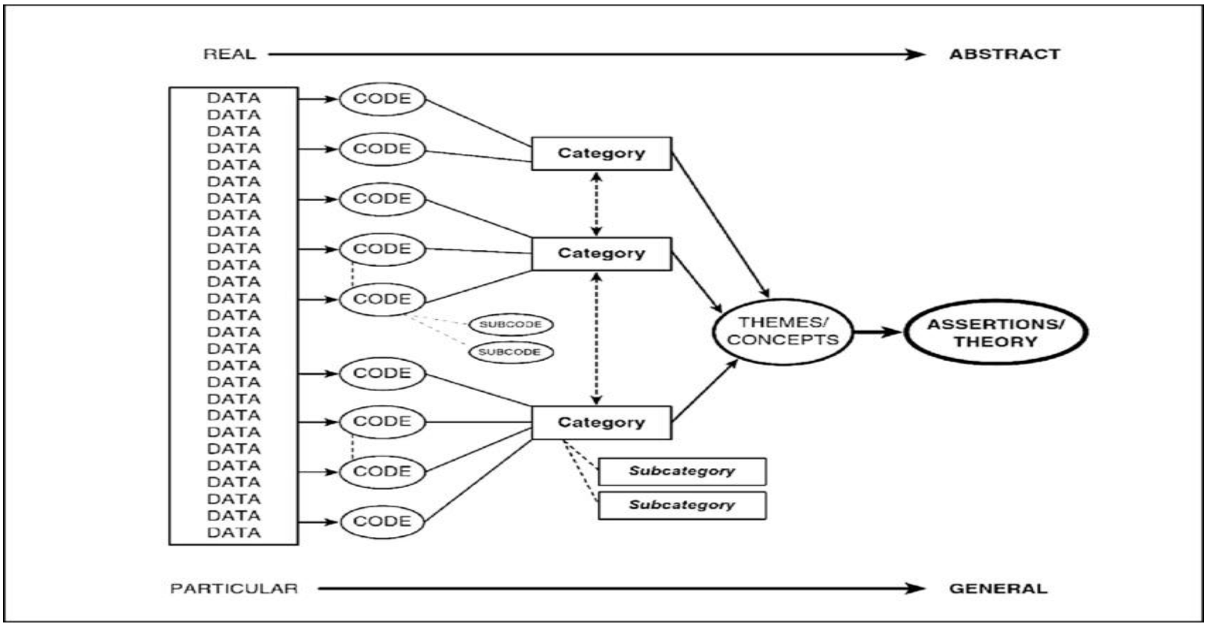


Figure 3.2: Codes-to-theory model for qualitative enquiry (Saldaña, 2016, p. 14)

The study's original notes were written in English and we (critical friend and I) translated them into the local language. The participants' discussions were recorded and video-taped in the local language as they were more comfortable using *Oshiwambo* than English. Firstly, I adopted Lederman et al.'s (2014) scoring criteria to analyse data from the VASI questionnaire. The scoring criteria measured the views of participants whether they were more naïve, mixed or more informed. Such scores aided me to code the eight aspects of scientific inquiry. I also used Atallah et al.'s (2010) criteria to analyse participants' attitudes towards scientific inquiry.

I narrated the data and colour-coded it into episodes in order to easily access specific data (Merriam & Tisdell, 2016; Nhase, 2019). Then I identified sub-themes and themes. Themes and sub-themes are discussed in relation to literature and Vygotsky's (1978) SCT focusing on the learners' ZPD, social interaction, mediation and self-regulation.

3.9 Trustworthiness

Cohen et al. (2011) add that validity is the legal strength that claims the trustworthiness of the research. Then again, Kudumo (2021) adds that validity refers to the extent to which the study findings reflect what it intended to measure. Trustworthiness is very important in qualitative research as it enhances confidence in the researcher's findings (Johnson & Parry, 2015a). The researcher needs to make sure that the data gathering tools used are systematic, credible and transparent (Bertram & Christiansen, 2015). This infers that the researcher must make sure that the research findings are well organised, clear and believable to avoid being bias. Research bias is the tendency that researchers have to collect, interpret or present data that support their own prejudgements, theories or goals (Airini et al., 2016). These scholars further suggest that to deal with validity and trustworthiness issues in research, there is a need to implement triangulation.

Triangulation is a combination of research methods in a study (Bertram & Christiansen, 2015). Different techniques of data gathering stated earlier helped to triangulate to strengthen the validity of the study. I watched the videos, analysed questionnaires, conducted a focus group interview, and reviewed learners' reflections together with the critical friend. The focus group interview proceeded as a validated technique because it allowed participants to reflect on the questionnaire and observation methods used earlier in the study. The interview assisted me to ask follow-up questions to validate data.

3.10 Ethical Considerations

Research participants are subjects not objects of research (Cohen et al, 2011). Hence, they need to be respected (Nhase, 2019). In this study, I was considerate of ethical issues that might arise during study time, and I henceforth highlight the ethical principles below.

3.10.1 Access and informed consent

Before the study, I wrote to the Oshana educational director to issue me a consent letter to conduct my study in the region. I then wrote to the school's acting principal to accord me permission to carry out the study at their school. I further asked permission from grade 5a parents and/or guardians to allow me to conduct the study with their children. Parents' consent letters were written in Oshiwambo for proper understanding of the goal of the study and parents were required only to tick or cross if they agreed or not. As seen in Section 3.3.3, parents were able to enquire about more information regarding the study especially if they did not get the aim of the study. I then gave learners consent forms to complete after an orientation to the study.

3.10.2 Respect and dignity

I first explained to the learners the aim of the study and assured them that the study would be conducted in their vernacular (Oshiwambo) language. Learners' human rights and dignity were respected in the study. For instance, the rights of learners who opted not to submit their questionnaires were fully respected and accepted in the study. This came after I earlier explained to the participants that the study was voluntary and would not be done in a coercive manner. Also, participants' time was respected. Therefore, since the study was conducted after school hours, I had to come to school on time and the time frame was limited to less than 40 minutes to avoid a long time at school while other non-participants reached home.

I informed the participants that their names would not be used in the thesis and they could use pseudonyms or rather not write any name on the questionnaire at all. Participants were informed that their faces were going to be hidden to avoid recognition. I considered this after O'Leary (2017) argued that pseudonyms may not be enough to hide identity, hence I asked for their permission before any recording, pictures or videotaping. The data collected was kept safe in hard copies in a locked-up cupboard, in Google cloud and on an electronic device. Additionally, the study was my own work and I acknowledged ideas that were not mine.

3.10.3 Transparency and honesty

The main aim of the study was explained to gatekeepers, my critical friend and learners. The aim of the study was explained in English and Oshiwambo to participants to make sure that they understood the purpose of the study. The reason for the translation was that some learners were not fluent in reading and writing English and might have felt left out. The first study process was orientation. The aim was to develop togetherness and Ubuntu in the study by asking general questions regarding living and non-living things. During orientation, I explained the research study and how it was going to be conducted.

Informed consent was received from the regional director, principal of the school, parents and learners. All of these consents were given without any hesitation because of the study's aims and sustainability. Honestly, consent was granted because all sectors believed that it was going to benefit the learners, the school and the region at large. Equally important, if someone denied this development, culturally they would be regarded as a jealous person who limits development. Hence, all consent was given in support of learners' education.

3.10.4 Accountability and responsibility

I conducted the study in accordance with the principles and guidelines for educational research without misusing my position (see Section 3.3.5). My duty was to develop good rapport with the participants. I showed respect to the learners, regardless of their age, cultural background or religion. After the study, I kept my data safe on an external drive. I was also in constant communication with my supervisors informing them of what was going on. For example, I informed my supervisors about four participants of group E who were not present for the selection of their representative for the focus group interview. Luckily, there was one participant of group E who then represented the group during the interview.

3.10.5 Integrity and academic professionalism

This study is my own work and I have acknowledged ideas that are not mine. I followed the APA Rhodes referencing guidelines. The right of the participants, anonymity and privacy were treated with a high degree of respect and confidentiality (Kudumo, 2021). I collected data by myself with the help of a critical friend.

3.4 Chapter Summary

In the chapter, I provided the research paradigm that underpinned the study. I discussed the scope of the study by outlining the research paradigm and research design. I specifically outlined the components of research design which are the case study, research goal, research questions and research process, research site, sampling and participants. Also under research design, positionality, research methods, data analysis and ethical considerations were discussed as seen in section 3.3. Lastly, the chapter ends with a summary. In the next chapter, I present, analyse and discuss data from the VASI questionnaire.

CHAPTER FOUR: VIEWS ON SCIENTIFIC INQUIRY

4.1 Introduction

The main goal of the study was to explore how the use of a mini-ecosystem enables and/or constrains grade 5 learners from an under-resourced rural school in Namibia to make sense of scientific inquiry. This chapter aimed to answer research question one:

> What are grade 5 NSHE learners' attitudes towards scientific inquiry before observing the mini-ecosystem?

In this chapter, I thus present, analyse, interpret and discuss data from the VASI questionnaires that assessed eight aspects of scientific inquiry adapted from Lederman et al (2014).

4.2 Sample Size

As explained in Section 3.3.5.1, I distributed and administered the VASI questionnaire to all 21 grade 5a learners at the school. Due to anticipated English language barriers, the participants were allowed to answer questions in Oshiwambo, which is their home language. However, since this study was voluntary and participants had the right to withdraw at any time as explained in Section 3.3.5.5, four participants did not hand in their questionnaires. Three learners out of four explained that they did not understand both English and Oshiwambo versions even after I had read the questions to them. Since this study was not coercive, the four participants were allowed to be part of the study even though they did not contribute to the questionnaire data. This implies that there were 17 active participants (81%) in the study. Figure 4.1 below shows learners busy answering the VASI questionnaire.

Figure 4.1: Shows learners busy answering the VASI questionnaire

4.3 Discussion of Results from the VASI Questionnaire

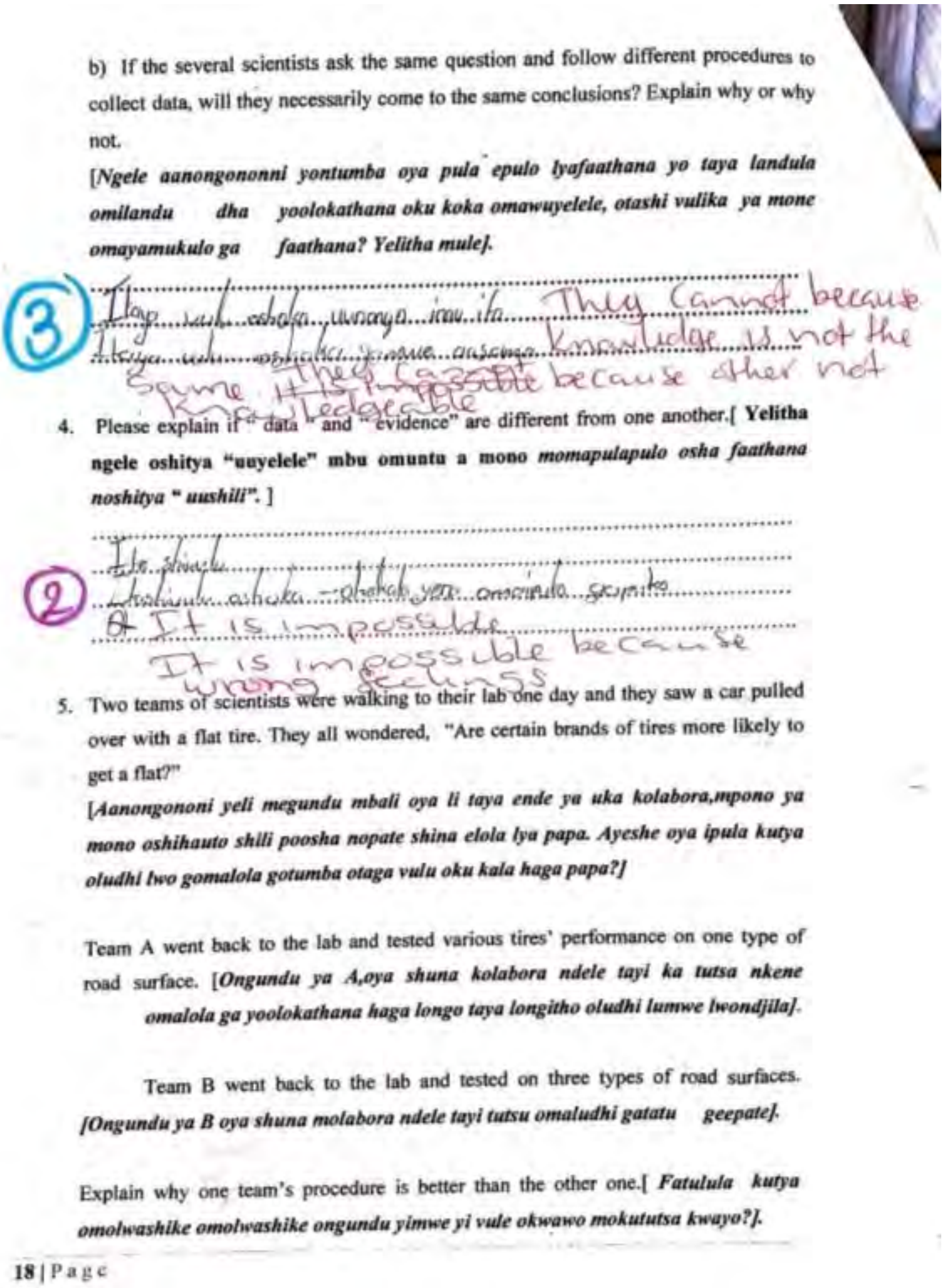
The questionnaire tests eight aspects of scientific inquiry (Penn, 2019) also known as Knowledge of Inquiry (Lederman et al., 2014) and the answers from the questionnaire were grouped into four categories: no response, naïve views, mixed views or informed views (Lederman et al., 2018) (see Table 4.1). These categories were then coded 0–3.

Table 4.1: Codes and scoring assigned to VASI questionnaire

Codes	No Response	Naïve	Mixed	Informed
Score allocated	0	1	2	3

Source: Adapted from Penn (2019, p. 79)

To elaborate and as stated earlier in Section 3.3.5.1, naïve views were considered when a specific response and the understanding were inaccurate, mixed views pertained to learners' responses consisting of an accurate response and inaccurate understandings, and lastly, more informed views were considered when the learners' response and understanding were complete. Each question was coded as seen in Figure 4.2 below.


b) If the several scientists ask the same question and follow different procedures to collect data, will they necessarily come to the same conclusions? Explain why or why not.

[Ngele aanongononni yontumba oya pula epulo lyafaathana yo taya landula omilandu dha yoolokathana oku koka omawuyelele, otashi vulika ya mone omayamukulo ga faathana? Yelitha mule].

3

They Cannot because Knowledge is not the same. It is possible because other not Knowledgeable

4. Please explain if "data" and "evidence" are different from one another.[**Yelitha ngele oshitya "uuyelele" mbu omuntu a mono** *momapulapulo osha faathana noshitya " uushili".*]

2

It is impossible

It is impossible because wrong feelings

5. Two teams of scientists were walking to their lab one day and they saw a car pulled over with a flat tire. They all wondered, "Are certain brands of tires more likely to get a flat?"

[Aanongononi yeli megundu mbali oya li taya ende ya uka kolabora,mpono ya mono oshihauto shili poosha nopate shina elola lya papa. Ayeshe oya ipula kutya oludhi lwo gomalola gotumba otaga vulu oku kala haga papa?]

Team A went back to the lab and tested various tires' performance on one type of road surface. *[Ongundu ya A,oya shuna kolabora ndele tayi ka tutsa nkene omalola ga yoolokathana haga longo taya longitho oludhi lumwe lwondjila].*

Team B went back to the lab and tested on three types of road surfaces. *[Ongundu ya B oya shuna molabora ndele tayi tutsu omaludhi gatatu geepate].*

Explain why one team's procedure is better than the other one.[*Fatulula kutya omolwashike omolwashike ongundu yimwe yi vule okwawo mokututsa kwayo?].*

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Figure 4.2: Sample of raw data coded from the VASI questionnaire

To interpret the data contained in Figure 4.2, each participant's response in question 1c was coded as informed views strongly indicating that scientific investigation can follow multiple methods. The participant scored a mixed view in question 2 of the VASI since the response was good but not followed by an informed view supporting why scientific investigations always start with a question. Another mixed view was scored by this participant in question 3 as there was no explanation as to why the same procedures might get the same result.

4.3.1 Learners' views about scientific inquiry

In general, the quantitative responses to every aspect of scientific inquiry showed that learners had a poor understanding of scientific inquiry (SI). This finding is consistent with scholars such as Lederman et al. (2014) and Penn (2019) whose findings revealed that learners were not exposed to SI; hence there is a need for teachers to be trained to teach and assess the understanding of SI. An understanding of SI could be achieved through using easily accessible models or materials (Asheela et al., 2021; Ramnarain, 2021). The detailed frequency Table 4.2 below shows the coded data showing all aspects of SI scored by the 17 participants.

Table 4.2: Frequency table showing data from the VASI questionnaire

NOSI Aspects	**VASI Question**	**No Response**	**Naïve**	**Mixed**	**Informed**
		Quantity	**Quantity**	**Quantity**	**Quantity**
Multiple methods	1(c)	1	10	3	3
Begin with a question	2	1	4	11	1
Same procedures, might not get in same result	3(a)	2	9	1	5
Procedures can influence results	3(b)	1	6	3	7
Data versus evidence	4	0	4	11	2
Procedures guided by the asked question	5	0	13	4	0
Conclusion consistent with data collected	6	0	2	8	7
Explanations are based on data and previous knowledge	7(b)	0	7	7	3
Total responses	5	51	47	29	132

The data from the frequency table is further presented in percentages showing how naïve, mixed and informed learners' views were during the questionnaire. This is reflected in Table 4.3 below which I later present as a bar chart in Figure 4.3.

Table 4.3 Grade 5a learners' views on scientific inquiry

NOSI Aspects	**VASI Questionnaire**	**No Response (%)**	**Naïve (%)**	**Mixed (%)**	**Informed (%)**
Multiple Methods	1c	5.9	58.8	17.6	17.6
Begin with a question	2	5.9	23.5	64.7	5.9
Same procedure might get same result	3a	11.8	52.9	5.9	29.4
Procedures influence result	3b	5.9	35.3	17.6	41.2
Data versus Evidence	4	0	23.5	64.7	11.8
Procedures guided by asked questions	5	0	76.5	23.5	0
Conclusions consistent with data collected	6	0	11.8	47.1	41.2
Explanations based previous data and prior knowledge	7(b)	0	41.2	41.2	17.6

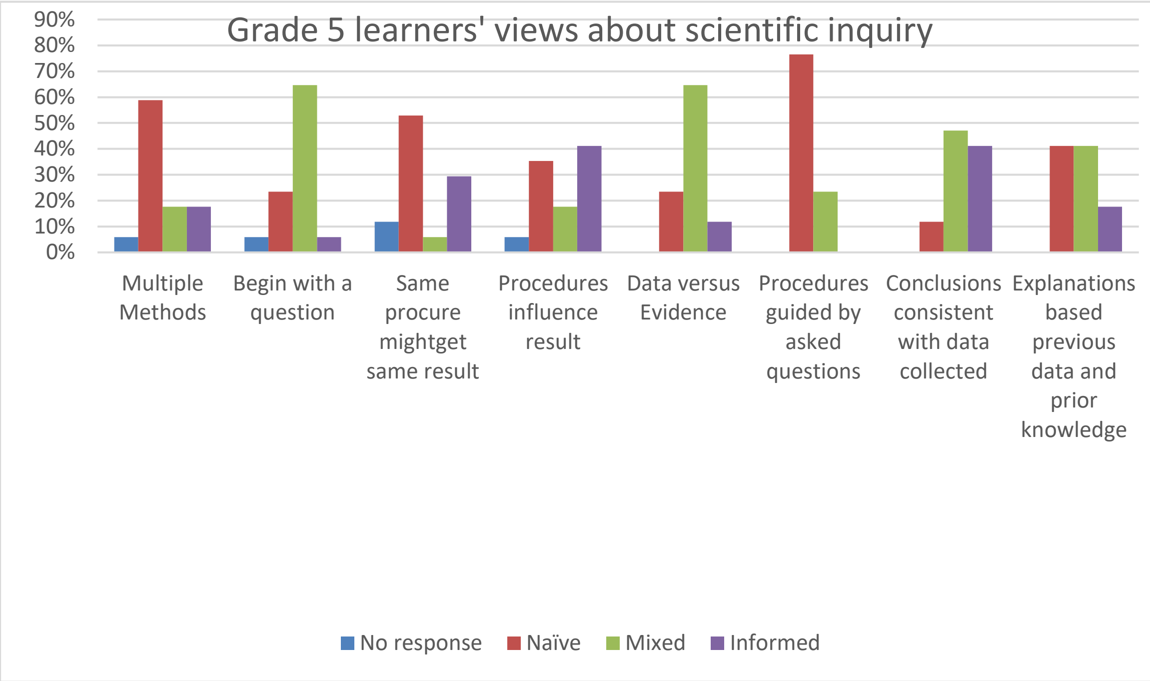

Figure 4.3: Shows a bar chart for grade 5a learners' VASI

Learners' views of scientific inquiry are presented in Figure 4.3 above. What is seen in the figure above is that when the bars for informed responses dropped, the bars for naïve responses increased in height. This implies that if learners could not answer with an informed view and a mixed view, then their answers were regarded as naïve. As seen in the graph, aspects 4, 5, 6 and 7 were not answered by all learners since there were only three bars in each aspect. In comparison, the graph shows that aspects 1, 2, 3a and 3b were responded to by all learners. To add on, aspects 3b and 6 were answered overall with informed views, with aspect 6 receiving the least naïve views as seen in the graph.

Table 4.4: Shows general responses to the VASI questionnaire

Codes	Informed	Mixed	Naïve	No responses	Total
VASI responses	29	47	51	5	132
Percentages	22.0 %	35.6%	38.6%	3.8%	100%

The total responses to the VASI questionnaire as seen in Table 4.3 above was further converted to percentages as seen in Table 4.3 and Table 4.4 above. The general discussion on learners' attitudes' toward the sense-making of scientific inquiry shows that 51 learners (38.6%) gave naïve view answers followed by a mixed category with 47 learners (35.6%), and informed views were recorded for 29 learners (22.0%). Five learners could not respond to some aspects tested in the VASI questionnaire and this figure constitutes 3.8%.

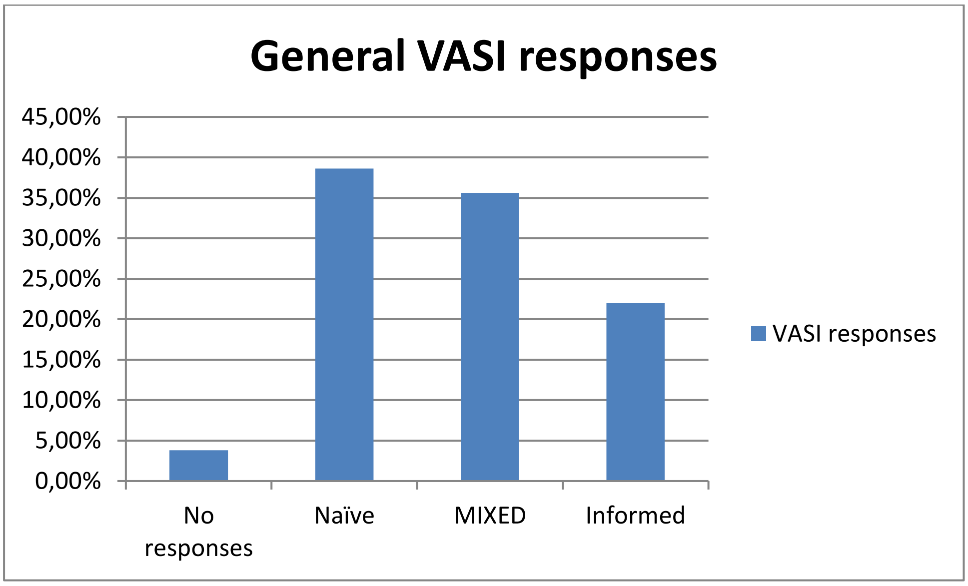

Figure 4.4: Shows bar chart of general responses from the VASI questionnaire

Figure 4.4 was created to give more insights in a simpler form and a better understanding of how learners performed when answering the VASI questionnaire. A more detailed discussion on all aspects of the VASI is provided below.

4.3.1.1 Scientific investigations begin with questions and do not always test a hypothesis

This aspect was assessed in question two (Q2) of the VASI questionnaire. It reads "two students are asked if scientific investigations must always begin with a scientific question". The specific question was "do you think scientific investigation can follow more than one method? If no, please explain why there is one way of scientific investigation". Learners' responses as shown in Table 4.3 and the bar chart in Figure 4.2 are as follows: 11 learners (64.7%) held mixed views, one learner (5.9 %) gave informed views, four learners (23.5%) showed naïve views and one learner (5.9%) did not show views toward the question.

The findings under this aspect "scientific investigations to begin with a question" showed that this aspect was not well answered. The 11 learners (64.7%) with mixed views reflected that learners could not explicitly understand the reason why scientific investigations begin with a question because their answers were regarded as informed views. Referring to Table 4.2, these 11 learners (64.7%) could not give a supporting sentence after they had agreed that scientific investigation begins with a question and there was only one learner whose answer was regarded as informed. That is, it could be argued that 16 learners did not understand this question. These findings corroborate with Hamed et al.'s (2017) and Penn's (2019) studies which also found that 65.4% and 74.4% of the learners showed naïve views respectively.

4.3.1.2 There is no single set or sequence of steps followed in all scientific investigations

This aspect was represented by question one (Q1) in the VASI questionnaire which assessed three sub-questions with the first two sub-questions 1(a) and 1(b) acting as leading questions to the assessed question 1c. Learners were expected to think about whether scientific investigations can follow more than one method and explain if they thought it was not needed. The findings revealed that 10 learners' (58.8%) responses were naïve views, three learners (17.6%) scored mixed views and informed views and there was one learner (5.9%) who did not answer the question.

The findings revealed that 10 learners (58.8%) showed a naïve understanding of the aspect of multiple methods in scientific investigations. Only three learners showed mixed views and three learners showed informed views, therefore 17.6% for each view. The high score of naïve views was revealed by other scholars like Penn (2019) and Hamed et al. (2017).

4.3.1.3 Same procedure might not have the same result

The aspect "same procedures might not yield same result" was assessed in question 3(a) of the VASI questionnaire. The findings revealed that 29.4% of learners showed informed views. Similar to the other two aspects discussed earlier, the naïve views scored a high percentage of 52.9% (nine learners) in this aspect. Only 5.9% representing one participant recorded mixed views of this aspect and there were two participants (11.8%) who did not answer this question.

The aim of testing this aspect was to establish whether learners were creative and applied logical thinking using sense-making examples to answer the question. Scientifically, the same procedure might not get the same result (Lederman et al., 2013). For this specific question, nine learners (52, 9%) had naïve view answers. This implies that a large number of learners' views were naïve, concluding that the question was less answered. This is the only aspect which scored a high percentage of no responses as compared to other aspects assessed. This suggests that many learners could not understand the scenario under the aspect "same procedures might deduce to different results" (Lederman et al., 2018; Penn, 2019).

4.3.1.4 Inquiry procedures can influence the results

The aspect of "inquiry procedures can influence the results" was assessed in VASI question 3(b) as appeared in Table 4.3. The table showed that seven learners' (41.2%) answers were informed views. There were three learners (17.5%) whose answers were regarded as mixed views and six (35.3%) of the learners' answers were naïve views, while there was one learner (5.9%) who did not answer question 3(b).

The findings revealed that this aspect was the first to receive a high percentage of informed views compared to all aspects discussed earlier. Only six participants (35.3%) who could not explicitly express themselves fell under the mixed views category. The reason for a high number of mixed views could be a result of a poor understanding of what scientific procedures are referred to in the question. There was only one participant (5.9%) who did not answer this question. This aspect was better answered and this was shown by the high number of seven learners (41.2%) having informed view responses.

4.3.1.5 Data differs from evidence

The aspect was tested in question (4) in the VASI questionnaire and learners were expected to explain if the data are the same as the evidence. Only two learners (11.8%) gave informed views, mixed views were scored by 11 learners (64.7%) and four learners (23.5%) gave naïve views. All learners answered this question.

The data revealed that four learners' answers were naïve views and scored 23.5%. The findings also showed that only 11.8% which stands for two learners understood the question and explained the difference between data and evidence. The 11 learners that constituted 64.7% could not provide a full distinction between data and evidence and the percentage was regarded as mixed views. Some learners could not understand the question and their findings were regarded as naïve views, represented by 23.5%. Question number four confused learners and 11 learners gave mixed response answers.

4.3.1.6 Procedures guided by the asked question

Table 4.3 above showed how the aspect "procedures guided the asked question" was answered by learners. This aspect was tested as question five (Q5) in the VASI questionnaire and authorised learners to compare two teams A and B and explain why one team's procedure was better than the other team's procedure. All learners answered the question. The data indicated that there was no response for informed views, while four learners (23.5%) scored mixed view responses and naïve view answers were given by 13 learners (76.5%).

This aspect of scientific inquiry was poorly answered because it shows a high percentage under naïve views compared to other aspects of scientific inquiry assessed (see Table 4.3). There was no learner whose view was rated as informed. Only four and 13 learners' views were rated as mixed and naïve respectively. The question was asking for an explanation as to why one procedure taken either by team A or Team B was better than the other. The learners whose views were rated as mixed almost fell under uninformed as they did not explain and defend their leading answers. This aspect was the first to not have informed views and was the worst answered question because more learners had naïve views (76.5%). This implies that learners were not able to conclude that procedures are guided by the asked questions.

4.3.1.7 Conclusions consistent with data collected

This sixth aspect of scientific inquiry was assessed as question six (Q6) of the VASI questionnaire which tested whether "conclusions are consistent with data collected". The data showed that both informed and mixed views were scored by only seven (41.2%) and eight (47.1 %) learners respectively.

No learner omitted this question under this aspect. This aspect was the first to be better answered under the informed views with 41.2% and mixed views with 47.1% compared with all the other eight aspects of scientific inquiry. The participants were able to work out that the conclusion was deduced from the data collected. The reason why question six was well answered could be because it was a multiple-choice question whereby some learners possibly guessed the answer.

4.3.1.8 Explanations are based on data and previous knowledge

Question seven tested whether "explanations are based on data and previous knowledge" in the VASI questionnaire. Question 7(b) required learners to reflect on the previous question 7(a) and give the type of information used to explain their conclusions. The data showed that three learners (17.6%) provided informed views on this aspect. Then seven learners (41.2%) recorded mixed views because they could not fully explain why explanations were based on data and previous knowledge. All participants answered this question.

Out of 17 learners who participated in the study, only three participants (17.6%) provided informed views on this question. Mixed views were recorded for seven learners (41.2%) out of 17 and the remaining seven (41.2%) recorded naïve view responses. From these results, it could be hypothesised that many learners could not understand the questioning skill of reflecting on the previous question and finding scientific inquiry-based on data and prior knowledge. A total of 14 (82.4%) learners could not get correct views on this aspect because they did not get informed views in the previous question (7a). If the previous data was not informed, it would affect 7(b) as well.

4.4 Learners' Attitudes Towards Scientific Inquiry Before the Use of a Mini-ecosystem

There was a record of 127 responses in total and out of the total five were recorded as no responses. Of the total responses, 51 responses were scored as naïve views (see Table 4.2) and this was 40.2%. The mixed views scored 47 responses in the whole VASI questionnaire and that recorded 37%. The informed views got a total of 29 responses in the total questionnaire and that gave 22.8%. In conclusion, these findings showed that learners' understanding of scientific inquiry was very poor because few aspects, that is 29 responses of the total 132 responses (22.0%), were explicitly answered.

4.5 Chapter Summary

The chapter presented data on grade 5 learners' VASI. The findings and discussions revealed that learners were mostly not well equipped with scientific inquiry knowledge during the questionnaire session. From these findings, it could be hypothesised that there is a need to promote scientific inquiry on every topic where possible for learners especially those learners from under-resourced rural schools in Namibia where resources like textbooks and science laboratories are not present.

CHAPTER FIVE: OBSERVATION, FOCUS GROUP INTERVIEW AND REFLECTIONS

5.1 Introduction

In this chapter, I present, analyse and discuss data generated from observations, a focus group interview and learners' reflections from monitoring a mini-ecosystem. Such data aimed to answer research questions 2 and 3:

- How does using a mini-ecosystem enable and/or constrain shifts in grade 5 NSHE learners' attitudes towards scientific inquiry?
- How does using a mini-ecosystem enable and/or constrain grade 5 NSHE learners in their sense-making of scientific inquiry in a rural school?

5.2 Development of Mini-ecosystems

As explained in Section 3.3.4, 21 learners participated in the study. Table 5.1 below shows their profiles.

Table 5.1: Profiles of the learners

Category	**Boys**	**Girls**
Age group	11-15	11-14
Gender	10	11
Grade repeaters	2	1
Condoned to grade 5	7	4

The observation as mentioned earlier in Section 3.3.5.2 aimed to establish how the use of a mini-ecosystem enabled and/or constrained shifts in grade 5 NSHE learners' attitudes towards scientific inquiry. I started with learners' class profiles and focused on their ages, gender, grade repeaters and those condoned to grade 5 (see Table 5.1 above).

I co-participated in the development of mini-ecosystems and then asked learners to use monitoring sheets to record all their results over two weeks. Twenty-one learners took part in the observation of their group's mini-ecosystem. I had five groups; four groups of four learners and a fifth group of five learners. These groups had representatives that were purposively chosen by other learners within the group and named their groups as Group A for apples, group B for bananas Group C for carrots, group D for dry berries (*eembe*) and group E for *eenyandi* (Jackal berries).

Firstly, I asked learners what they thought the use of the bottles was. "*Iilonga yuukende oya shike"* (What do you think is the use of the bottles)? Learners in their groups gave the following responses:

> Groups A&B: *Atu kunu mo?* (Do we plant in the bottles)?
> Group C: *Ohatu ka tula mpa mpena oonte dhetango* (We put it where there is sunlight).
> Group D*: Atu tula uumeno ndele atu sikileko, atu tsuko eembululu koshi* (We will put small plants and then we close it, then we make holes under the container);
> Group E: *Hatu tula uumeno pomutenya muukende wa patuluka* (We put plants in the bottles and place them in the direct sunlight in open bottles)

Regarding the above responses, they show that learners have some knowledge about what the bottle could be used for. I liked groups A and B's question: "*Atuu kunu mo?"* (Do we plants in the bottles?) because it stimulated the rest of the groups to answer the first question. Group C did not answer the question but rather added to groups D and E's responses. I then asked these five groups to give me the difference between living and non-living organisms: "*Omushi eyooloko pokati kiinima hayi ithanwa: living and non-living things?"* (Do you know the difference between living and non-living things?). The aim of this question was for learners to see features of living and non-living organisms during the monitoring of their closed bottles.

Figure 5.1: Shows introduction during recapping of grade 4 ecosystem topic

Learners in Group E were able to differentiate between living and non-living organisms in the Savannah ecosystem. For instance, they pointed out that "*uuwanawa womiti ohadhi gandja oonhenya dhoku kuna omiti omipe"* (The advantage of plants is that they give seeds that can be used to grow new plants). Group A also added to the advantages of non-living organisms like dead plants: "*ohatu kufa po iikuni"* (We get firewood). I asked a follow-up question: What do we get from firewood? Group C answered: "*Omulilo opo tu teleke"* (We get heat for cooking).

Thereafter, I asked the learners to give advantages of living organisms: "*Yo iilonga yomiti dhi inadhi sa oya shike*? (What are the advantages of living plants)? I was testing learners' understanding of oxygen and carbon dioxide during the process of photosynthesis. Here are learners' responses: Group C responded*: "Omiti ohadhi ningi iikulya yadho yene"* (Plants make their own food). I asked them how. Group B answered: "*uuna pena oonte dhetango nomeya, nena omiti ohadhi ningi iikulya moku pitila momafo"* (When there is sunlight and water, then plants make their food through leaves). I further probed learners to explain the process of plants making their own food. Learners explained as follows:

> Group A: *Ohashi ithanwa photosynthesis* (It is called photosynthesis).
>
> Group B: *Omiti ohadhi ningi iikulya oku pitila momafo* (Plants make food through the leaves).
>
> Group D: Carbon dioxide *ndji hatu fudhamo oyo hai longithwa oku ninga iikulya yomit* (The carbon dioxide we breathe out is used to make plants' food).

Learners' responses in this part showed that they were not explicitly good at explaining the process of photosynthesis. Nonetheless, Groups A and B tried their best to answer the question. They seemed to show some understanding of the process of photosynthesis, however, they could not fully explain the process. I could not question further because I wanted learners to navigate the process of photosynthesis during the monitoring of their mini-ecosystem.

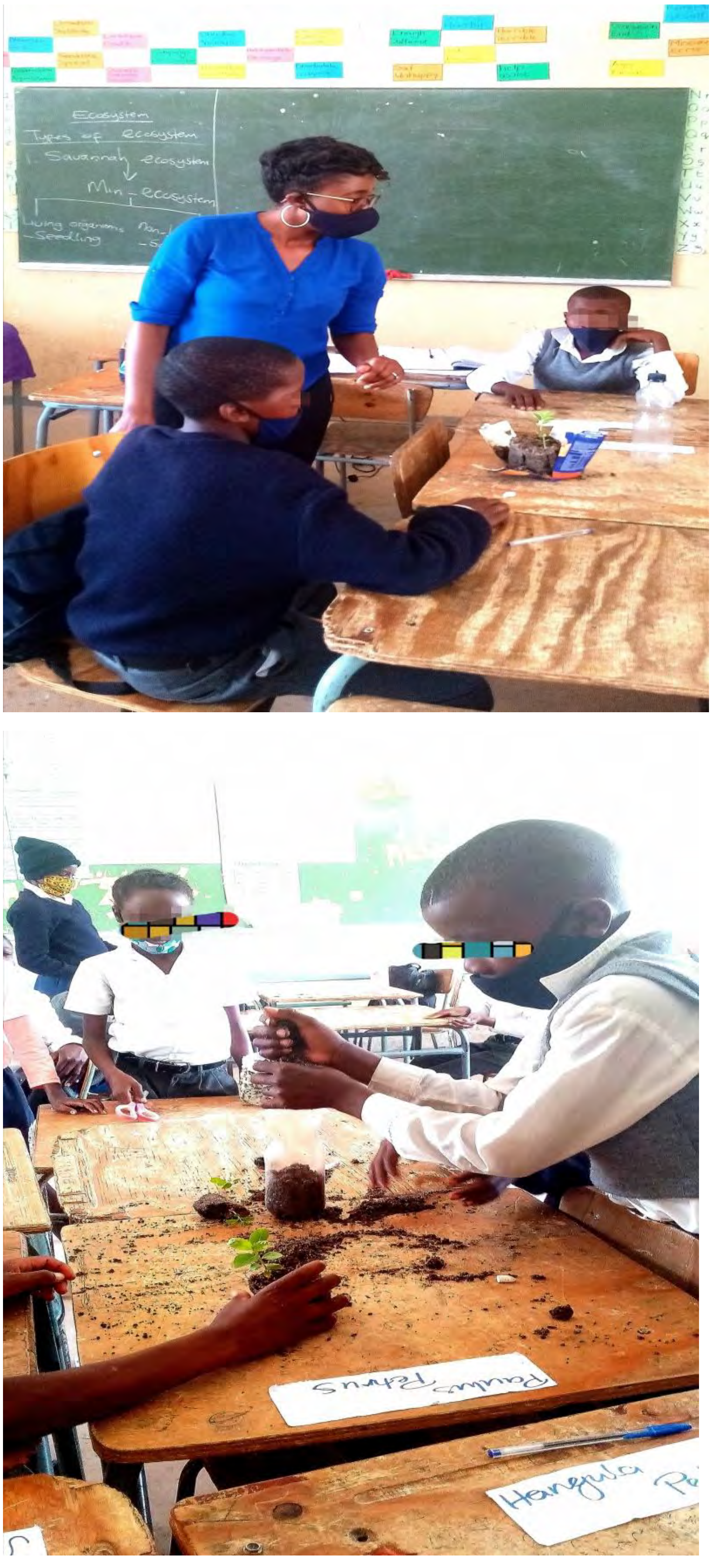

Figure 5.2: Shows learners making their mini-ecosystems

5.3 Raw Data from Monitoring Mini-ecosystems

Figure 5.3 below shows a sample of one of Group C's reflection sheets with the first column answered by learners. The second column shows the English translation by me and the third column shows scientific concepts that emerged from the learners' observations.

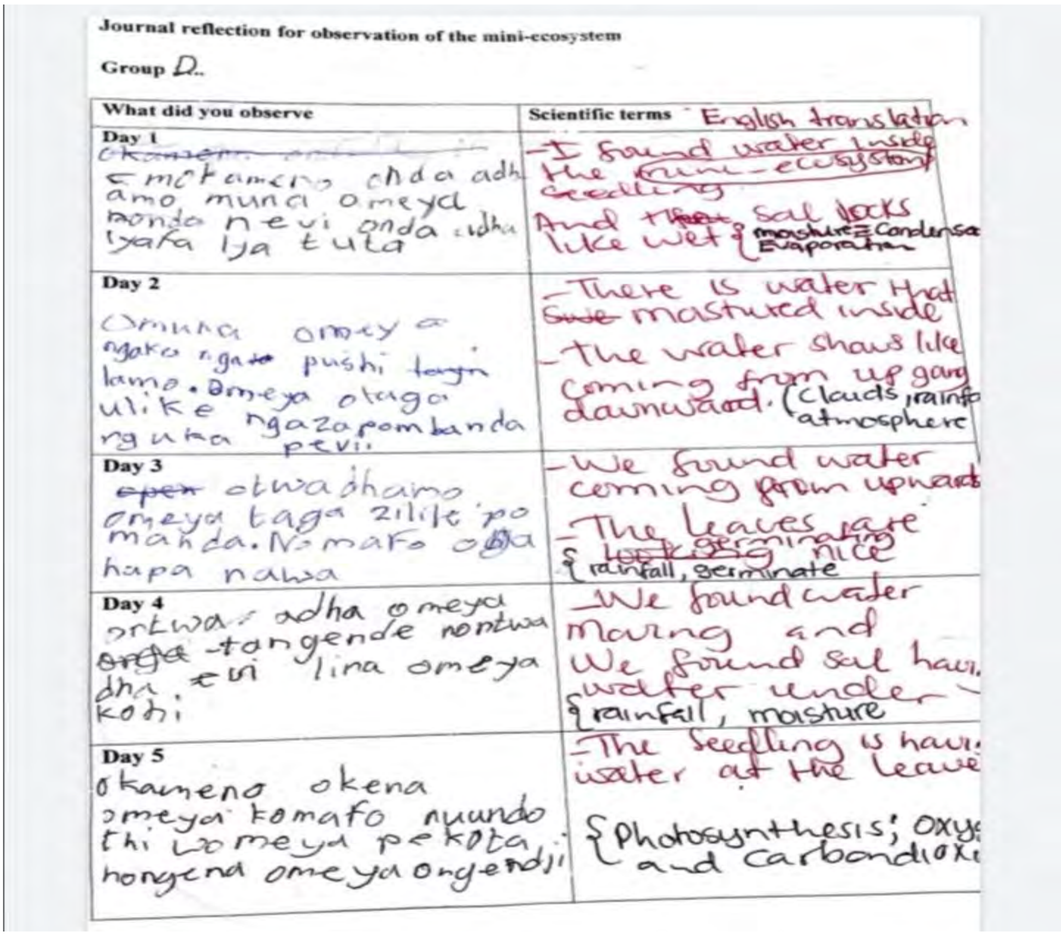

Figure 5.3: Shows a sample of a monitoring sheet

During day one of the observation, five groups recorded as follows:

Group A: *Otwa adha omata gomeya mokameno* (There were drops of water in the bottle) "*nevi okwali lya tuta"* (the soil was wet).

Group B: *Otwa adhamo omeya nevi tali ulike lya tuta"* (There was water and the soil was wet).

Group C: *Otwa adha omeya mokakende* (There was water in the bottle).

Group D: *Onda adhamo omeya mokameno nevi olya fa lya tuta* (There was water in the plant and the soil was like wet).

Group E: *Okwali muna omeya taga kunguluka taga zi mokakende ga uka pevi* (There was water flowing from up going downward).

Day 2

On the second day of observation of their mini-ecosystems, the following was recorded:

Group A: *Omwali muna omeya taga zi mevi ndi lya tuta, okameno omo keli, nomeya ngoka geli mo otati ogo'evaporation* (There was water in the soil, the plant is there and the water that is there we are saying was evaporation).

Group B: *Okena omwenyo evi olya tuta mo omuna omeya ga pusha sho kwasikilwa, otaga ulike taga ziko guka kokameno* (The plant is alive, the soil is wet and there is water moisture as it was closed, it's showing water coming to the plant).

Group C: *Mokakende omuna omeya, evi olya tuta nawa nokameno oka hafa, omeya otaga ende guuka kevi ndi lili kohi yokameno* (There was water in the bottle, the soil is nicely wet and the plant was looking nice and the water was moving to the soil that was under the plant).

Group D: *Omuna omeya ngoka ga pushilamo, omeya otaga ulike gaza pombanda ga uka pevi* (There is water that forms moisture, the water showed that it was coming from up going down).

Group E: *Evi olya tuta, okameno oka ziza nawa ko okena omeya* (The soil is wet, the plant is nicely green and it is having water).

Figure 5.4: Shows water moving down to the soil from the inner wall of the bottle

Day 3

On day 3, the groups observed the following:

> Group A: *Omeya otaga ngongoloka, evi olya tuta, okameno oka shuna pevi kashona nomafo ogeli koshi yevi* (Water was flowing and soil was wet, the plant moved down a bit and the leaves are under the soil).
>
> Group B: *Evi olya tuta, mo omuna omeya, okameno otaka ulike ka hapa nawaa* (The soil is wet and there is water and the plant looks fresh).
>
> Group C: *Mokameno omuna omeya taga tondoka ga uka pevi, okameno oka koka kuuka pevi* (There is water in the plant, the water is running going down and the plant is growing downward).
>
> Group D: *Otwa adha mo omeya taga zilile pombanda, nomafo oga hapa nawa* (We found water coming from up and the leaves are fresh).

Group E: *Mokakende otwa adha mo omeya ga ninga ondjila guuka kevi lyokameno nokameno oka koka nawa nevi olya tuta nawa* (We found water in the bottle making lines going down the soil where the plant is, and the plant is nicely grown and the soil is wet).

Figure 5.5: Shows Group A's bottle on day 3

Day 4

The groups made the following observations:

Group A: *Okali taka tsapuka ashike ohela okali kuuka pombanda* (It was growing and developing leaves but yesterday it was going up).

Group B: *Evi olya tuta mo omuna omeya taga tondoka* (The soil was wet and the water was running).

Group C: *Okameno oka mena nawa, omuna omeya nevi olya tuta* (The plant is nicely growing and there was water and the soil was wet).

Group D: *Otwa adha omeya taga ende notwa adha evi lina omeya* (We found water moving and the soil was having water).

Group E: *Omeya otaga ende guuka kevi, okameno oka koka, evi olya tuta nawa nokamenooka hafa nawa* (Water is moving going down to the soil, the plant has grown and the soil was wet and the plant is fresh).

Day 5

The findings for the fifth day were as follows:

Group A: *Nena otwa adha omafo geli koshi yevi ko otaka shuna pevi, nomeya taga kunguluka nevi olya tuta* (We found the leaves under the soil and the plant was falling down, the water was running and the soil was wet).

Group B: *Evi olya tuta nawa, okameno okena omwenyo ko oka ziza nawa* (The soil was wet and the plant was alive and nicely green).

Group C: *Omuna oomwidhi dha koka, okameno oka pitilila mo, okameno oka ziza nawa* (There were grasses growing, the plant was nicely grown exceeding the bottle and the plant is nicely green).

Group D: *Okameno okena omeya komafo nuundothi womeya pekota, ko okena omeya ogendji* (The plant is having water on the leaves and drops on the stem and it is having much water).

Group E: *Mokakende omuna omeya nevi ndi tali ulike kutya oecosystem ohati ulike mokakende omuna okameno ka koka nevi olya tuta* (There is water in the bottle and the soil that shows that ecosystem – shows in the bottle there is a plant that has grown very well and the soil is wet).

Figure 5.6: Shows growing plants/seedlings, wet soil and water on leaves

Additionally, Group D found there was water on the leaves and stem. I found this finding applicable to groups B, C and E because their plants also had water on the leaves but they did not indicate it. Group E's comments were not clear on day 5: they wrote "show in the bottle there was a plant" and another unclear finding of "soil that shows ecosystem". I could not write any comment on their observation comments above because I did not get what they meant.

5.4 Themes and Sub-themes That Emerged from the Observations

Table 5.2: Shows themes and sub-themes

Themes and sub-themes	**Literature/theory**
Learning ability Interactions among learners Sharing ideas and commonalities	Atallah et al. (2010); Vygotsky (1978) Ekawati (2017); Lederman et al. (2013); Kavoc (2005)
Learning opportunity Scientific inquiry Science concepts emerged	NRC (1999); Lederman (2010); Penn (2019); Shinana (2019)

In this section, I present themes and sub-themes that emerged from the observation sheets during the monitoring of the mini-ecosystems (see Table 5.2).

5.4.1 Learning ability

From day one's observation, groups detected the common findings that "*Otwa adha mo omeya nevi olya tuta"* (There was water in the bottle and the soil was wet).

This meant that all groups had common findings as they learned that all bottles had water inside. For instance, Group A on day 2 indicated that the water was from the wet soil. Learners had common findings emerging from monitoring their mini-ecosystems. For example, all groups found that water which was inside the bottle was coming from the soil. Vygotsky (1978) avers that learning is a social process and it happens in two ways: by interacting with one another and by integrating knowledge into individual mental structures. These learners integrated knowledge well during the monitoring of the mini-ecosystems and they were able to make sense of scientific inquiry during the teaching of the ecosystem. Hence, the mini-ecosystem model used in this study increased learners' knowledge of how the ecosystem reflects in a real-life situation (MEAC, 2016).

On day two of the observation, groups found the following:

> Group A: *Omeya otaga zi mevi ndi lya tuta* (Water is coming from wet soil).
>
> Groups B and C: *Omeya otaga ende guuka kokaneno'nokevi lyokameno* (Water is moving toward the plant and to the soil).
>
> Group D: *Omuna omeya taga ulike ga za pombanda ga uka pevi* (There is water that seems from the top of the bottle to the soil).

Day two still had common findings. All groups found that there was water in their bottles. The fact that all groups got the same findings was because they recorded them on the same day and at the same time as I had instructed them and this resonates with Kavoc (2005). This researcher believes that teachers play a role in learners' abilities to develop self-regulation. On day two, I detected a shift in learners' findings such as: "*Omeya otaga ende taga zi pombanda ga uka pevi"* (Water was moving from the bottle going to the soil). All groups saw water moving down to the soil and they did not observe this on day one. Hence, learners were able to make their own observations and hypothesise (Penn, 2019).

During day three, Group A noticed that there was something wrong with their plant: *"Omeya otaga ngongoloka, evi olya tuta, okameno otaka shuna pevi"* (Water is running, the soil is wet and the plant is getting down).

These observations made learners investigate the cause of their plant falling down and this was facilitated by the representative of Group A who was entrusted by the group members as the more knowledgeable other (Penn, 2019; Stott, 2016; Vygotsky, 1978) to lead during this study. Another member of Group A stated: "*Okameno ketu okasa shashi okeli mokakende ka thinana"* (The plant died because it was in a small bottle and there was not enough space).

Group B noted: "*Evi olya tuta, omuna omeya, okameno oka hapa nawa"* (The soil is wet, there is water and the plant is looking nice). This was the first time Group A's findings differed from the other four groups. One Group A learner suggested that the plant might have died because the day they put it in the bottle some roots were damaged. This was scientific reasoning because their investigation was learning through inquiry (Capps & Crawford, 2013).

On the last day, the group findings were different as well:

> Group A: *Omafo gokameno ogeli koshi yevi* (The leaves are under the soil).
>
> Group C: *Omuna oomwidhi dha koka, okameno oka koka nayi, okameno oka ziza nawa* (There are grasses growing in the bottle, the plant has grown, the plant is nicely green).
>
> Group D: *Okameno okena omeya komafo nuundothi womeya pekota* (The plant has water on the leaves and drops on the stem).

From the learners' findings above, I noticed that there were some differences in their observations. Group A observed the leaves of their plant were under the soil and the next day's observation showed that the plant was falling down and that meant that the plant was dying. The size and structure of the bottle (different shape from other containers) (see Figure 5.5) might have caused the dying of Group A's plant. The closed bottle was the only one with a seedling that did not survive. Group A's model gave learners a living demonstration which enabled them to reach a deeper understanding (Bruner, 2012) of how sometimes, living things die if not well maintained. This is also supported by Elpick and Mackenzie (2015) that there is a need to advocate environmental awareness of how to maintain the ecosystem. To add, Group C's findings revealed that grasses were growing inside the bottle and this gave them the courage to keep on monitoring their mini-ecosystem. This finding was not detected by other groups, despite the fact that there were small seedlings in all closed bottles.

All these findings contributed to the learning of science through scientific inquiry which is central to a learner-centred approach (Nyambe & Wilmot, 2012). During learner-centred learning, learners are afforded an opportunity to understand how scientists develop knowledge (Lederman et al., 2013) and how they make sense of scientific inquiry through observation. Learners figured out through interaction with each other and with the aid of cultural tools (Hogan, 2019; Vygotsky, 1978).

5.4.2 Learning opportunities

The data gathered from the observations revealed that learners were able to reason scientifically. In most of the learners' findings, many of their reasons were scientifically oriented. For example, Group A stated that: "*Omeya otaga zi mevi ndi lya tuta"* (The water is from the wet soil). For example, on day one all groups were talking about drops of water: "*Otwa adhamo omeya mokakende, evi olya tuta"* (The bottle was having water and the soil was wet). These findings indicate that learners were able to deduce the terms evaporation, moisture and droplets, pigment, growth and many others.

Another science concept that emerged from learners' observations was condensation and this was stated by Group A: "*Omwali muna omeya taga zi mevi ndi lya tuta, nomeya ngoka geli mo otatuti ogo evaporation"* (There was water coming from the wet soil as a result of evaporation). The water was extracted from the wet soil into the atmosphere. In this case, the atmosphere was the wall of the bottle of a mini-ecosystem. As it was seen on the wall of the bottles, the water vapour changed to liquid water. All groups stated that water was running down to the soil and that implies that the condensation process was taking place. It seems that learners were able to remember water cycle terms from grade 4. That was evident as Group A highlighted the process of the water cycle as the knowledge they learned earlier from their previous classes (Elpick & Mackenzie, 2015; Mavhunga & Rollnick, 2016; Nhase, 2019). Other scientific concepts that emerged from the study are presented in Figure 5.6.

It could be concluded, therefore, that there was a shift in learners' attitudes toward science because their mini-ecosystem enabled them to make sense of scientific inquiry. Learners developed such shifts during the observation of their mini-ecosystem and the focus group interview. These learners were able to practically find out answers to the questions while observing their closed bottles and Hogan (2019) refers to this as figuring something out.

5.5 Themes that emerged from the focus group interview

The focus group interview was aimed at probing learners' sense-making of scientific inquiry which was not explained during the VASI questionnaire and observations. Essentially, the focus group interview was aimed at answering my research question three:

> How does using a mini-ecosystem enable and/or constrain grade 5 NSHE learners in their sense-making of scientific inquiry in a rural school?

Different techniques of gathering data helped to triangulate and strengthen the validity of the study (Bertram & Christiansen, 2015). For instance, data obtained from the VASI questionnaire was transcribed and findings revealed that participants' views towards scientific inquiry were not well established. This was shown by the high number of naïve responses (38.6%) (see Table 4.4). However, questions 6 and 7 of the VASI questionnaire afforded participants an opportunity to learn science concepts and reasoning that worked as prior knowledge to carry on with observations. Hence, observations of the mini-ecosystems enabled participants to gain data that helped them to answer focus group interview questions. In every technique, there was a shift. So, participants' involvement in the focus group interview and reflections were satisfactory. Agreeing to these, participants discovered many scientific concepts that are found in a Savannah ecosystem such as evaporation, rainfall, moisture and condensation. As result, participants were enabled to make sense of scientific inquiry during the teaching of the topic of the ecosystem.

The use of home language used in the study was also supported by Kudumo (2020) in his study as he avers that the use of home language influenced the degree of concentration and understanding among his participants. I decided to code participants' responses in the focus group interview in the same way I coded the VASI questionnaire; no response, naïve, mixed and informed responses. The coding was given according to learners' views in answering the interview questions. The main reason for choosing the same codes was to establish shifts in all three stages of data collection in this chapter.

Table 5.3: Shows themes that emerged from data

Themes	Literature/Theory
Theme 1: Understanding of scientific inquiry prior to the study Learners scientific knowledge	Schwart, Lederman and Crawford (2003); Friesen (2017); Asheela et al. (2021); Kakambi (2021); Kudumo (2021); Nyamakuti (2021)
Theme 2: Attitudes toward learning scientific inquiry Curiosity in learning	Atallah et al (2010); Ekawati (2017); Agunbiade et al. (2017); Ainely and Ainely (2011)
Theme 3: Shifts in learning Enhancement of learners' scientific inquiry	Vygotsky (1978); Asheela et al. (2021); Shabani (2016); Harrison and Muthivhi (2013); Hashondili (2020)

Themes were developed from the data and these are presented in Table 5.5 above. Five learners were interviewed. These learners used their group codings as Group A, Group B, Group C, Group D and Group E.

5.5.1 Prior knowledge of the understanding of scientific inquiry

Learners were asked to give their views about their understanding of scientific inquiry before they were introduced to a mini-ecosystem. Their responses indicated that the knowledge of developing a mini-ecosystem was new to them. For example, some groups indicated that:

> Group A: *Shi tu uvite ko paife ka kwali tweshi uva ko grade 4* (How we understand now is not how we understood ecosystem in grade 4).
>
> Group B: *Shi tashi popiwa ngaingeyi ka kwali tweshi ilongwa ko grade 4* (What is being presented now was not taught in grade 4).
>
> Group AR: *Okwali ndi hole oku tala kehe esiku opo ndi tale ngele ngula sho nena osho shili mo ngula* (I liked everyday monitoring of our mini-ecosystem because we were observing if today's findings differed from yesterdays).

From these excerpts, it was clear that learners had not been exposed to any model or easily accessible resources (Asheela et al., 2021) that could enhance their understanding of the ecosystem. Hence, it could be concluded that perhaps the grade four teachers lacked understanding of teaching through an inquiry-based approach (Harlen, 2015; Ramnarian & Hluatswayo, 2018) because learners revealed that they did not use a mini-ecosystem in grade

4. During reflections, Group A posted that they were happy to use the previous day's information and compare them to the current (today's) information. The previous day's information in this case represented learners' prior knowledge (Kakambi, 2012; Kudumo, 2021, Nyamakuti, 2021; Nhase, 2019). In addition, Group B's statement exposed that hands-on and minds-on activities are crucial (Asheela et al., 2021) because, without hands-ons, minds-on activities, it can lead to memorising concepts without understanding. Consequently, science teachers are cautioned by Shinana et al. (2021) to be facilitators and allow learners to discover information by themselves. They are also cautioned to always test learners' prior knowledge by asking them what they had learned previously (Nhase, 2019).

5.5.2. Learners' views toward scientific inquiry

The data from the focus group interview question one and that from learners' reflections revealed that learners had positive attitudes toward scientific inquiry. For example:

> Group B: *Okwali twa uva nawa shaashi atuka longwa oshinima inaatu shi longwa nale* (We felt good because we were going to be taught something we were never taught before).

> Group CR & Group ER: *Okwali ndi hole oku tala eyoloko pokati kuumuti* (I liked to compare and get differences between plants).

From this excerpt, it seemed that learners were looking forward to learning new ideas. They were so inquisitive to learn about scientific inquiry. Aijzen (2001) defines attitudes as evaluative judgements by a person. It was obvious that whatever activity learners were involved in, they were aiming for new development of ideas. Hands-on practical activities (Asheela et al., 2021) promote social interactions that contribute to learning (Vygotsky, 1978). This implies that learners were happy to learn as a group, sharing ideas and findings. Working in groups promoted learners' ZPD (Vygotsky, 1978) by allowing MKOs to help the less knowledgeable (Vygotsky, 1978). In their respective groups, some participants who understood better than others during observations and/or the focus group interview, always gave answers and participated more. In the process, these particpants played the role of MKOs (Vygotsky, 1978) and through their partipation, they helped the less knowleagable others to gain scientific skills in questions they were not able to provide answers for. So, learning through social interactions was accorded.

This was shown by learners' activeness during the focus group interview. For instance, Group C stated: "*Otwali tu uvite nawa shaashi atu ka longwa opo eilongo lyetu liye komesho"* (We were so happy because we were going to be taught new ideas to enhance our science knowledge).

Learners indicated that they were positive about what was going to happen. They could not wait to learn things from of their bottles (mini-ecosystem). Developing a mini-ecosystem was an indication to learners that they were going to practically learn something new. As reinforced by the National Research Council (NRC, 2012), science practicals need to be delivered through inquiry. Hence, to integrate learning through SCT which promotes social interaction (Vygotsky, 1978) learning must be transitioned from controlled to uncontrolled processes via practices.

Group C posited that "*otwali tu uvite nawa shaashi atu kiilonga shina sha nomiti"* (we were so happy to learn about plants). These learners live in a rural Savannah ecosystem, where plants and animals need each other for survival (Elphick & Macernzie, 2015). They believed that learning about their environment would help to maintain their environment. The environment needs to be looked after because most people especially Africans survive by using natural resources directly or indirectly (Egoh et al., 2012). Learning about plants accorded learners an opportunity to sustain them. Namibia, just like other countries supports ESD. One objective of ESD is aimed at promoting a sense of responsibility toward restoring and maintaining ecological balances through the sustainable management of natural resources (SEEN, 2005). Teaching with this objective as a teacher, means they need to implement, investigate and problem solve, demonstrate, cooperate in groups and use experimental methods of teaching (Dreyer & Loubser, 2005; O'Donoghue, 2015).

5.5.3 Shifts in scientific inquiry

This theme illuminates whether or not a mini-ecosystem enabled and/or constrained sense-making of learners' scientific inquiry. Starting from the development and monitoring of a mini-ecosystem, learners in their groups were involved in discussions and asked many questions – this resonates with Vygotsky's (1978) concept of social interactions. Considering learners' findings, the groups during the focus group interview and during learners' reflections stated the following:

Group B: *Ondiilongo mo kutya okameno otaka shendje, ano taka koko, shi weka adha nena hashoweka adhele ohela* (I learned that the plant was growing because what you find it today will not be the same as what you find it yesterday).

Group E: *Sho kwali hatuya oku tala okameno, okwali hatu adha omeya ko ota ka koko maara ka kwali hatu tulamo omeya* (When we used to come monitor the bottle, we used to find water in the bottle and the plant was growing, however, we were not putting water in).

Group DR: *Ondi ilonga nkene okameno haka ende taka koko. Ondi ilonga mo nkene to vulu oku tsika okameno.Ondi ilongamo kutya pokati living things and non-living things* (I learned how plants grow inside the bottle. I learned how to plant. I also learned about living and non-living organisms).

This was indeed an answer to whether the plant survives or dies when placed in a closed bottle under wet soil. Vygotsky (1978) believes that learners can learn better when they are involved in discussions. The class discussions and collaborations with peers during the developing and monitoring of a mini-ecosystem enabled learners to achieve an understanding of the activities and the curriculum (Shabani, 2016; Vygotsky, 1978). It also allowed learners to learn through scientific inquiry. In addition, the PEEOE approach by Asheela et al. (2021) that was considered during the development and monitoring of a mini-ecosystem afforded learners an opportunity to explore. Group C's (during focus group interview) findings revealed that "*ondi ilonga mo kutya okameno mboli sha weka tula mokakende wa sikilako, otamu kala muna omeya"* (I now know that if I put the plant in a closed bottle, there will be water).

Learners were able to make sense of their findings as they were comparing their bottles. This was also grasped by Group DR as they learned about plant growth, planting as well as the differences between living and non-living things. These comments indicated that there was a shift (Hashondili, 2019; Kakambi, 2021; Kudumo, 2021; Nyamakuti, 2021) as learners gained some science concepts and scientific methods of planting and from observing closed bottles. As stated earlier in the chapter, some of the concepts learned are shown in Figure 5.7 below.

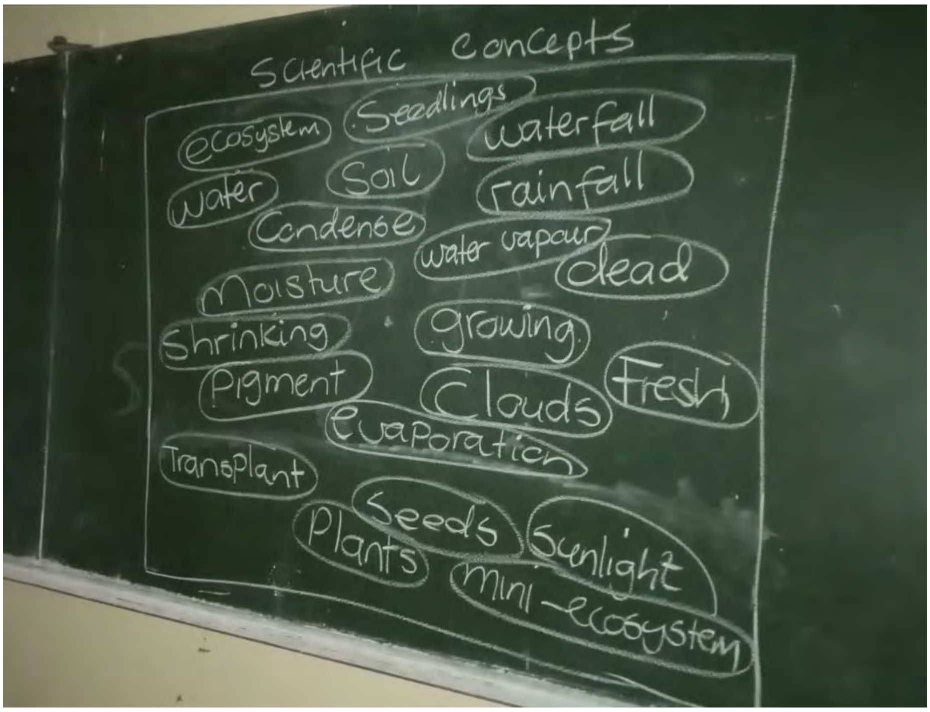

Figure 5.7: Shows science concepts that emerged from the observation of a mini-ecosystem and focus group interview

All these concepts were mentioned by learners throughout the study. However, some concepts were mentioned in English while others were translated from learners' home language (Oshiwambo). For example, concepts like ecosystem and evaporation were written in English while the rest of the words in Figure 5.4 were translated from Oshiwambo to English.

5.6 Chapter Summary

In the chapter, I presented, analysed and discussed data generated from observations, the focus group interview and learners' reflections. The aim was to address my research questions two and three. The findings revealed that learners gained some understanding and sense making of scientific inquiry. Findings also revealed that learners were motivated by the use of a model (mini-ecosystems) as a way to enhance their understanding of the Savannah ecosystem. Besides this, the third research question sought to find out whether the use of a mini-ecosystem enabled and/or constrained the sense making of scientific inquiry. The mini-ecosystem did not constrain the sense making of scientific inquiry because science concepts were recorded from day one of the observation. Even though Group A's plant died, it never stopped giving signs of scientific processes inside the bottle like that of water flow and moisture, the same as was seen in other bottles with live plants. Regardless, Group A managed to find scientific concepts such as green pigments and soil colour change which still enabled the sense making of these scientific concepts exactly like other concepts from the study.

In the next chapter, I present the summary of findings, recommendations and conclusion.

CHAPTER SIX: SUMMARY OF FINDINGS, RECOMMENDATIONS AND CONCLUSIONS

6.1 Introduction

The main goal of the study was to explore how a mini-ecosystem enables and/or constrains grade 5 learners from an under-resourced rural school to make sense of scientific inquiry. To achieve this goal, I employed a qualitative research design to generate data through a VASI questionnaire, observations, a focus group interview and learners' reflections. Data in this study were analysed using a thematic approach to come up with sub-themes and themes. Thereafter, discussions were made using relevant literature and theory.

To achieve this goal, the following research questions were addressed:

1. What are grade 5 NSHE learners' attitudes towards scientific inquiry?
2. How does using a mini-ecosystem enable and/or constrain shifts in grade 5 NSHE learners' attitudes towards scientific inquiry?
3. How does using a mini-ecosystem enable and/or constrain grade 5 NSHE learners' sense-making of scientific inquiry in a rural school?

I thus present a summary of my findings in relation to three research questions. I also present recommendations, areas for further study, limitations of the study, my personal reflections and the chapter conclusion.

6.2 Summary of Findings

The findings of the study are presented in relation to my three research questions.

6.2.1 Research question 1

What are grade 5 NSHE learners' views toward scientific inquiry before doing the mini-ecosystem?

In general, findings revealed that initially, learners had a poor understanding of scientific inquiry because they seemed not to have been exposed to it. For example, during answering the questionnaire, some learners feared making mistakes, hence they requested that their papers must not be marked. This implies that learners were sceptical about their answers and they were uncomfortable with their outcomes. These findings resonate with Penn (2019) who states that teachers need to receive training to teach and assess the understanding of scientific inquiry in order to expose them to learners.

So, there were both positive and negative attitudes towards learners' scientific inquiry through the VASI questionnaire (Lederman et al., 2018). The negative attitudes came from those learners who were not willing to learn new knowledge while positive attitudes were seen in learners who were keen to learn new knowledge from answering the questionnaire, observations, the focus group interview and learners' reflections. Learners' attitudes varied depending on the nature of the activity. If the activity was complicated, then learners were less likely to be interested in completing it. These ideas are also mentioned by Osborne et al. (2003) who stipulate that learners' attitudes toward science vary depending on the subject and topic.

The study further revealed through the focus group interview that learners felt good about being taught something new. For instance, one of the learners remarked that "*otwali tu uvite nawa shaashi atu longwa opo eilongo lyetu lyiye komesho*" (We felt so happy because we were going to be taught new ideas to enhance science knowledge). This resonates with Roschelle (1995) who says that new knowledge is learned if there is a new experience. In this regard, Aijzen (2001) defines attitudes as evaluative judgements by a person. Hence, the positivity of learners awarded them with the positive tendency to want to learn new things.

6.2.2 Research question 2

How does using a mini-ecosystem enable and/or constrain shifts in grade 5 NSHE learners' views toward scientific inquiry?

The findings revealed that a mini-ecosystem enabled the sense-making of scientific inquiry among the groups. Through social interaction, learners gained insights through discussions, sharing ideas and asking questions (Vygotsky, 1978). It is also believed that class discussions and collaborations with peers enabled learners to understand the activities (Shabani, 2016; Vygotsky, 1978).

Additionally, learners showed their positive attitudes toward plants, planting and the whole process of observing a closed bottle. The findings also confirm those of Ekawati (2017), who believes that to be scientific means that one has such attitudes as curiosity, rationality, honesty, open mindedness, objectivity and humanity among others. Learners' curiosity was aroused during observation of their mini-ecosystems as they were always looking to find and compare current findings and the next day's findings of their closed bottles (mini-ecosystem).

This finding has an affinity to what is reiterated by scholars such as Asheela et al. (2021) and Finnerty (2020) that hands-on practical activities have the potential to help learners visualise science concepts. For example, shifts in learners' responses were noticed (Kudumo, 2021; Kakambi, 2021; Nyamakuti, 2021) when the question was asked: what will happen if we put a plant in a closed bottle? Learners gave two answers: "*Okameno ota ka si"* (The plant will die) and others were: "*Okameno itaka si"* (The plant will not die). Also during learners' reflection, a learner in group D (Group DR) reflected that they learned how the plant grows inside the bottle. The learner also indicated that they learned how to plant as well as the differences between living and non-living things found inside a mini-ecosystem.

Finally, they learned that plants could survive or die in the bottle depending on the environment, the size of the bottle and the handling of the plant. Moreover, during the monitoring of the mini-ecosystem, learners were also enthusiastic to come to school to monitor them and coming to school developed their self-regulation through observation and dialogues as emphasised by Harrison and Muthivhi (2013).

6.2.3 Research question 3

> *How does using a 'mini-ecosystem' enable and/or constrain grade 5 NSHE learners in their sense-making of scientific inquiry in a rural school?*

Learners reflected that: "*Omwali muna omeya taga zi mevi ndi lya tuta, nomeya otatu ti ogo evapoaration"* (There was water that comes from the wet soil and the process is called evaporation). Also during learners' reflections, Group ER indicated that "*otwali twi longamo living organism"* (they learned about living organisms). This was supported by group D (Group DR) as one learner pointed out that they learned about living and non-living things.

From these findings, it could be concluded that learners were enabled to make sense of the scientific inquiry. Moreover, learners were able to derive an understanding of concepts like evaporation, pigment, condensation, rainfall (precipitation) and others. This implies that learners were making sense of the process of the water cycle and how the plants survive or are damaged in an ecosystem. Group A's findings enhanced learners' understanding of living and non-living things found in an ecosystem. In brief, sense-making is defined as an activity that is always situated within the cultural and historical contexts where people interact with each other (Fitzgerald & Palincsar, 2019).

Another response that shows the sense-making of scientific inquiry was: "*Omeya otaga kunguluka guuka pevi lyokameno*" (water flows going down) representing rainfall. From this excerpt, the scientific concept that emerged was condensation. If there is water running on the wall of the bottle that implies that after evaporation, the water changed from water vapour to liquid. The liquid formed lines of water running towards the soil. This process is called the water cycle, whereby water which was in the soil is recycled. "*Ekota lyomuti otali ningi eshona*" (The stem of the plant became small) hence the concept of shrinking.

All groups when they were interacting (Vygotsky, 1978) revealed that the stems of their plants were getting smaller, yet it did not limit the plant's growth. The PEEOE approach by Asheela et al. (2021) considered during the development and monitoring of a mini-ecosystem afforded learners an opportunity to learn through experimentation. So, involving physical activity and dialogue increased learners' understanding and sense-making of science (Nikodemus, 2017).

6.3 Recommendations

The study recommends that there is a need for scientific inquiry to be incorporated into the teaching of science. This implies that teachers need to be trained on how to teach through scientific-based approaches (Nhase, 2019; Penn, 2019; Ramnarain, 2021) because the main reason why teachers do not teach through scientific inquiry is that they are not well trained. By implementing training, learners could always have positive attitudes toward learning science.

Furthermore, the study recommends that teachers should bring artefacts or models or any easily accessible resources (Asheela et al., 2021) to class. Learning by seeing sustains knowledge and eliminates rote learning (Harlen, 2015; Ramnarian & Hluatswayo, 2018). Also, Penn (2019) states that it is crucial for learners to make own observations and interpret their findings.

I also recommend that the Namibian MEAC should identify science studies involving scientific inquiry-based approaches either in the form of models, artefacts and/or easily accessible resources to present to teachers during workshops. Such exercises might ease the burden of teaching challenging science topics for teachers when preparing their lessons. Further, I recommend that science teachers should also be technology-wise and get activities and other information from the internet and other educative social media, rather than just sticking to the textbooks. I recommend that teachers give learners time to explore, share ideas and develop scientific inquiry by themselves rather than spoon-feeding them.

During the study, the use of the Oshiwambo language contributed to the sense-making of scientific inquiry in the study. So another essential recommendation is that teachers need to consider using vernacular languages, especially at Namibia's primary level where English is the mode of instruction from grade 4. At the grade 5 level, learners are not yet ready to answer explicitly in English. For that reason, if teachers could use their home language and not English, learners' participation would not be as affected, especially when teaching challenging topics.

Subsequently, I recommend that learners should always focus and pay attention to whatever teachers bring to class in order to make sense of it. However, learners need to be critical of whatever the teacher brings to their discussion table. This implies that if learners use critical reasoning, they will be able to question the teacher, give their opinions and make their own evaluations during the teaching and learning process. I was impressed by my participants who came to school to observe their mini-ecosystem even though they were supposed to be home.

This shows that learners were eager to learn and more importantly, to find every day's changes inside the bottle and make their critiques.

6.4 Areas for Future Research

The study identified opportunities for further research on topics like the water cycle, energy and state of matter. A similar study could be carried out by grade 7 learners using vernacular language in order to find a comparison on the levels of sense-making of scientific inquiry between grade 4 and grade 7. Another reason for carrying the study out in grade 7 is because the VASI questionnaire is aimed to be administered from grade six upward. Another area of further study is to carry out a study in urban primary schools using English as the medium of instruction to avoid translation.

6.5 Limitations of the Study

The study participants were grade 5 NSHE learners from the Oshana region. This study was limited to only half a class of grade 5 (5a) learners because the class was divided due to covid-19 regulations. Therefore, the findings cannot be generalised to represent all NSHE learners in the Oshana region. However, the study findings provide some insights on how a mini-ecosystem enabled grade 5 learners to make sense of scientific inquiry.

Another limitation of the study was that it was conducted during afternoons, that is, after school hours. Some learners had to walk long distances to and from school. Hence, during the study, some learners were not patient enough to wait as they were very hungry and tired. That could be the reason why group E absconded during the focus group interview selection. This implied that learners who attended the afternoon activity of the study could have felt hungry because they did not come with lunch boxes, hence, the situation might have affected learners' concentration during the study.

The study was conducted in Oshiwambo and the use of the Oshiwambo language might have brought about the advantage of social interaction (Mavuru & Ramnarian, 2019; Vygotsky, 1978); however, I am mindful of the fact that the translation to English might have distorted the true meaning of learners' responses. Hence, to neutralise this, I called on my critical friend to help me with double-checking the translation.

6.6 Personal reflections

My research journey started in 2018 as I enrolled as a second-year student doing an Honours Degree with Rhodes University at Okahandja. During that time, I was introduced to the topic of learners' scientific inquiry by Prof Ngcoza and Dr Nhase, my supervisor and co-supervisor respectively. This encouraged me to register as a master's student in 2019 and focus on issues of scientific inquiry that my learners encounter during the teaching and learning process. My journey of developing a proposal title and research questions was not easy at all. I remember there was a time I wanted to give up. However, my supervisors and my study buddies encouraged me to work hard as it was not easy for every researcher.

My research understanding was elevated during the research design course at Rhodes University, Grahamstown (now called Makhanda) in March 2019. For instance, presentations by experts in research education opened my eyes on how to formulate the research topic and questions. During this time in Makhanda, I attended a presentation by an expert community member, Mama Nolingo on how to brew [3]*Umqombothi*. The presentation gave insights that scientific knowledge could be embedded in traditional practices. My time in Makhanda was really worthwhile and I learned a lot from other people's presentations; I was finding a way to draft my research topics and questions, paradigms, theories and approaches as presented and highlighted by many scholars in their presentations.

The main challenge for me in this study had to do with ethics. The fact that the application had to be filled out online on the university website was indeed quite devastating. It was stressful because you had to complete one question for the next question to appear. Another challenge was the village network – since I was on holiday, I could not complete my ethics application on time. During the ethics review, the university noted my statement that read: "*My critical friend will assist with my study"* and the committee commented, "*We have noted that the critical friend will assist you with your research – be careful that she does not do your research*

[3] *Umqombothi* is a traditional mostly common in South Africa made from maize, sorghum malt, yeast and water.

*for you, as the degree must be issued for your own work"(*Appendix A(i)). Because my critical friend already had a master's degree from Rhodes, the ethics committee thought that she might do the work on my behalf. Yet, the purpose of including a critical friend in my study was for validation purposes. Such a comment took us by surprise and my supervisors advised me to do my own work and not get help at all. However, the help I referred to was not supposed to go beyond the normal work of a critical friend. Fortunately, during my two weeks of study, my critical friend was on sick leave, and I had to find a new critical friend from the school who at the time was an Agricultural Science teacher for grades 6 and 7.

Another challenge was that of balancing the study, work and family. Being a student, a married woman and a teacher were not easy for me. I had to attend to all house duties of taking children to school and hospital and doing their homework and at the same time, I needed time to attend to my study. I thank Mrs Kambeyo and Mrs Iindombo, my study buddies who kept on calling and checking on my progress. Even though my progress especially from mid-2020 was very slow, I never gave up and I have to thank my supervisors for their constant support, especially when I lost my beloved mother. May God bless you Prof Ngcoza and Doctor Nhase!

I faced challenges during the journey of collecting my data as we all know that 2020 was not a normal year in teaching history. The classes were split in half to accommodate covid-19 regulations of a one-metre distance between learners. The wearing of masks was compulsory and not everyone could speak with the mask on, and this was a challenge because there were no facial expressions as a way of drawing attention from both teacher and learners. The schools were delayed from opening until July and some schools with suspected cases stayed closed for a long time. Despite, covid-19 challenges, I was able to complete my data gathering process as planned.

I gained magnificent experience and knowledge related to scientific inquiry. I learned that learners enjoy hands-on practical activities as reiterated by Asheela et al. (2021) and other scholars. I learned that the study conducted in a vernacular language resulted in all learners participating because it was very easy to express themselves in their acquired language. I noticed that if some topics could be taught using hands-on practical examples, models or easily accessible resources, there would not be difficulties in understanding scientific inquiry.

6.7 Conclusion

The study sought to explore how the use of a mini-ecosystem enables and/or constrains learners from an under-resourced rural school to make sense of scientific inquiry. To achieve this goal, I used the VASI questionnaire, observation, a focus group interview and learners' reflections as data techniques methods.

Findings from the study revealed that the use of a mini-ecosystem model enabled learners to make sense of scientific inquiry. That is, learners' observation of mini-ecosystems enabled them to interact and participate in information sharing in their groups (Sedlacek & Sedova, 2017; Vygotsky, 1978). As a result, learners were able to identify some scientific concepts such as evaporation, condensation, water cycle, rainfall and others mentioned as seen in Figure 5.7.

It also emerged from the study that learners' attitudes play a role in scientific inquiry. This was evidenced by Group B who said: "*Otwa li twa uva nawa shaashi atuka longwa oshinima inaatu shi longwa nale"* (We were so happy because we were going to learn something we never taught before). From this finding, it could be deduced that learners developed positive attitudes towards scientific inquiry as a result of the mini-ecosystem. Aijzen (2001) defines attitudes as evaluative judgements by a person. Hence, from these findings teachers are advised to incorporate learning through an inquiry-based approach as a way of attracting learners' positive attitudes toward learning science. According to Harlen (2015), an inquiry-based approach has the potential to eliminate rote learning.

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Appendices

Appendix A: Ethical clearance

RHODES UNIVERSITY
Where leaders learn

FACULTY OF EDUCATION
Rhodes University
PO Box 94, Grahamstown, South Africa 6140
• Tel:(0)46-603 7276 • Cell: (0)82-7394378
E-mail: e.rosenberg@ru.ac.za

28 September 2020

Ruusa Taimi Tobias (student number 17T8183)

Supervisors: A-Prof K. Ngcoza and Dr Zukiswa Nhase

Dear Ms Ruusa Tobias, Prof Ngcoza and Dr Nhase,

Re: Exploring how the use of a 'mini-ecosystem' enables and/or constrains grade 5 learners from an under-resourced rural school to make sense of scientific inquiry

ETHICS CLEARANCE APPLICATION NUMBER 16-04-13-08

This letter confirms that your research ethics application has now been **APPROVED** by the Education Faculty Research Ethics Committee. We have received permission letters from the principal and the regional director in the Ministry of Education, Arts and Culture in Namibia. You may proceed with your study.

Approval is granted for one year. A progress report will be requested in order to renew approval at the end of 2020. An e-mail reminder will be sent in this regard to your Rhodes-registered address.

Please notify the Committee Chair should any substantive change(s) that deviate from this application, be made during the research process. Please also provide a brief report to the Committee on the completion of the research. The purpose of this report is to indicate whether the research was conducted successfully, or if any problems arose that the ethical standards committee should be aware of. If the research results in the completion of a thesis lodged in the Rhodes University Library, please provide the Committee with the details of the submission as well.

Kindly safeguard this approval letter for the duration of your study, and for publication purposes thereafter.

Sincerely,

ERosenberg

Prof Eureta Rosenberg

Chair: Education Faculty Research Ethics Committee

1

Appendix B: Permission from Oshana Regional director

REPUBLIC OF NAMIBIA

OSHANA REGIONAL COUNCIL
DIRECTORATE OF EDUCATION, ARTS AND CULTURE
ASPIRING TO EXCELLENCE IN EDUCATION FOR ALL

Tel: 065 - 229800/25
Fax: 065 - 229834

Private Bag 5518
Oshakati

Enquiries: Hileni M Amukana
Ref. 13/2/9/1

Ms Ruusa Taimi Tobias
Cell: 0813317056

SUBJECT: PERMISSION TO CONDUCT A RESEARCH IN OSHANA REGION

Your letter dated 25 August 2020 on the above caption bears reference.

Kindly be informed that permission is hereby granted to conduct research study at Ontinda Combined School in Onamutai Circuit, Oshana Region.

This permission is subject to the following strict conditions; **(i)** There should be minimal or no interruption on normal working schedule **(ii)** Ethical issues of confidentiality and anonymity should be respected and retained throughout this activity i.e. Voluntary participation, and consent from participants

Both Parties should understand that this permission could be revoked without explanation at any time.

Furthermore, we humbly request you to share your research findings with the Directorate of Education, Arts and Culture, Oshana Region. You may contact Ms. Nuunyango-George, the Acting Deputy Director; Programs and Quality Assurance (PQA) for the provision of summary of your research findings.

We wish you the best in conducting your study.

Yours sincerely,

01/09/2020

OSHANA REGIONAL COUNCIL
01 SEP 2020

HILENI M. AMUKANA
REGIONAL DIRECTOR

Cc: Inspector of Education: Onamutai Circuit

All Official Correspondence must be addressed to the Regional Director

Appendix C: Consent letter from parents

Letter to the parent [Oshiwambo translation]

Rhodes University

Drostdy Road

Grahamstown

6139

Omusimanekwa

Re: Ekutho-mbinga moshi etwapo shedhina 'mini-ecosystem' shono tashi vulu oku etela aanasikola omadhiladhilo nomapulo gomuule mulongwa uunongononi.

Ongame Ruusa Taimi Tobias, ndili omulongwa-longi andi iilongele onzapo yopombanda muunongononi (Master) koRhodes Univesirti ya South Africa. Nesimaneko enene otandi ku indile opo u pitike okanona koye ka kuthe ombinga meilongo lyange ndika.

Uuwanawa meilongo ndika owo mbuka kutya; Uunona otawu ka hwepopaleka ekuthombinga moontundi dhawo sho taya ka longwa nkene o'mini-ecosystem' hayi etwapo. Onda inekela wo kutya okunongonona o 'mini-cocsystem' otaya ka zamo niilongithwa-tya oyindji yopaunongononi. Eilongo ndika otali ka gwedhela euveko lyange mokulonga aanona mbaka na eilongo ndika otali vulu woo oku longithwa kaalongi yamwe oyaakwetu.

Nesimaneko oto lombwelwa ngeyi kutya,okuthombinga lyokanona koye olili molupe lwokwiiyamba, tashi ti okanona okena uuthemba wokutinda, nonando opena ekugililo opo kehe okanona ka kuthe ombinga omolwashoka oshinyangadhalwa oshili ombinga yeilongo lyako. Iiyetwapo yokanona oya simanekwa nitayi ka hololwa ku kehe omunhu nedhina lyokanona lyoshili itali ka longithwa.

Ngele owuna epulo kombinga yeilongo ndika, kwatathana nangame kongodhi 0813317056. Otandi ku indile opo wu ulike nokashani (✓) ngele owa zimina nenge (×) ngele ino zimina moka kololo muka.

Elongelokumwe lyoye otandi li simaneke unene. ☑

Goye

Ruusa Taimi Tobias

Appendix D: Participants consent form

CHILD PARTICIPATION'S ASSENT FORM

INFORMED CONSENT DECLARATION

(Child participation)

Project Title: Exploring how the use of a 'mini-ecosystem' enables and/or constrains grade 5 learners from rural under-resourced school to make sense of scientific inquiry.

Researcher's name: Ruusa Tanni Tobias

Name group A **of** ______________ **participant:**

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

   YES ☒ NO ☐

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

   YES ☒ NO ☐

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

YES X NO

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

YES X NO

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

YES X NO

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

YES NO X

7 Has the researcher answered all your questions?

YES X 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 X NO

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

YES X NO

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

YES X NO

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

YES NO X

12 Are you willing to take part in the research?

YES X NO

S. Shooya 17-09-2020

Signature of Child **Date**

Appendix E (1): Access letter requesting permission to conduct research

Rhodes University
Drostdy Road
Grahamstown
6139

The Director of Education
Oshana Education Directorate
P O Bag 2028
Oshakati

31 March 2020

Dear Mrs Ileni Ankana

Re: Request for permission to conduct educational research with grade 5 Natural Science and Health Education in Oshana region.

I am Ruusa Taimi Tobias (student number: 17T8183), a part-time student doing Masters in Science Education at Rhodes University, South Africa. I am a Mathematics and Science teacher at Ontinda Combined School. I hereby humbly request your permission for me to conduct a research study with grade 5 Natural Science and Health Education learners at Ontinda Combined School in Oshana region. I plan to conduct the study for about two weeks in May/June 2020.

The National Curriculum for Basic Education and the grade 5 Natural Science and Health Education syllabus emphasize the importance of teaching of science through inquiry. However, it is not clear how teachers should use the approach to mediate learning of science. This becomes a challenge on learners' way of scientific inquiry. Hence, the focus of the study is to explore how the use of a 'mini-ecosystem' enables and/or constrains the grade 5 learners in a rural under-resourced school to make sense of scientific inquiry.

Learners will be required to develop a mini-ecosystem, complete VASI questionnaire, interact with other learners and do focus group interview. All these activities will be observed and videotaped. In order to involve learners in my study, I will seek permission from their parents and from learners themselves by writing consent letters.

In order to attain this main goal, the following specific research objectives were developed to enable me to find out:

- Grade 5 Natural Science and Health Education learners' attitudes towards scientific inquiry.
- How a 'mini-ecosystem' enables and/or constrains grade 5 Natural Science and Health Education learners in rural under-resourced school to make sense of scientific inquiry.

The focus of the study will be on a ‘mini-ecosystem’ and it will be conducted in three phases. In the first phase learners will complete questionnaires on Views About Scientific Inquiry (VASI) and this will conducted during normal teaching time. The second phase will observation where learners will predict what will happen when putting the seedling in a bottle. The last phase will be focus group interview. Since learners seat in groups, I will purposively choose one group that will present the whole class during the interview.

The benefit of the study will be that learners’ class participation might be furthered by the presentation of a developing a 'mini-ecosystem'. I am also hoping that the monitoring of a 'mini-ecosystem' for two weeks might bring up so many science concepts that might help learners make sense of the scientific inquiry. The study findings will improve my academic teaching strategy. The study might also be used as a reference in any science related lesson.

I hereby seek your consent to conduct my research as part of the university requirement in fulfilment of this degree with Ontinda Combined School learners.

I wish to work in an ethical manner and ethics approval will soon be obtained from Rhodes University ethics committee. Should you require any further information, please do not hesitate to contact me at 0813317056 or my supervisor Prof Kenneth M. Ngcoza (E-mail: k.ngcoza@ru.ac.az). I wish to work in an ethical manner. However, at any stage of this research should you feel uncomfortable or may have concerns, you are welcome to raise your concerns with Rhodes University by contacting Mr Siyanda Manqele at ethics-committee@ru.ac.za.

I would further like to assure your office that, should I be granted permission, the research ethics will apply throughout the process of the study. The identity of the participants and their views will be treated with high degree of confidentiality and anonymity. The identity of the school and that of the participants will be anonymous, and pseudonyms will be used instead of real names.

Be assured that my study intention is to enhance learners’ scientific thinking, reasoning and inquiry. As such, the study will take place during normal teaching time. Upon completion of the study, I undertake to provide you with feedback.

Your consideration in this regard will be highly appreciated.

Yours Sincerely

Ruusa Taimi Tobias

Appendix E (2): Access letter requesting permission to conduct research

Rhodes University
Drostdy Road
Grahamstown
6139

The Principal
Ontinda Combined School
Onamutai Circuit

31 March 2020

Dear Sir /madam

Re: Request for permission to conduct educational research with grade 5 Natural Science and Health Education

I am Ruusa Taimi Tobias (student number: 17T8183), a part-time student doing Masters in Science Education at Rhodes University, South Africa. I am a Mathematics and Science teacher at Ontinda Combined School. I hereby humbly request your permission for me to conduct a research study with grade 5 Natural Science and Health Education learners from your school. I plan to conduct the study for about two weeks in May/June 2020.

The National Curriculum for Basic Education and the grade 5 Natural Science and Health Education syllabus emphasize the importance of teaching of science through inquiry. However, it is not clear how teachers should use the approach to mediate learning of science. This becomes a challenge on learners' way of scientific inquiry. Hence, the focus of the study is to explore how the use of a mini-ecosystem enables and/or constrains the grade 5 learners in rural under-resourced school to make sense of scientific inquiry.

They will be required to develop a mini-ecosystem, complete VASI questionnaire, interact with other learners that is more knowledgeable and less knowledgeable and do focus group interview. All these activities will be observed and videotaped. In order to involve learners in my study, I will seek permission from their parents and from learners themselves by writing consent letters.

In order to attain this main goal, the following specific research objectives were developed to enable me to find out:

- Grade 5 Natural Science and Health Education learners' attitudes towards scientific inquiry.
- A 'mini-ecosystem' enables and/or constrains grade 5 Natural Science and Health Education learners in rural under-resourced school to make sense of scientific inquiry.

The focus of the study will be on a 'mini-ecosystem' and it will be conducted in three phases. The first phase learners will complete questionnaires on Views About Scientific Inquiry

(VASI) and this will conducted during normal teaching time. The second phase will observation where learners will predict what will happen when putting the seedling in a bottle. The last phase will be focus group interview. Since learners seat in groups, I will purposively choose one group that will present the whole class during the interview.

I hereby seek your consent to conduct my research as part of the university requirement in fulfilment of this degree with grade 5 learners.

The benefit of the study will be that learners' class participation might be furthered by the presentation of a developing a 'mini-ecosystem'. I am also hoping that the monitoring of a 'mini-ecosystem' for two weeks might bring up so many science concepts that might help learners make sense of the scientific inquiry. The study findings will improve my academic teaching strategy. The study might also be used as a reference in any science related lesson.

I wish to work in an ethical manner and ethics approval will soon be obtained from Rhodes University ethics committee. Should you require any further information, please do not hesitate to contact me at 0813317056 or my supervisor Prof Kenneth M. Ngcoza (E-mail: k.ngcoza@ru.ac.az).I wish to work in an ethical manner. However, at any stage of this research should you feel uncomfortable or may have concerns; you are welcome to raise your concerns with Rhodes University by contacting Mr Siyanda Manqele at ethics-committee@ru.ac.za.

I would further like to assure your office that, should I be granted permission, the research ethics will apply throughout the process of the study. The identity of the participants and their views will be treated with high degree of confidentiality and anonymity. The identity of the schools and that of the participants will be anonymous, and pseudonyms will be used instead of real names.

Be assured that my study intention is to enhance learners' scientific thinking, reasoning and inquiry. As such, the study will take place during normal teaching time. Upon completion of the study, I undertake to provide you with feedback.

Your consideration in this regard will be highly appreciated.

Yours Sincerely

Ruusa Taimi Tobias

Appendix E(3): Participant information and consent letter

Rhodes University
P O Box 94 Grahamstown

Drosdty Road

31 March 2020

Dear Sir/ madam

Re: Participation in research on exploring how the use of a 'mini-ecosystem' enables and/or constrains the sense making of grade 5 learners scientific inquiry.

I am Ruusa Taimi Tobias, a full-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 two to four weeks in May/June 2020.

I am inviting you to participate in this research by affording me time to give you questionnaire that will last for at least 40 minutes with your permission. I will as well want to teach observation lesson where we are going to predict what will happen to the seedling in the bottle. I intend to videotape for one lesson. Thirdly, I will put you in groups and you will develop a 'mini-ecosystem' and observe it for one to two weeks in order to observe the process and the science in it. Lastly, I will conduct a focus group interview, where I will choose one group that will represent the class in the interview and the interview might take 10 to 15 minutes.

The focus of the study will be on a 'mini-ecosystem' and it will conduct in three phases. The first phase learners will complete questionnaires on Views About Scientific Inquiry (VASI) and this will conducted during normal teaching time. The second phase will observation where learners will predict what will happen when putting the seedling in a bottle. The last phase will be focus group interview. Since you will seat in groups, I will purposively choose one group that will present the whole class during the 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. Your identity will be anonymous, and pseudonyms will be used instead of your real name and the name of your school. 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. I hope my request will receive your favourable consideration.

Should you be interested and once you are satisfied, please complete the consent form below. By signing this consent form you have agreed to participate in the study, audio recording interview and videotape that we are going to attend.

My contact details are: cell number-0813317056; email: gwanamutopi@gmail.com. I wish to work in an ethical manner and ethics approval which will soon obtained from Rhodes University ethics committee. However, at any stage of this research should you feel uncomfortable or may have concerns, you are welcome to raise your concerns with Rhodes University by contacting Mr Siyanda Manqele at: ethics-committee@ru.ac.za or my supervisor Prof Kenneth M. Ngcoza at k.ngcoza@ru.ac.za.

Your cooperation will be highly appreciated

Yours Sincerely

Ruusa Taimi Tobias

Child participation's assent form

INFORMED CONSENT DECLARATION

(Child participation)

Project Title: Exploring how the use of a 'mini-ecosystem' enables and/or constrains grade 5 learners from rural under-resourced school to make sense of scientific inquiry.

Researcher's name: Ruusa Taimi Tobias

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

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

YES	NO

2. Has the researcher explained why 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 Ethics Coordinator: ethics-commitee@ru.ac.za
t: +27 (0) 46 603 7727 f: +27 (0) 86 616 7707
Room 220, Main Admin Building, Drostdy Road, Grahamstown, 6139

Appendix E: (4)(i) Letter to the Parent [English]

Rhodes University

Drostdy Road

Grahamstown

6139

31 March 2020

Dear Parent

Re: Participation in research on exploring how the use of a 'mini-ecosystem' enables and/or constrains the sense making of grade 5 learners from rural under-resourced school to make sense of scientific inquiry.

I, Ruusa Taimi Tobias, a part-time student doing Master's in Science Education at Rhodes University. I hereby request for your permission to allow your child to be a participant in my study.

The benefit of the study will be that learners' participation might be furthered by the presentation of developing a 'mini-ecosystem'. I am also hoping that the monitoring of a 'mini-ecosystem' for two weeks might bring up so many science concepts that might help learners make sense of the scientific inquiry. The study findings will improve my academic teaching strategy. The study might also be used as a reference in any science related lesson.

Kindly be informed that the participation of your child in the research is completely voluntary and she or he can withdraw at any time he or she wish to do so. The data collected will be used for academic purpose. The views or contributions and identity of the child will be treated with a high degree of confidentiality and anonymity.

If you have any questions about the research, please feel free to contact me at 081 3317056. I henceforth request you to indicate your choice by ticking **(✓)** in the box below if you have agreed to my request and cross **(×)** in the box if you disagree.

☐

Signature ________________________________

Your co-operation is this regard is highly appreciated.

Yours Sincerely

____

Ruusa Taimi Tobias

Appendix E(5)(i): Letter to the parent [Oshiwambo translation]

Rhodes University
Drostdy Road
Grahamstown
6139

Omusimanekwa

Re: nkene ekutho mbinga moshisheetwapo shedhina 'mini-ecosystem' tashi vulu oku etela aanasikola omadhiladhilo nomapulo gomuule miilongwa guunongononi.

Ongame Ruusa Taimi Tobias, ndili omulongwa-longi andi iilongele onzapo yopombanda muunongononi Master) koRhodes Univesirti ya South Africa. Nesimaneko enene otandi ku indile opo u pitike okanona koye ka kuthe ombinga meilongo lyange ndika.

Uuwanawa meilongo ndika owo mbuka kutya; Uunona otawu ka hwepopaleka ekuthombinga lyo moontundi sho taya ka longwa nkene o'mini-ecosystem' hayi etwapo. Onda inekela wo kutya okunongonona o 'mini-eocsystem' otaya ka zamo niilongithwa-tya oyindji yopaunongononi. Eilongo ndika otali ka gwedhela euveko lyange mokulonga aanona mbaka na eilongo ndika otali vulu woo oku longithwa kaalongi yamwe oyaakwetu.

Nesimaneko oto lombwelwa ngeyi kutya,okuthombinga lyokanona koye olili molupe lwokwiiyamba, tashi ti okanona okena uuthemba wokutinda, nonando opena okugililo opo kehe okanona ka kuthe ombinga omolwashoka oshinyangadhalwa oshili ombinga yeilongo lyako. Iiyetwapo yokanona oya simanekwa nitayi ka hololwa ku kehe omunhu nedhina lyokanona lyoshili itali ka longithwa.

Ngele owuna epulo kombinga yeilongo ndika, kwatathana nangame kongodhi 0813317056. Otandi ku indile opo wu ulike nokashani **(✓)** ngele owa zimina nenge **(×)** ngele ino zimina moka kololo muka.

☐

Eshainokasha ______________________________

Elongelokumwe lyoye otandi li simaneke unene.

Goye

Ruusa Taimi Tobias

Appendix F (i): Views about scientific inquiry (english and oshiwambo translation)

Views about Scientific Inquiry

Questionnaire for grade 5

This study is voluntary and confidential.

Instructions;

- The questions in this paper are for views related to scientific investigations. Hence, there no right or wrong answers.
- Answer each question in a space provided
- Use own ideas and understand, so do not copy

VASI

1. A person interested in plants, tries to look at different flowering plants and start thinking how they adapt to their environment in order to survive. She carries out an investigation and noticed that different plants do not grow in the same way. Thus plants do not have same height and same weight. She also noticed that, roots and leaves play a great role in plants growth.
   (***Omuntu ena eitulomo momiti, okwa kambadhala oku tala komiti dhengala dha yoolokathana, nokwa tameke nduno oku dhiladhila nkene omiti dhoka hadhi hupu momudhingoloko gwadho. Okwa kutha etokolo opo a nongonone kombinga yomadhiladhilo ge nokwa mono kutyaomiti dha yoolokatha ohadhi ihadhi koko momukalo gumwe. Sho osho sha eta nomukalo nguka omiti kadhina uule nuunene wu thiike pamwe. Omuntu oye tuu nguka okwa mono wo kutya omidhi nomafo gomiti otaga dhana onkandangala moku koka komiti).***
   a) Do you think this person's investigation is scientific? Explain why or why not.
      [***Oto dhiladhila kutya omuntu nguka oku nongonona kwaye okuli pondondo yuudhindoli]? Yelitha omatompelo goye.***

b) Do you consider this person's investigation to be an experiment or not? Please explain.
[***Owa tala ko uunongononi womuntu nguka tawu uvithako nenge ahawe?] Yelitha alikana.***

c) Do you think that scientific investigations can follow more than one method? If no, please explain why there is only one way of conduct a scientific investigation.[***Oto dhiladhila kutya oshinyangathalwa shopaunongononi otashi vulu oku etwa po momikalo dha yooloka? Ngele hasho, fatulula kutya omolwashike pena ashike omukalo/omulandu gumwe moshinyangadha lwa shopaunongononi .***

2. Two students are asked if scientific investigations must always begin with a scientific question. One of the students says 'yes' while the other says 'no'. Whom do you agree with and why? [***Aanasikola yaali oya pulwa ngele okunongonona uudhindoli oshina alushe oku tamekithwa neepulo. Omunasikola gumwe okwa yamukula tati; 'eheno' omanga mukwawo okwati 'ayee'. Olye to tsu kumwe naye na omolwashike?***

3. a) If the several scientists ask the same question and follow the same procedures to collect data, will they necessarily come to the same conclusions? Explain why or why not.
[***Ngele aanongononi yontumba oya pula epulo lyafaathana yo taya landula omilandu dha faathana oku koka omawuyelele, otaya vulu ngaa lela oku mona omayamukulo ga faathana? Yelitha mule].***

b) If the several scientists ask the same question and follow different procedures to collect data, will they necessarily come to the same conclusions? Explain why or why not.
[***Ngele aanongononni yontumba oya pula epulo lyafaathana yo taya landula omilandu dha yoolokathana oku koka omawuyelele, otashi vulika ya mone omayamukulo ga faathana3? Yelitha mule].***

4. Please explain if " data " and " evidence" are different from one another.[***Yelitha ngele oshitya "uuyelele" mbu omuntu a ngoka momapulapulo osha faathana noshitya " uushili".***]

5. Two teams of scientific were walking to their lab one day and they saw a car pulled over with a flat tire. They all wondered, "Are certain brands of tires more likely to get a flat?"
[***Aanongononi yeli megundu mbali oya li taya ende ya uka kolabora,mpono ya mono oshihauto shili poosha nopate shina elola lya papa. Ayeshe oya ipula kutya oludhi lwo gomalola gotumba otaga vulu oku kala haga papa?]***

Team A went back to the lab and tested various tires' performance on one type of road surface. [***Ongundu ya A,oya shuna kolabora ndele tayi ka tutsa nkene omalola ga yoolokathana haga longo taya longitho oludhi lumwe lwondjila]***.

Team B went back to the lab and tested on three types of road surfaces. ***[Ongundu ya B oya shuna molabora ndele tayi tutsu omaludhi gatatu geepate].***

Explain why one team's procedure is better than the other one.[***Fatulula kutya omolwashike omolwashike ongundu yimwe yi vule okwawo mokututsa kwayo?].***

6. The data below shows the relationship between plant growth in a week and the number of minutes of lights received each day.[***Omauyelele geli pevi otaga ulike ekwatathano pokati ka nkene omuti ha gu koko moshiwike no ku ulika ishewe ominute dhuyelele esiku kehe.***

Minutes of light each day	Plant growth-height (cm per week)
0	25
5	20
10	15

15	5
20	10
25	0

Given this data, explain which one of the following you agree with and why.

[***Mokupewa uuyelele watya ngaho, fatulula kutya oshinipo minima mbika tayi landula mpaka to tsu kumwe nasho na omolwashike?***

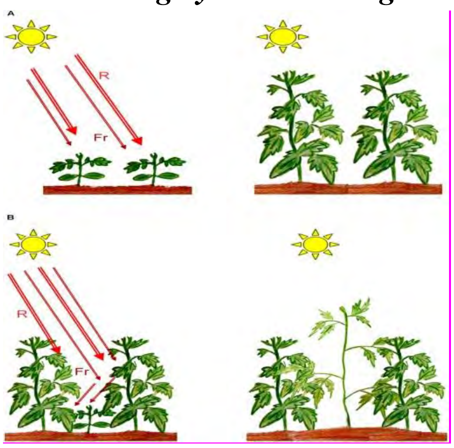
Please circle one:

a) Plants grow taller with more sunlight [***Omiti ohadhi koko ngele pena uuyelele owundji]***.

b) Plants grow taller with less sunlight.[***Omiti ohadhi koko ngele pena uuyelele uushona]***.

c) The growth of plants is unrelated to sunlight.[***Oku koka komiti ina ku kwatathana nuuyelele wetango]***.

7. Two groups of seedlings were planted in the direct of sunlight. Group A consists of two same sized seedlings and group B consist of three seedlings; two equal ones with the third small seedling between as indicated. Both group A and B shows seedlings during planting and some days after planting. ***[IImeno iishona oya tsikwa meengundu dhili mbali ya taalela koonte dhetango. Ongundu ya A oyi na iimeno iyali yithiike pamwe nongundu ya B oyina iimeno itatu; iyali yokeesha oyithiike pamwe omanga shopokati oshishona. Oongundu adhishe mbali otadhi ulike iimeno manga yali iishona sigo okonima ethimbo lyontumba].***



<u>Adopted from internet: www.frontiersin.org</u>

a. Describe at least two reasons why you think most of the scientists agree that the seedlings in group A had the best spacing, positioning and germination? [***Gandja omatompelo gaali nenge ge vule po kutya omolwashike mbela aanongononi oyendji ya tsu kumwe kutya iimeno yomongundu ya A oya topoka nawa, oya kunwa nawa nosho wo oya pita nawa].***

b. Thinking about your answer to the question above, what types of information do scientists use to explain their conclusions?***[Mokwiipula eyamukulo lyoye lyepulo lya (a) pombanda,mbela aanongononi oya longitha omaludhi gomauyelele gatya ngiini opo ya thike peshulilo lyaashi ya mona po/ opo ya adhe ethikilo lyawo?***

Adapted from Lederman, Lederman, Bartels & Jimenez (2013)

Appendix F(ii): A sample of answered VASI questionnaire

VASI

1. A person interested in plants, tries to look at different flowering plants and start thinking how they adapt to their environment in order to survive. She carries out an investigation and noticed that different plants do not grow in the same way. Thus plants do not have same height and same weight. She also noticed that, roots and leaves play a great role in plants growth.

(Omuntu ena eitulomo momiti, okwa kambadhala oku tala komiti dhengala dha yoolokathana, nokwa tameke nduno oku dhiladhila nkene omiti dhoka hadhi hupu momudhingoloko gwadho. Okwa kutha etokolo opo a nongonone kombinga yomadhiladhilo ge nokwa mono kutya omiti dha yoolokatha ihadhi koko momukalo gumwe. Sho osho sha eta nomukalo nguka omiti kadhina uule nuunene wu thiike pamwe. Omuntu oye tuu nguka okwa mono wo kutya omidhi nomafo gomiti otaga dhana onkandangala moku koka kwadho).

a) Do you think this person's investigation is scientific? Explain why or why not.

[Oto dhiladhila kutya omuntu nguka oku nongonona kwaye okuli pondondo yuudhindoli]? Yelitha omatompelo goye.

(1) Yunongononi gyuudhindoli shoosho okusha nkene ~~omen~~ omiti hadhi hupu.
Science for investigation because he/she knows how plants survives

b) Do you consider this person's investigation to be an experiment or not? Please explain.

[Owa tala ko uunongononi womuntu nguka tawu uvithako nenge ahawe?] Yelitha alikana.

Yunongononi ~~otau~~ otawu uvitha ko shoshi otawuta bogo nkene nomutu omete omiti nomeho noku hupitha ~~omiti~~ omiti shoshi omafo nomidhi ota yi kwathele okukoka.
(2) Science is making sense because it teach how people measure plan[ts] by seeing and make plants surv[ive] because leaves and roots hel[p] to grow

c) Do you think that scientific investigations can follow more than one method? If no, please explain why there is only one way of conduct a scientific investigation.[*Oto dhiladhila kutya oshinyangathalwa shopaunongononi otashi vulu oku etwa po momikalo dha yooloka? Ngele hasho, fatulula kutya omolwashike pena ashike omukalo/omulandu gumwe moshinyangadhu lwa shopaunongononi.*

[illegible]

Yes because things times like you did something and if you did a [illegible] it cannot be wrong it [illegible] compared with [illegible]

(1)

2. Two students are asked if scientific investigations must always begin with a scientific question. One of the students says 'yes' while the other says 'no'. Whom do you agree with and why? [*Aanasikola yaali oya pulwa ngele okunongonona uudhindoli oshina alushe oku tamekithwa neepulo. Omunasikola gumwe okwa yamukula tati; 'eheno' omanga mukwawo okwati 'ayee'. Olye to tsu kumwe naye na omolwashike?*

Eheno [illegible]

Yes it need to start with a question because you can teach without giving a question

(2)

3. a) If the several scientists ask the same question and follow the same procedures to collect data, will they necessarily come to the same conclusions? Explain why or why not.

[*Ngele aanongononi yontumba oya pula epulo lyafaathana yo taya landula omilandu dha faathana oku konga omawuyelele, otaya vulu ngaa lela oku mona omayamukulo ga faathana? Yelitha mule].*

Eeno [illegible] kalo dhafaathana

Yes because they follow same procedures

(1)

b) If the several scientists ask the same question and follow different procedures to collect data, will they necessarily come to the same conclusions? Explain why or why not.

[Ngele aanongononni yontumba oya pula epulo lyafaathana yo taya landula omilandu dha yoolokathana oku koka omawuyelele, otashi vulika ya mone omayamukulo ga faathana? Yelitha mule].

....

(2) Aaye shisho nokonga datha ka faathana.
No because he/she did not look for same help

4. Please explain if " data " and " evidence" are different from one another.[**Yelitha ngele oshitya "uuyelele" mbu omuntu a mono** ***momapulapulo osha faathana noshitya " uushili".***]

Eheeno shosho oshitya uuyelele otashi
Omuntu uuyeleluka nawa kutya uuyelele kwa
nawa noshitya uushili uushili
(1) Yes because the word 'data' means a person understood very well means you understood very well in reality.

5. Two teams of scientists were walking to their lab one day and they saw a car pulled over with a flat tire. They all wondered, "Are certain brands of tires more likely to get a flat?"

[Aanongononi yeli megundu mbali oya li taya ende ya uka kolabora,mpono ya mono oshihauto shili poosha nopate shina elola lya papa. Ayeshe oya ipula kutya oludhi lwo gomalola gotumba otaga vulu oku kala haga papa?]

Team A went back to the lab and tested various tires' performance on one type of road surface. *[Ongundu ya A,oya shuna kolabora ndele tayi ka tutsa nkene omalola ga yoolokathana haga longo taya longitho oludhi lumwe lwondjila].*

Team B went back to the lab and tested on three types of road surfaces. *[Ongundu ya B oya shuna molabora ndele tayi tutsu omaludhi gatatu geepate].*

Explain why one team's procedure is better than the other one.[*Fatulula kutya omolwashike omolwashike ongundu yimwe yi vule okwawo mokututsa kwayo?].*

7. Two groups of seedlings were planted in the direct of sunlight. Group A consists of two same sized seedlings and group B consist of three seedlings; two equal ones with the third small seedling between as indicated. Both group A and B shows seedlings during planting and some days after planting. / ***Iimeno iishona oya tsikwa meengundu dhili mbali ya taaleta koonte dhetango. Ongundu ya A oyi na iimeno iyali yithiike pamwe nongundu ya B oyina iimeno itatu; iyali yokeesha oyithiike pamwe omanga shopokati oshishona. Oongundu adhishe mbali otadhi ulike iimeno manga yali iishona sigo okonima yethimbo lyontumba].***

Adopted from internet: www.frontiersin.org

a. Describe at least two reasons why you think most of the scientists agree that the seedlings in group A had the best spacing, positioning and germination? ***[Gandja omatompelo gaali nenge ge vule po kutya omolwashike mbela aanongononi oyendji ya tsu kumwe kutya iimeno yomongundu ya A oya topoka nawa, oya kunwa nawa nosho wo oya pita nawa].***

Ongundu oya ... A ... ~~oombute edhakum~~ oyaku ... nuwa ya naw shoshi ongundu oyahimbue oomba ... to ... ndjauu ukilila nawa

3

Group A sown very well because the group was sown seeds are far from each other not close to each other getting nice straight sunlight

b. Thinking about your answer to the question above, what types of information do scientists use to explain their conclusions?/ ***Mokwiipula eyamukulo lyoye lyepulo lya (a) pombanda, mbela aanongononi oya longitha omaludhi gomauyelele gatya ngiini opo ya thike peshulilo lyaashi ya mona po/ opo ya adhe ethikilo lyawo?***

[illegible]
They did not get equal Sunlights

6. The data below shows the relationship between plant growth in a week and the number of minutes of lights received each day.[***Omauyelele geli pevi otaga ulike ekwatathano pokati ka nkene omuti ha gu koko moshiwike no ku ulika ishewe ominute dhuyelele esiku kehe.***

Minutes of light each day	Plant growth-height (cm per week)
0	25
5	20
10	15
15	5
20	10
25	0

Given this data, explain which one of the following you agree with and why. ***[Mokupewa uuyelele watya ngaho, fatulula kutya oshinipo minima mbika tayi landula mpaka to tsu kumwe nasho na omolwashike?***

Please circle one:

a) Plants grow taller with more sunlight [***Omiti ohadhi koko ngele pena uuyelele owundji].***

b) Plants grow taller with less sunlight.[***Omiti ohadhi koko ngele pena uuyelele uushona].***

c) The growth of plants is unrelated to sunlight.[***Oku koka komiti ina ku kwatathana nuuyelele wetango].***

[illegible]
[illegible]
(1) Yes because plants needs sunlight

Adapted from Lederman, Lederman, Bartels & Jimenez (2013.

Appendix G: Observation Schedule

Name of School: ________________________ Observation Date: __________________

Name of Teacher: _______________________ Grade: ___________________________

Subject: _______________________________ Number of Learners: _______________

Lesson Topic: __________________________ Observer: ________________________

Research question 2

How a mini-ecosystem does enables and/or constrains sense making of scientific inquiry in rural grade 5 class?

Organisation	Notes
Teacher and learners are well prepared for class	
Teacher records learners' attendance	
Teacher and learners use class time efficiently	
Teacher relates new topic to previous topic(s), or provides learners with opportunities to do so	
Teacher provides and follows an outline or organisation for the class lesson	
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 task	
Teacher completes the scheduled topics	

Teacher summarises periodically throughout and at end of class or prompts learners to do so	

Instructional method	**Notes**
Teacher uses a variety of instructional methods	
The learning materials demonstrate a logical progression with learners' prior experience and knowledge	
Teacher allows adequate wait time when asking questions	
Teacher responds to wrong answers constructively	
Teacher draws non-participating learners into activities/discussion	
Teacher prevents specific learners from dominating activities/discussion	
Teacher asks probing questions when learners' answers are incomplete	
Teacher responds to questions clearly and promptly	
Teacher guides the direction of the discussion	
Teacher refrains from answering own questions	
Teacher mediates conflict or differences of opinions	

Teacher uses active learning strategies (group work, paired discussion, polling)	
Teacher provides explicit directions for active learning tasks	
Teacher allows sufficient time to complete in-class activities	
Teacher specifies how learning tasks will be evaluated (if appropriate)	
Teacher provides opportunities for learners to practice what they have learnt	
Teacher carryout demonstrating experiments with learners	
Teacher uses teaching technique(s) appropriate to the instructional goals for this lesson	
Teacher proceeds at an effective pace	
Teacher uses positive reinforcement to encourage learners' participation	
Teacher uses appropriate technology (e.g., multimedia, electronic grade book, etc.)	

Appendix H(i): Shows a journal reflection for observing a 'mini-ecosystem'

Group name:…………

What did you observe	**Scientific terms**
Day 1	
Day 2	
Day 3	
Day 4	
Day 5	

Appendix H (ii): Sample of learners' journal observation of their 'mini-ecosystem'

Journal reflection for observation of the mini-ecosystem

Group .C..

What did you observe	~~Scientific terms~~ English translation	terms
Day 1 onda adha mo omeya nokameno oka kamonikana nawa evi oli li talimonikanawa lya ~~nawa~~ tutanawa	There was water ~~in the~~ The plant looks nice The soil was looking nice and nicely wet	{rainfall, moisture evaporation
Day 2 nokakende omuna omeya evi ota li uli ke nya tuta nawa nokameno oka hafa omeya otaga ende gu uka kevi ndiilyi li laoti okameno	There is water in the bottle The soil is wet The plant is Happy The water flows down to the soil. ~~that~~ down to the plant	{atmosphere, water, rain fall/Precipitation
Day 3 mokameno omuna omeya. omeya ogato ndoka guuka pevi. koka kuuka pevi. okameno oka evi olyatuta.	There is water in the bottle water is running downward The plant grow and it was going downward Soil is wet.	{water, rainfall, growth, soil moisture
Day 4 okameno okaziza nawa omuna omeya evi olyatuta	The plant is nicely green There water The soil is wet	Green pigment Chlrill. moisture
Day 5 omuna oomwiidhi ~~t~~dhakaka. okameno okapitililamo okameno okazigza nawa	There are glasses that are growing The plant have grown beyond ~~and reach~~ the top The plant is nicely green	{growing plants green pigment

Appendix I(i): Focus group interview questions

1. How did you feel when you heard that you were going to do a 'mini-ecosystem'? **Okwa li wa uva ngiini shono mwa lombwelwa kutya ota mu ka eta po oka 'mini-ecosystem'?**

2. What was your understanding of scientific inquiry before you were introduced to the 'mini-ecosystem'? **Eyuveko lyoye/lyeni kombinga yuunongononi omanga inamu longwa shina sha noku eta po o 'mini-ecosystem' olya li ngiini?**

3. What have you learnt from developing a 'mini-ecosystem'? **Owa ilongo mo shike mo ku eta po oka 'mini-ecosystem'?**

4. What have you learnt in the process of observing and monitoring a 'mini-ecosystem'? **Owa ilonga mo shike momu kokomoko goku konakona noku tala oka 'mini-ecosystem'?**

5. What science concepts did you learn from observing and monitoring of a 'mini-ecosystem'? **Iitya yini yuunongononi wa ilonga okuza moku nongonona o 'mini-ecosystem'?**

6. What do you think what are the advantages for science teachers to use a 'mini-ecosystem' in the science classroom? Lombweleni nge; **uuwanawa wa shike mwa mona mo sho omulongi guunongononi a longitha o 'mini-ecosystem' mongulu yelongo**?

7. What do you think what are the disadvantages for science teachers to use a 'mini-ecosystem' in the science classroom? **Mbela uuwinayi wuni weyapo to dhiladhila ,sho omulongi guunongononi a longitha oka 'mini-ecosystem' mongulu?**

8. Are there any comments you would like to share with me? **Omuna poo ma gwedhelepo?**

Appendix I (ii) Oshiwambo version of Focus Group interview

Speakers	**Questions and answers**	**Code**
Researcher	Q1. Okwali wa uva ngiini sho mwa lombelwa kutya otamu ka ninga /etapo o 'mini-ecosystem'?	
Groups	B-"Okwali tu uvite nawa shaashi atu ka longwa oshinima inaatu shi longwa nale" C- "otwali tu uvite nawa shaashi atu ka longwa opo eilongo lyeni lyiye komesho". A- Otwa li tu uvite nawa shaashi atu ka longwa shina sha niimeno.	
Researcher	Q2. Euveko lyeni kombinga yuunongononi omanga inamu ninga/etapo ?o 'mini-ecosystem' olya d li ngiini? A- Shi tu uvite ko paife ka kwali tweshi uva ko grade 4 B- Shi tashi popiwa ngaingeyi ka kwali twesh ilongwa ko grade 4 Rsesearcher: Shino shini po hano? A-Sho ka 'mini-ecosystem'. C- Oshilongwa shi tatu longwa paife, opwali nga pena natango iinima iikwawo inayi shangwa mo mwiya, maara mbi tatu longwa paife inai faathana naambi kwali tatu longwa mo grade 4 Researcher: mbi inai faathana oyini? D- Iinima mbi tatu ningi paife inashi fa shi twa longwa ko grade 4.	
Groups		
Researcher	Q3. Owa iilongo mo shike moku eta po o 'mini-ecosystem'?	
Groups	A- Ondi ilonga mo shina sha noku kuna , oku tsika B- Ondi ilongo nkene okameno to ka kutha mpa keli to ka tula mokakende. C- Ondi ilongo mo kutya ngele oweka kutha mo nayi eto tokola omidhi otaka kala inaka ka koka.	
Researcher	Q4. Owa iilonga mo shike momukokomoko goku konakona o 'mini-ecosystem'?	
Groups	B- Ondi ilonga mo okameno taka shendje, shi weka adhele ohela hasho toka adha nena, Researcher: otaka koko ngiini hano? Otaka koko ko otaka kal kena omeya meni. A- Ondi ilongo mo kutya sha okameno weka tula mevi ndele to sikileko evi otali ningi enzinzi. C- Ondi ilongo mo kutya mboli okameno sha we ka tula mokakende wa sikileko, otamu kala muna omeya. Rsearcher: ngele wa sikileko otamu kala muna omeya? Ee ngele wa tula mo evi lya tuta. Researcher: Omeya mbela oga za peni?	

	Mboli okameno she eike weka tsike mokaima eto siikileko, ekota lya ko otali ningi eshona molutu. Researcher: ekota otali ningi eshona molutu? Koo taka ningi okaleleka Researcher: Shi mwatala uumuti weyi owundji owa ninga uushina? All groups: eeee! C-Ekota otali ningi eshona ko ohaka koko. D- Sho kwali hatu ya tu tale uumeno okwali hatu adha munomeya ko otaka ende taka koko maar aka kwali hatu tekelemo omeya. Rsearcher: Osho kwali nda hala ku pula kutya omeya gokameno ohaga zi peni hano? C-Omeya ihaga tulwa mo, Shi kwa sikilwa otaka ende taka pushu, taka ningi omeya taga kunguluka. Researcher: Maara mbela go gene oga za peni maani? Evi shi kwali mweli tula mo? A? A- Evi shaashi evi etalala Rsearcher: Evi sho etalala osha hala shi fele kombula pamwe? Omwa longwa otopic yimwe tayi kwatathana pamwe nomeya nga geli mokakende? D- Omeya oga zi momafo Researcher: Momafo? Eeee Researcher: Group D otati omeya ogazi momafo, opena gumwe teshi koleke? Opena gumwe ahala oku gwedha po kutya omeya ogaza peni? B- Omeya ogaza mevi Researcher: Otamu dhimbulukwa o water cycle? All : eeeee! Researcher : Osho nee o water cycle osho? Olye te tu yilemo mo water cycle? C- Omvula sho tayi loko, omeya taga kunguluka , taga yi komilonga,taga yi mee Dama. Researcher: Omutenya sho gweya? Go otaga pwinepo. Researcher: Otaga yi nga mevi? Kwatheleni mukweni! A- Otaga yi mevi nokente dhetango Researcher: Osha hala okutya ngiini? Okakende otweka tuleni peni? D- Opekende Researcher: Opo shike? E- Opo ka dhengwe keente dhetango. Researcher: Oonte dhetango otadhi kwathele shike? A- Otashi kwathele oshimeno shi koke Researcher: Onda hala mu lombwele nge kombinga yomeya noonte dhetango, mbela omeya nga geli kokakende oga za peni? B- Oga za mevi , ga shilwamo ketango	

	Reseracher: Omeya sho taga zi pombanda yokakende ga uka pevi oga thikamenapo shike?Eengjila dhomeya odha thikamena po shike? ……….., Researcher: Omvula? All: Yes	
Researcher	Q5. Iitya yini po wa iilonga mo shi kwali tamu konakona o 'mini-ecosystem'?	
Groups	A- Omeya taga kunguluka D-Evi lya ziza B- Evi tali tutu C- Ekota tali ningi po eshona E-Okakende otaka homonoka omeya A- Okameno otaka ende taka koko Researcher: Group A, oshaka enda ngiini okameno keni kase hano? Shaashi oka egamena kokandini Researcher: Oka piyaganekwa nee?Opo mu mone kutya okameno okafa ka piyaganekwa, itaka koko omwa mono shike esiku lyotango sigo etitau lwapo? Na okasa mesiku etingapi? Day 3 Researcher: maara mokakende kamuna nande omwiidhi wumwe wa pita mo? Aayee Kamunasha? Researcher: Opena yamwe yena omwiidhi wa pita kawali mokameno ndele owa pita mo? B,C,D,E : muukende wawo omuna uumeno wa pita mo ka wali mo Reseracher : omolwashike mbela okameno ha kasa kamuna sha sha pita mo, omanga mbu inawu sa muna uumeno? Otashi ti ngiini mbela? B- Omidhi inadhi yamo dha ukilila nawa A- Okakende okashona Researcher: Pamwe oshashi okashona, ko oko ashike ka yoolokathana po puwukwawo? All: eeeee. Researcher : Okay	
Resaercher	Q6. Lombeleni nge, uuwanawa wa shike mwa mona mo shi omulongi go science a longitha o 'mini-ecostystem' mo class?	
Groups	A- Uuwanawa woku ilonga nkene wuna okutsika iimeno. B-Opo tu ilonge mo sha. Researcher: Maara nande okwali inandi mu etela oka 'mini-ecosystem' natango ngeno otamu ilongo mo ashike! C-Oku ulukilwa onawa opo wu mone kutya oshinima oshike	
Researcher	Q7. Oto dhiladhila kutya oshike mbela kutya uuwinayi wa shike mwa mono po sho omulongi go science a longitha o 'mini-ecosystem'?	

Groups	C-Oshoka inatu ka longwa omvula ya zako ……………………………………………………....	
Researcher	Q8.Omuna po omagwadhelwepo?	
Groups	B- Evi olya ziza koshike? D-Okameno oka koka koshike ko kokakende okwa siikilwa ko itaka tekelwa? Researcher: Okameno oka koka koshike hano? C-Oka koka kevi ndi lyayimo lya talala, naashi keli pekende taka dhengwa keente dhetango. D-Okameno oshike taka ningi po oka leleka ko okena ekota eshona? C-uumeno mbu wulimo uushona owa mene koshike? C-Sho evi lya tuta. A- Uumeno otawu zi komuti ngu okanene D-Okameno sho ka tulwa mokakende omwali muna onanga yimwe inayi mena. E-Uumeno mbu wulimo uushona owazi mevi ndi twa tula mo. Researcher:Opena epulo nenge egwedhelelepo? All: ayeee Researcher:Keshe wumwe na etepo o 'mini-ecosystem' kegumbo na keshe gumwe otaka etelela oka 'mini-ecosystem'kosikola. Onde mu pandula sho mwa kutha ombinga. Andi kemu lombwela iizemo yeilongo ndika komaisku gokomesho. Tangi unene.	

Appendix I (iii) Shows data collected during Focus group interview coded to English

Speakers	Question and answers	Code
Researcher	Q1. How did you feel when you heard that you were going to do a 'mini-ecosystem'?	
Groups	B- I felt good because we were going to be taught something new we never taughtt before. C- We felt good because we are going to be taught so that we enhance our study A- We felt nice because we were going to be taught about plants	Informed
Researcher	Q2. What was your understanding of scientific inquiry before you were introduced to the 'mini-ecosystem'?	
Groups	A- What we understand now, we never understood in grade 4. B- What is being spoken now was never taught in grade 4. Researcher: Which one? A 'mini-ecosystem'?	Mixed

	C- The subject that we being taught now, there was other things not written there but the one taught now is not the same as the one taught in grade 4. Researcher: Which ones are not the same? D- What we are doing now are not the same as what we were taught in grade 4.	
Researcher	Q3. What have you learnt from developing a 'mini-ecosystem'?	
Groups	A- I learned how to sow, how to plant B- I learned how to take a plant/seedling were it is and put it in then bottle. C- I learned that if you mistakenly damage the roots when removing it, it will not grow	Mixed
Researcher	Q4. What have you learnt in the process of observing and monitoring a 'mini-ecosystem'?	
Groups	B- I learned that the plant changes, how you find it yesterday is not the same as how you will find it today. Researcher: How does the plant grow? B-it grows and it has water inside. A-I learned that if you put a plant in the soil and then you closed, the soil turn to green. C- I learned that if you put the plant in the bottle and you closed it, the bottle will have water inside. Researcher:So it means if close the bottle there will be water? C-yes .if you put in wet soil. D- If you plant the seedling/ plant in something and you covered it, the stem shrinks. Researcher: Do the stem become small and shrinks? D-yes and it grow taller. Researcher: Do all plants stems became so small? Shrinks? All groups answered: Yes. C-The stem became small and the plant keeps growing. E- When we were coming to observe the plant, we use to find water and the plant grow but we were not watering it. Researcher: I wanted to ask where the water inside the bottle coming from does. C-we do not put water, the bottle get moist when it closed and moisture turn to water and water flows. Researcher: Where exactly do the water came from? How about the soil? A- Because the soil is wet. Researcher: What does moisture represent? Does it represent rain? Were you taught any topic that talks something related to the water in the bottle? D-The water came from leaves Research : From the leaves? D-Yes.	Informed

	Researcher: Group D said water came from leaves. Is there anyone who want tell us where came from? ……………………… Researcher: Do you know water cycle? All: yes. Researcher: Who will tell us how water cycle works? C-When the rain falls, water flows to rivers and dams. Researcher: When is sunny? C-then water dry out. Researcher: Do all water dry going under the soil? Help group C please! A- The water go down and also go to the sun lights. Researcher: What do you mean? Where do we put our 'mini-ecosystem'? D- We put them at t he widows. Researcher: Why? E- For it to be at the direct of sunlight. A-It helps the plant to grow. Researcher: What are the uses of sunlight? A- It helps the plant to grow. Researcher: Tell me more about water and the sunlight, where do you think the water inside the bottle came from? B- Water came from the soil, drawn out by the sun. Researcher: What does water that flows from the top of the bottle to down represent? ………………………………………………… What do the lines formed by water represent? ,…………………………………………… Researcher? Do the lines represent rain ? All: Yes Researcher: who can explain more? ………………………………….. Next question	
Researcher	Q5. What science concepts did you learn from observing and monitoring of a 'mini-ecosystem'?	
Groups	A- Water flow B- Soil moisture C- Shrinking stem E-the bottle with flowing water A-plant grows Researcher: Group A, what happen and caused your plant to die? A-Because it was lining to the bottle. Researcher: Was it then disturbed? And what have you seen that the plant was about to die?	Mixed

	A- It died in day three. Researcher: Is there no grasses grow in group A's bottle? A- No. there was nothing. Researcher: are there some bottles with growing grasses or other plants inside? Yes. (that was group B,C, D and E). Researcher: Why do you think there are no grasses in the bottle with dead plants, yet there are grasses in the bottle with live plants? B- The root of group A plants were not straight. A- The bottle was too small. Researcher: Could the shape of the bottle be the course of the failure of the plant grows? All: Yes Researcher: Okay.	
Researcher	Q6. What do you think what are the advantages for science teachers to use a 'mini-ecosystem' in the science classroom?	
Groups	A- Advantage of planting Researcher: What advantage does it have if I come to class carrying a 'mini-ecosystem'? B- For us to learn something Researcher: Do you think bringing a bottle in class is the same as when did not bring anything? ……………… C- to show clearly for you to see what exactly what it is	Naïve
Researcher	Q7. What do you think what are the disadvantages for science teachers to use a 'mini-ecosystem'?	
Groups	C- Because we were taught not about it last year. D- Researcher: anyone to add? ………………….	Naïve
Researcher	Q8. Are there any comments you would like to share with me?	
Groups	B-What caused soil moisture? D-What caused the plant to grow, yet the bottle was closed and it was not watered? Researcher: What cause the plant to grow? B-It grows because of the wet soil and also that it at the window at direct of sunlight. D-Why do the plant growing taller while the stem getting smaller? C-What cause the small plants in the bottles? Researcher: Let us answer the questions please C-Plant grow due to wet soil	Informed

	A-Plants that are in the bottles are coming from the big plant D-When we put the soil in the bottle, it had seeds that were not germinate E-The small plants growing from the soil Researcher: is the any comment or question? All: No. Researcher: If there is no question, I thank you for your participation. I want every one of you to develop a 'mini-ecosystem' at home and I will let you know when to bring it at school. I will also come and discuss the study findings with the whole class, Thank you and have a good day.	

Appendix J(i): Journal reflection questions

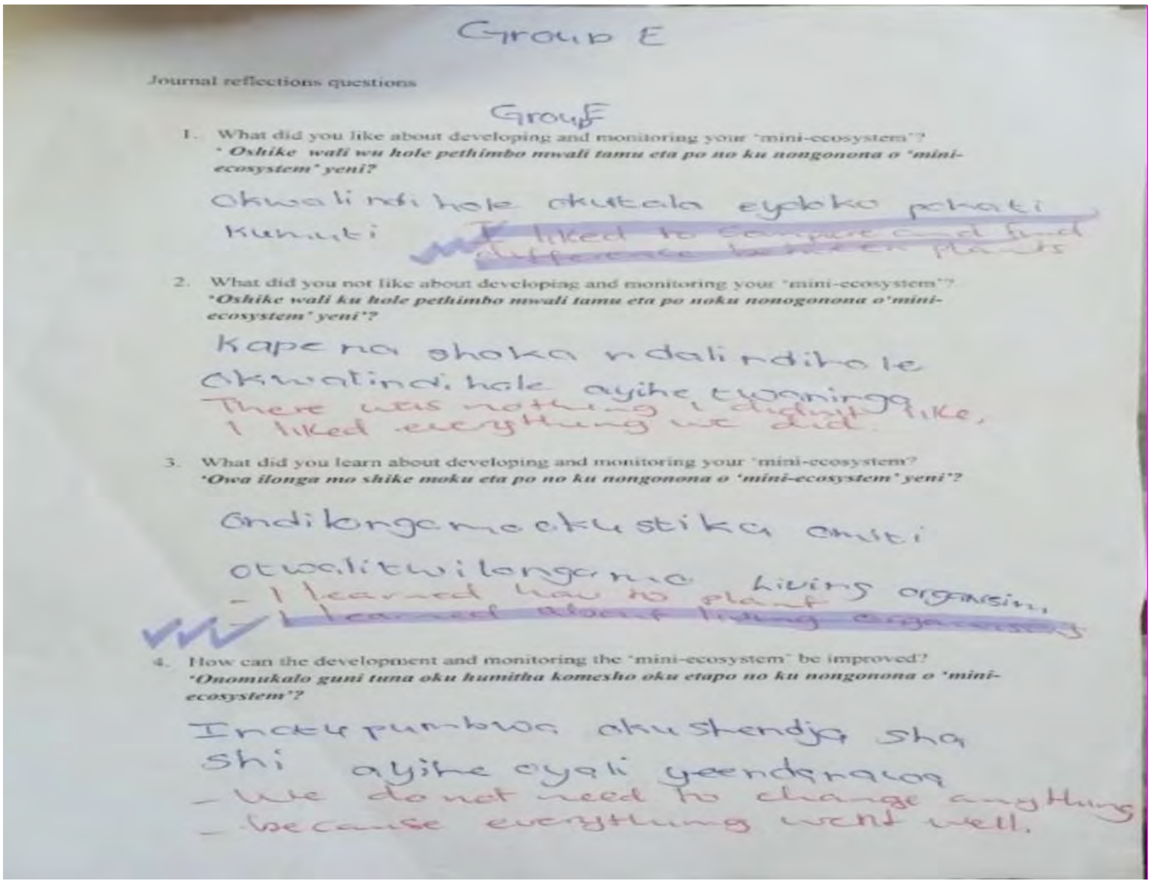
1. What did you like about developing and monitoring your 'mini-ecosystem'?
   ' Oshike wali wu hole pethimbo mwali tamu eta po no ku nongonona o 'mini-ecosystem' yeni?

2. What did you not like about developing and monitoring your ‘mini-ecosystem’?
   ‘Oshike wali ku hole pethimbo mwali tamu eta po noku nonogonona o‘mini-ecosystem’ yeni’?

3. What did you learn about developing and monitoring your ‘mini-ecosystem?
   ‘Owa ilonga mo shike moku eta po no ku nongonona o ‘mini-ecosystem’ yeni’?

4. How can the development and monitoring the ‘mini-ecosystem’ be improved?
   ‘Onomukalo guni tuna oku humitha komesho oku etapo no ku nongonona o ‘mini-ecosystem’?

Appendix J(ii): Samples of learners' reflections



Group E

Journal reflections questions

GroupF

1. What did you like about developing and monitoring your 'mini-ecosystem'?
   ' Oshike wali wu hole pethimbo mwali tamu eta po no ku nongonona o 'mini-ecosystem' yeni?

   Okwali ndi hole okutala eyooko pokati kumuti
   I liked to compare and find difference between plants

2. What did you not like about developing and monitoring your 'mini-ecosystem'?
   'Oshike wali ku hole pethimbo mwali tamu eta po noku nonogonona o'mini-ecosystem' yeni'?

   Kapena shoka ndali ndihole okwatindi hole ayihe twaninga
   There was nothing I didn't like, I liked everything we did.

3. What did you learn about developing and monitoring your 'mini-ecosystem'?
   'Owa ilonga mo shike moku eta po no ku nongonona o 'mini-ecosystem' yeni'?

   Ondilongemo okustika omiti otwalitwilonga mo living organism,
   - I learned how to plant
   - I learned about living organisms

4. How can the development and monitoring the 'mini-ecosystem' be improved?
   'Onomukalo guni tuna oku humitha komesho oku etapo no ku nongonona o 'mini-ecosystem'?

   Inaku pumbwa okushendja shashi ayihe oyali yeendanawa
   - We do not need to change anything
   - because everything went well.

Appendix J(iii): English version of grade 5 learners' reflections

Questions	Responses	Coded
1. What did you like about developing and monitoring your "mini-ecosystem"?	GrpA: I liked everyday monitoring of our "mini-ecosystem" and observe if today's findings differ from yesterdays.	Informed
	GrpBR: I like that if you close the bottle, tomorrow you will find water inside.	Mixed
	GrpCR: I like to find every day differences and find what happen.	Mixed
	GrpDR: I like the way our "mini-ecosystem" was changing every day and it was looking very nice.	Mixed
	GrpER: I liked to compare and find differences between plants	Informed
2. What you did not like about developing and monitoring your "mini-ecosystem"?	GrpAR: I never liked the way our group opened our bottle and was the only one dead amongst plants.	Informed
	GrpBR: I does not like when a plants is dying.	Mixed
	GrCR: Our plants was not growing faster	Informed
	GrpDR: I never liked a day pass without seeing our "mini-ecosystem"	Mixed
	GrpER: There was nothing I does not like, I liked everything.	Naïve
3. What did you learn about developing and	GrpAR: I learn how to plant without damaging the roots	Mixed

monitoring your “mini-ecosystem”?	GrpBR: I learned that when you closed a bottle, water appears.	Mixed
	GrpCR: I learned how the plant grows inside the bottle and how plants make food in the water.	Mixed
	GrpDR: I learned how plants grow inside the bottle. I learned how to plant. I also learned about living and non-living organisms.	Informed
	GrpER: I learned how to plant inside the bottle. I also learned about living organisms.	Mixed
4. How can the development and monitoring the “mini-ecosystem” be improved?	GrpAR: We need to change because the bottle was small and the plant was taller than the bottle.	Informed
	GrpBR: We do not need to change anything.	Naïve
	GrpCR: It was fine and grow very well and we were seeing plants nicely.	Mixed
	GrpDR: We do not need to change because our ‘mini-ecosystem’ was fine and surviving well.	Informed
	GrpER: We do not need to change anything because everything went well.	Informed