EXPLORING TEACHERS' PERCEPTIONS AND PRACTICES OF EDUCATION FOR SUSTAINABLE DEVELOPMENT IN LIFE SCIENCES CLASSROOMS

by

Lerato Alphonsina Mofokeng

Submitted in fulfilment of the requirements for

the degree of Master of Education in the

Department of Mathematics, Natural Sciences and Technology Education

Faculty of Education

UNIVERSITY OF THE FREE STATE

Supervisor: Dr Maria Tsakeni

DECLARATION

I, Lerato Alphonsina Mofokeng, declare that the thesis, *exploring teachers' perceptions and practices of Education for Sustainable Development in Life Sciences classrooms*, submitted for the qualification of the Master of Education at the University of the Free State, is my own, independent work.

All the references I have used have been indicated and acknowledged by means of complete citations.

I furthermore declare that this work has not previously been submitted by me at another university or faculty for the purpose of obtaining a qualification.

28/07/2023

SIGNED **DATE**

DEDICATION

This work is dedicated to my mother Kise Josina Mofokeng and my father Teboho Mofokeng who continuously supported me throughout the whole thesis. Thank you so much for your motivation.

ACKNOWLEDGEMENTS

My deepest gratitude goes to the following people:

- I would like to thank God Almighty for giving me wisdom and strength to complete this study. You have made it possible for me.
- My supervisor Dr Maria Tsakeni for her support, informative guidance, and timeous feedback. Thank you for being patient with me. Your guidance in this study was wonderful and I am grateful for that.
- To my mother Josina Kise Mofokeng and my father Teboho Mofokeng, thank you for your prayers and for supporting me on every journey I take.
- The Free State Department of Education, Thabo Mofutsanyana District for granting me permission to collect data from the schools
- Thanks to the principals of the schools that granted me permission to collect data from their teachers
- Teachers who took part in the study, thank you so much for the information you have shared to make this study a success. I am grateful for your participation.

ABSTRACT

There are many sustainability challenges that humanity faces such as poverty, freshwater crisis, population growth, solid and hazardous waste and sewage problems. Education is one of the key strategies earmarked to respond and provide solutions to the sustainability challenges. The educational strategies seek to motivate learners to become sustainably engaged citizens through their commitment to environmental stewardship, and reflection about the interaction of social justice, ethics, wellbeing, and ecological and economic factors. One educational strategy is widely referred to as education for sustainable development (ESD) and can be implemented through both informal and formal teaching and learning devoted to sustainability. Teachers are therefore considered capable agents of change who prepare learners to be responsible citizens and be aware of the consequences of their actions and behaviour. The aim of the study was to explore teachers' perceptions and practices of ESD in Life Sciences classrooms. The pedagogical content knowledge (PCK) for the science teaching model was used to interpret and understand teachers' perceptions and practices of ESD in Life Sciences classrooms. The study used a qualitative research approach, a case study design to explore the teachers' practices in implementing ESD in the Life Sciences classrooms. Purposive sampling was used to select three Life Sciences teachers who practiced the teaching of ESD. Data were collected using semi-structured interviews, classroom observations and document analysis (lesson plan analysis) and were analysed using thematic data analysis. Findings were categorised into three themes according to the three sub-research questions of the study. The themes are teachers' perceptions of ESD in Life Sciences classrooms, integrating ESD in Life Sciences classrooms and the influence of teachers' perceptions on practicing ESD in Life Sciences. Findings revealed that participants had different perceptions of ESD. The teachers perceived ESD as capable of promoting interactive learning, preparing learners to become responsible citizens, promoting a culture of accountability, allowing for creative thinking, and promoting problem solving and decision-making skills. Participants employed different teaching strategies such as inquiry-based approach, participatory and exploratory learning, and collaborative learning. Activities such as

presentations, debates and problem-based learning were conducted in classrooms during the integration of ESD. Participants used project-based assessment, group assessment and concept tests to assess learners. Participants' perceptions influenced the practice of ESD as all three sustainability pillars were included in their teaching. In their lessons, there was an inclusion of the environmental pillar (air and soil pollution), social pillar (interaction and peace) and the economic pillar (economic growth and business skills). Out of the three sustainability pillars, the environmental and social pillars were more practiced and to a lesser extent, the economic pillar. Participants indicated that some of their challenges of integrating ESD were lack of ESD knowledge, lack of resources, time constraints and the ATP being too packed. Participants suggests that the Department of Education intervene and provide development programmes that will equip them with the required knowledge and subject advisors and district officials should be involved. They suggest that the department release funds for resources and school trips to expose learners to different environments. Lastly, the Life Sciences ATP should incorporate ESD concepts.

Key words: education for sustainable development, ESD integration, sustainability pillars,

LIST OF ACRONYMS AND ABBREVIATIONS

CAPS Curriculum for Assessment and Policy Statement

ESD Education for Sustainable Development

FET Further Education and Training

NCS National Curriculum Statement

SDG Sustainable Development Goals

MDG Millennium Development Goals

SMK Subject Matter Knowledge

Content Knowledge (CK)

PCK Pedagogical Content Knowledge

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER ONE

INTRODUCTION AND ORIENTATION TO THE STUDY

1.1 INTRODUCTION

The issues facing the world become more complex and diverse every day. Research indicates that most of today's global environmental issues do not only threaten survival, but the global environment and natural environment's existence (Chipindo, 2019). Sustainable development is one of the fundamental goals of today's politics that aims to construct a sustainable society (Bezeljak, Torkar & Scheuch, 2019). It was coined against the background in which the activities of man on earth have resulted in many sustainability challenges (UNESCO, 2016). Education is considered one of the keys to achieve the aim of a sustainable society. Education for Sustainable Development (ESD) plays an important role in dealing with some of the urgent challenges society is facing today (Barth, Michelson, Rieckmann & Thomas, 2016).

ESD is implemented to ensure that the goals of Sustainable Development Goals (SDGs) are met. Implementing ESD in science subjects could be a complicated process hence it is essential for teachers to have adequate skills and knowledge to meet the objectives of SDGs (Bezeljak *et al*., 2019). Pedagogical Content Knowledge (PCK) will be used in this study to explain the teachers' perceptions and practices of ESD in Life Sciences classrooms. PCK is crucial for teachers to successfully practice ESD in their science classrooms and to engage learners in sustainability education for their society. For teaching ESD, Subject Matter Knowledge (SMK) is not enough, teachers need to be more knowledgeable about how to plan teaching, address sustainability issues and how to engage learners in discussions hence it is important for teachers to have good PCK for ESD learning (Brandt, Burgener, Barth & Redman, 2019). For learners to understand the concept of ESD and expand their knowledge, it is important that science teachers acquire knowledge in multiple areas to ensure that the concept of ESD is integrated by

using different learning strategies and teaching strategies in classrooms, as well as different instructional methods (Botha & Reddy, 2011).

1.2 BACKGROUND TO THE STUDY

There are many sustainability challenges that humanity faces such as poverty, freshwater crisis, overpopulation, solid and hazardous waste, and sewage problems. One of the 21st century goals of humanity is to build a sustainable society and to accomplish this goal; education is considered one of the keys (WCED, 1987). According to Chapter 36 of agenda 21, education plays a very important part in achieving a sustainable society and addressing the sustainability challenges facing humanity (UNCED, 1992). Sustainable development, according to the World Conference on Environment and Development, is development that meets present needs without affecting the potential of future generations to meet their own needs (WCED, 1987). Before the current sustainable development goals (SDGs), Millennium development goals (MDGs) were defined as the eight target goals which were set to better the lives of the people of the world (UN, 2006). The MDGs ranged from supplying universal primary education to reducing child mortality aimed to be achieved between the years 2004 and 2015. The MDGs were criticized as unambitious and narrow, and, as a result the sustainable development goals were introduced in 2016 (UN, 2006).

Sustainable development goals (SDGs) are bold, universal agreements that intend to eradicate poverty and hunger, and bring about justice, equality, and a secure world. The universally accepted framework of sustainable goals and targets provided by SDGs assists society to achieve justice, environmental security, and prosperity (DESA, 2015). Education for sustainable development (ESD) is defined as a tool that can bring a change in the society to achieve a state of sustainability (Kioupi & Voulvoulis, 2019). According to (UNCED, 1992), there are four main objectives of ESD: Improve basic education, address sustainable development through orientation of the existing education, and create public understanding, awareness, and training.

The teaching for ESD is guided by a framework consisting of at least five pillars which are social, political, environmental, economic, and cultural (Bezeljak *et al*., 2019). The five pillars are an expansion of the initial basic pillars of sustainability which are the economic, social and environmental. There is a relationship between the environmental, social, and economic pillars. The three sustainability pillars are interdependent and true sustainability can be achieved only if they are combined. If one pillar is weak, the whole system is unsustainable. Hence the conception of sustainable development lies essentially on the three pillars, and it is only when all three pillars are in balance can true sustainability be achieved. When considering the environmental factors, economic and social factors must also be considered in sustainability hence true sustainability requires the balance of environmental, economic, and social factors (Taylor, 2016). It is crucial for teachers to have discussions about sustainable practices and the effects of students' behaviour on the environment. Learners' ought to develop negotiating, problem-solving, and decision-making abilities through dialogues when discussing ecological, economic, social, and ethical concepts (Burmeister & Eilks, 2013).

It is significant to determine the competencies teachers require to develop and apply ESD and to achieve specific educational goals with their learners (Aceska & Nikoloski, 2017). Pedagogical content knowledge (PCK) was determined by Shulman (1987) as the knowledge of how to teach (planning, assessment, etc.) and is established in the beliefs as well as teachers' practices. According to Shulman, PCK includes a knowledge of the assumptions and prejudices that learners of all ages and backgrounds bring with them, which might make learning about particular topics easy or difficult (Shulman, 1987). PCK is regarded as the foundation of learning, teaching, and understanding, and is essential to enhance teaching, learning and understanding (Shulman, 1986).

Teachers' attitudes form part of the PCK and are regarded as factors that influence the PCK (Ikupa, Wilfried, Berry & Saab, 2019). It is of importance for science teachers to possess adequate and sufficient knowledge of how to incorporate the concept of ESD so that they can contribute to learners' understanding, which depends on the teaching strategy that the teachers use to present scientific principles effectively (Lombard, 2015). When teachers lack the content knowledge, it leads to the inability to integrate

ESD concepts into the Life Sciences Learning area. Shulman (1986) states that teachers are required to be mindful of the concepts and misconceptions that learners find difficult to understand. Exploring teachers PCK will provide evidence as to which learning, and teaching formats help to further which ESD aspects. The NCS-CAPS incorporates the majority of ESD components, despite the fact that the conversation around ESD in South African education is still in its infancy (Department of Education, 2011; Lombard, 2015; Mudaly & Ishmail, 2016). Therefore, the South African Life Sciences curriculum assists in understanding and appreciating the concept of ESD among learners. Topics for sustainable future include the sustainable usage of natural resources, climate change, health, biodiversity, global welfare, multiculturalism and cultural heritage (UNESCO, 2005), It is crucial to depict Life Sciences as an active branch of science education, where learners take part in social and political activism and begin to effect change (Aceska & Nikoloski, 2017). Sustainable development ensures that people understand the composite features and man-made environments developing from the interactions among biological, social, cultural, economic and physical views (Kioupi & Voulvoulis, 2019). It makes it possible for individuals to take part in environmental management and address sustainability challenges.

Thus, producing a sustainable world needs people to understand how ecosystems function, acknowledging the associations and interrelationships (Capra, 2007). To ensure that learners participate in social dialogues about sustainable development, concepts related to sustainability are being incorporated into the content knowledge of the Life Sciences (Bezeljak *et al*., 2019; Chipindo, 2019). One of the challenges of implementing ESD in science teaching in South African education is insufficient teacher knowledge and understanding of teaching approaches (UNESCO, 2014, 2017; Mudaly & Ishmail, 2016). Science teachers should possess sufficient knowledge of how to incorporate the concept of ESD so that they can contribute to learners' understanding, which depends on the teaching strategy that the teachers effectively use to present scientific principles (Lombard, 2015). It is essential for Life Science teachers who apply ESD in their teaching to recognize possible orientations of science teaching that accommodate the objectives of ESD and develop citizens who acquire knowledge regarding the environment who will be capable of dealing with sustainability issues.

1.3 PROBLEM STATEMENT

The challenge of integrating ESD at school requires the teachers to be prepared, in the pedagogies that promote the competencies that enables teachers to function as capable change agents and therefore must be embraced (Bertschy, Kunzli & Lehmann, 2013; Howlet, Ferreira & Blomfield, 2016; Rieckmann, 2018; Qablan, 2018). WCED (1987) acknowledged the role of teachers in ensuring the success of ESD. It emphasised their importance and the central role in addressing sustainable development and the well-being of the people. However, the biggest challenge to ESD globally is teacher knowledge and understanding (McKeown, 2010). It was also argued that in South Africa, lack of capable and knowledgeable teachers is one of the challenges facing ESD (Le Grange, 2010). As a result, to overcome the challenge of implementing ESD in South Africa, teachers need to be equipped with the knowledge of how to integrate ESD in teaching their subjects.

It is stated in the report of UNESCO (2016) that one of the important challenges for the future is preparation of teachers for ESD. To achieve the learning purpose for sustainability in teacher education is still a difficult task because sustainability issues require specific knowledge (CK), effective skills in planning learning and teaching formats (PCK), motivation (attitude) and willingness (Brandt *et al*., 2019). Hence Karaarslan and Teksoz (2016) contend that integrating ESD in science is not enough; competent science teachers for ESD are needed. It is required that teachers should have positive attitudes towards ESD and be knowledgeable so that they can produce environmentally literate learners.

1.4 RESEARCH QUESTIONS AND OBJECTIVES

1.4.1 Research questions

1.4.1.1 Main research question:

What are the teachers' perceptions and practices of education for sustainable development in Life Sciences classrooms?

1.4.1.2 Subsidiary questions:

1. How do the teachers perceive education for sustainable development teaching in Life Sciences?

2. How do the teachers facilitate education for sustainable development in Life Sciences classrooms?

3. How do the teachers' perceptions of education for sustainable development influence classroom practices?

1.4.2 Research aim and objectives

1.4.2.1 Research aim

The aim of the study was to explore teachers' perceptions and practices of education for sustainable development in Life Sciences classrooms.

1.4.2.2 Objectives

1. To explore teachers' perceptions of education for sustainable development in Life Sciences classrooms.
2. To explore how teachers facilitate education for sustainable development in Life Sciences classrooms.
3. To examine how teachers' perceptions of education for sustainable development influence classroom practice.

1.5 RATIONALE OF THE STUDY

As a Life Sciences teacher, the researcher is interested in understanding teachers' perceptions and practices of ESD in Life Sciences classrooms. It is essential for the researcher as a Life Sciences teacher to understand how ESD concepts in Life Sciences teaching are integrated. ESD is not only intended to supply information, but to allow individuals to fit in the society and be re-orientated towards the practices of sustainability (McKeown, 2010). The researcher is interested in understanding how to contribute to a sustainable society and how to teach learners to be responsible citizens through Life Sciences teaching. Karaarslan and Teksoz (2016) emphasize that to develop a good framework for teaching ESD, teachers are required to be prepared to assist learners identify issues of sustainability that relate to sustainable development and are required to produce important skills which will enable them to analyse the problems and issues that relate to ESD. Thus, it relates to the researcher's career and the interest of the concepts of ESD in Life Sciences teaching. The study intends to contribute to the existing literature and to provide understanding of teachers' knowledge about ESD in science education. Knowledge about secondary school teachers' perceptions and practices of ESD is limited; hence the study intends to add to the information that is lacking.

1.6 SIGNIFICANCE OF THE STUDY

This study may be of help to the national and regional implementers of the curriculum as they may be aware of the teachers' perceptions and practices of ESD in Life Sciences classrooms. The findings of the study could improve how ESD is taught in Life Sciences classrooms. They may also add to the teachers' reflexivity of their PCK practiced in classrooms and might help teachers to improve the teaching of the concept of ESD (Laughran *et al*., 2016). The findings of the study could also contribute to the betterment in teaching of ESD in other subjects as well as in the primary schools. Other scholars may benefit from the knowledge produced through the article that may be written after the M.Ed study has been completed.

1.7 THEORETICAL FRAMEWORK

According to Gabriel (2008), a theoretical framework is the framework that a research theory is built upon. It presents and clarifies the theory that underlies the research problem. The study will employ PCK as a theoretical framework. This framework will enable the researcher to search teachers' perceptions and practices of ESD in Life Sciences classrooms. PCK is a concept that is used to examine teacher knowledge and to discover the information required to be a successful teacher (Rollnick & Mavhunga, 2017). PCK is outlined as a concept of various elements connected with the transformation of content knowledge into pedagogical strategies, but it is required that PCK elements be discovered in a specific subject (Jing-Jing, 2014). PCK includes the prior conceptions that are brought to class by the learners, the knowledge of the subject from the teachers, and teaching that develops with time, the attitude and perceptions of teachers, and beliefs they have towards a subject which will also affect their teaching (Burgener & Barth, 2018). The study adapted the PCK model from Magnusson, Krajcik, and Borko (1999) for science education which consists of the following five components in the context of ESD teaching:

1. Orientation towards ESD in Life Science teaching,
2. Knowledge and beliefs about learners' understanding of ESD in Life Science,
3. Knowledge and beliefs about ESD in the Life Science curriculum,
4. Knowledge and beliefs about instructional strategies for ESD in Life Science,
5. Knowledge and beliefs about assessment of student learning of ESD in Life Science.

1.8 CONCEPTUAL FRAMEWORK

Conceptual framework is an organization of concepts, beliefs, expectations and theories that affirm and inform the study. It describes the main elements (key factors, concepts and variables) to be studied (Jabareen, 2008). According to UNCED (1992) the main aim of ESD is to solve global issues by preparing today's generation to become future

responsible citizens (Aksland & Rundgren, 2020). Learners must be responsible for their behaviour on the environment, take responsibility for themselves, take part in a democratic society and serve to build it into a sustainable environment. The national curriculum has incorporated ESD in Life Sciences with the perspective of creating a sustainable society (Aksland & Rundgren, 2020). The aim of ESD is to build a sustainable society, thus, it is necessary for teachers to know what specific competencies and attitudes children need to develop in order to achieve this goal. Sustainable issues are at the interface of science and multiple societal considerations (Evers, 2018). Science represents key aspects of any sustainable development hence it is responsible for incorporating the learning and teaching of ESD in classrooms (Eilks, 2015).

Studying Life Sciences is intended to encourage citizens and educate them about responsible actions towards the environment (DBE, 2011). Sustainable development places a strong emphasis on a trajectory of progress that is primarily based on economic, social, and environmental considerations. According to Lobo, Pietriga, and Appert (2015), an economic production system must be able to meet present demand levels without endangering future needs. Social sustainability embraces the notion of empowerment, equity, cultural identity, participation, accessibility and institutional stability (Mensah, 2019). The natural environment and how it can remain robust and productive to support human life are the foundations of environmental sustainability (Evers, 2019). The Life Sciences curriculum includes environmental concepts (ecosystem services, water quality, air quality, resource integrity and stressors), social concepts (resource security, human health, environmental justice, participation, and sustainable communities) and economic concepts (jobs, costs and incentives). All these pillars need to be integrated to achieve sustainable development which requires realizing the potential of the key dimensional pillars simultaneously.

Teachers are required to have specific knowledge to deal with ESD and teach Life Sciences lessons. They need subject matter knowledge (SCK) in those issues related to ESD to build a base to start teaching ESD in Life Sciences classrooms. Moreover, they require the knowledge of sustainability, sustainable development and their meaning is

required (Evers, 2018). Teachers need knowledge of integrating all the three sustainable development pillars simultaneously in their lessons. In this study, five indicators were used to examine teachers' PCK: learners' prior knowledge, ideas about domain-specific instructional strategies, ideas about the curriculum, knowledge of assessing learning and knowledge about justifications to teach topics in science classes (Rollnick & Mavhunga, 2017).

1.9 RESEARCH METHODOLOGY

1.9.1 Research paradigm

According to Kivunja and Kuyini (2017), a paradigm is a lens that a researcher uses to approach the subject of their research. In this study, an interpretivist paradigm was used because interpretivism stresses different forms of reality (Hartley, 2010). It also focuses on the experiences of people, understanding and the nature of knowledge hence the focus was on the views, perceptions, and ways of teaching. The aim of using an interpretive approach was to understand the world from an individual's views through the experiences of teachers. Mugo (2011) argues that the purpose of an interpretative paradigm is to establish how people comprehend the setting in which they live and work. In order to explore how teachers perceive ESD when instructing Life Sciences in their classrooms, the researcher adopted an interpretive paradigm. The paradigm helped the researcher to understand teachers' perceptions and experiences and develop an understanding of their practices rather than their point of view (Taylor & Medina, 2013). As a result, the paradigm's primary objective is to explain how truth is generated in society (Thanh & Thanh, 2015). The research used an interpretive paradigm to develop an understanding and interpretation of the data collected. The researcher wanted to produce accurate and sincere perspectives of how teachers approached and used ESD in their classrooms (Taylor & Medina, 2013). The practices of ESD in teachers' classrooms were examined using their perceptions.

1.9.2 Research approach

The current study employed a qualitative research approach. According to Baytek et al. (2011), a qualitative research method is a process that makes inquiries to understand the behaviour of humans. In this qualitative research approach, non-numerical data, in the form of verbal utterances were collected from participants. A qualitative research approach was used to establish multiple interpretations of the perceptions and practices of ESD of existing Life Sciences teachers. This research method explored the teachers' perceptions and practices of ESD in Life Sciences classrooms using a PCK lens. This approach was appropriate for the current study because the researcher was able to observe the participants and capture their views (Creswell, 2008).

1.9.3 Research design

In the study, an exploratory case study design was used, which is defined as a case study intended to explore situations in which the intervention being assessed has no obvious, singular set of outcomes (Yin, 2003). According to Bromley (1991), a case study is described as a systemic investigation into a single event or a series of connected events with the aim of describing the phenomena of interest. An exploratory design allowed a researcher to explore an area about which he/she has little or no knowledge (Yin, 2014). It is an exploratory case study as it provides an in-depth exploration of "what" and "how" the phenomenon under study is carried out in Life Sciences classrooms (Creswell, 2009). To answer the research questions, it was important to explore multiple sources of information through in depth data collection. This research study investigated the perceptions and practices of three Life Sciences teachers from Phuthaditjhaba, Thabo Mofutsanyane district. The evidence derived from the exploratory case study is frequently greater than that from other case study designs, which is why the researcher preferred this research strategy (Heale & Twycross, 2017).

1.9.4 Participant selection (population and sampling)

The participants of the study were purposefully sampled. Etikan and Bala (2017) state that the researcher should judge the participants who he/she believes will supply only useful information to meet the goals of the study. Participant selection in a case study is

referred to as the selection of the best data sources to comprehend the case (Gentles, Ploeg & McKibbon, 2015). According to Alvin (2016), only teachers who satisfy the requirements of the study and meet the needs of the criteria should be approached because they are believed to bring the best information that is needed for the study. Three Life Sciences teachers from Phuthaditjhaba in the Free State (Thabo Mofutsanyane Disctrict) were selected. Only teachers in the secondary schools with experience of more than two years in teaching ESD in Life Sciences classrooms took part in the study (Creswell, 2008). The researcher's focus was to explore perceptions and practices of a small sample of Life Sciences teachers and not generalise the conclusions to a larger population. The three participating teachers' information was gathered through semi-structured interviews, classroom observations, and document (lesson plan) analysis (Moser & Korstjens, 2018). Each participant was subject to one interview and one classroom observation.

1.9.5 Instrumentation and data collection

In this qualitative study, three strategies were used to collect data. The first strategy was one-on-one semi-structured interviews. Creswell (2007) states that although interviews are costly and time consuming; they are the most relevant method to use to collect data. Three teachers were interviewed, who were allocated 30-40 minutes duration for the recorded interviews. To record the interviews, the researcher used an audio tape to record all interviews of the participants. Interviews addressed the main research question and the question of how teachers perceive ESD teaching in Life Sciences. The researcher gleaned information about the knowledge teachers had about the concept of ESD and how they perceive and teach it.

Classroom observation is the second strategy that was used for data collection. The reason for choosing classroom observation as a second strategy was because the researcher wanted to know how teachers integrate the concept of ESD in their classrooms. The researcher also wanted to explore if the teachers' perceptions towards ESD influence their teaching and compare how the responses from the teachers' interviews are reflected in their teaching in classrooms. There was only one lesson

observation per teacher. The researcher in this strategy had an observational role, a non-participant who did not intervene or participate in the teaching.

Document analysis is another strategy that was used in the study to examine lesson plans designed by the Life Sciences teachers. Three lesson plans were analysed. One of the advantages of collecting documents is that all the information that appears on the lesson plans are from the teachers as they are the ones who created them (Creswell, 2007). Classroom observations and lesson plan analysis addressed the question of how teachers facilitate ESD and how their perceptions influence classroom practices. The researcher got an opportunity to see how teachers teach the concept of ESD as well as their attitude towards ESD. Lesson plan analysis provided information of how teachers plan to integrate the concept of ESD in the teaching, the teaching strategies they use, how they engage learners in their teaching as well as how they assess them.

1.9.6 Data analysis

Thematic data analysis is the strategy that was used. According to (Johnson & Christen, 2008), the researcher should be able to connect and interpret data by recognising patterns, themes and categories. During thematic analysis, six steps were followed: firstly, the organisation of data whereby the data collected were prepared and organised by the researcher. The data from the audio were transcribed into text verbatim (Jameison, 2016). Field notes were also typed and read. The second step is where the researcher read through the data from transcripts produced to make sense of them and grasp their overall meaning. The researcher ensured that she avoids personal bias as she read through the data (Jamesion, 2016). The third step is where coding of data took place. Here segments of data sets were formed (Theron, 2015). The fourth step is the generation of the themes whereby categories and themes from the previous step were read, refined and renamed (Jasmeison, 2016). Then, in order to leverage each category's collective essence to address the primary study problem, they were organized into codes (Maguire & Delahunt, 2017). The fifth step was the description of the themes which is discussed in detail in chapter 4. In this step, the researcher looked for patterns between themes and used relevant literature to interpret the data (Theron, 2015). The data collected from semi-structured interviews and classroom observations

were combined with data from lesson plans with the aim of finding the link and interaction between the themes and their categories (Maguire & Delahunt, 2017). The final step which was the interpretation of the results is discussed in detail in chapter 5 where conclusions are made based on the findings of the study. The data were analysed with the aim of answering the main research question: What are teachers' perceptions and practices of ESD in Life Sciences classrooms?

1.9.7 Validity and trustworthiness

Validity and credibility are described as truthfulness and authenticity by Merriam (2009). In a qualitative study, validity implies the application of various strategies including member checking, peer examination, triangulation of data, and flexibility (Merriam, 2009). According to Brantley (2009) validity in a qualitative research assist in bridging data and the phenomenon. Researchers who use qualitative techniques present accurate, reasonable, and fair descriptions of the viewpoints of the people who have encountered a specific phenomenon. In a qualitative approach, internal validity means the researcher is expected to show that the results are credible from the participants' view (Brantley, 2009). External validity means the power to transpose the results of one study another setting (Brantley, 2009; Merriam, 2009). To establish authenticity of the results, participants were asked to check the data (Hatch, 2002; Creswell, 2009). To ensure trustworthiness of the data, theoretical triangulation of PCK and the ESD concept were used. Descriptive field notes were summarised from the observations as well as the lesson plans and documents from the teachers to develop themes and categories.

The validity of data interpretations was improved by the use of triangulation. To follow the recontextualization process, the researcher used field notes, transcripts of observations, along with evaluation questions from teachers. Triangulation means that two or more methods of collecting data are used to express human behaviour (Cohen *et al*., 2007). In a qualitative research, credibility aims to maintain the controversy that the findings are "worth paying attention to" (Cuba & Lincoln, 2005: 34). I ensured trustworthiness by describing in full the process that will be undertaken to add to the internal validity of the study. In addition, I employed member checking for the validity of

the results. During member checking participants can give their input on the accuracy of the interpreted data from the interviews. The member checking process involves participants checking the accuracy of the interpreted data provided in their interviews. According to Carlson (2010), member checking is an efficient manner of determining if the data analysis is congruent. It gives the participants the chance to edit, clarify, and elaborate the interpreted themes and patterns that the researcher had recorded.

1.9.8 Ethical considerations

I began by applying for ethical clearance from the University of the Free State, then applied to the Head of the Department of Basic Education to grant me a permit for collecting data from schools. I wrote letters to the gatekeepers of the school to select participants who have the potential to participate in the study. All selected participants received participation letters requesting them to participate in the study voluntarily.

The teachers who participated were ensured anonymity and confidentially to establish trust with them. Participants were assigned pseudonyms for confidentiality. The pseudonyms for interview participants were participant 1, participant 2, etc. Consent and agreement forms for participating in the study were supplied to all the participants. The aim of the study was explained clearly at the beginning of the interviews. All participants were protected as reasonable precautions were made. The confidentiality of the participants was ensured, and they were aware of their choice to decline or leave the study at any moment.

1.10 LIMITATIONS

A key limitation is that the results from the sample cannot be generalised to a larger population of teachers as participants were sampled purposely. Because the study was conducted in Thabo-Mofutsanyane district located in Phuthaditjhaba, three qualified teachers with experience in teaching ESD principles in the Life Sciences made up the small sample of teachers that the study specifically targeted.

1.11 DELIMITATIONS

The first one is related to the interviews that were limited only to qualified teachers who had two years of teaching experience or more teaching ESD in Life Sciences classrooms in Phuthaditjhaba. The participants were not limited by age or gender, but the study was limited to only one district. The study intended to explore teachers' perceptions and practices for teaching ESD in Life Sciences using a PCK framework. Therefore, the study only interviewed three teachers from schools in Phuthaditjhaba. The participants represented Life Sciences in different grades (10-12).

1.12 DEFINITION OF TERMS

Education for Sustainable Development (ESD): Is defined as a tool that can bring transformation that the society requires to achieve a sustainable state (Kioupi & Voulvoulis, 2019).

Pedagogical Content Knowledge (PCK): Is the knowledge that is described to be unique to teachers and described the teachers' pedagogical knowledge as related to their subject matter knowledge (Wilson & Shulman, 1989).

Sustainable Development Goals (SGD): Are bold, universal agreements that intend to eradicate poverty and hunger, and bring about justice, equality and a secure world (DESA, 2015).

Millennium Development Goals (MDG): Are eight goals with measurable targets and clear deadlines introduced to improve the lives of the people of the world (UN, 2006).

1.13 LAYOUT OF CHAPTERS

This research consists of five chapters:

Chapter One: Introduction and orientation to the study.

This chapter represents an introduction, background and problem statement of the study. It includes research questions, objectives, the rationale and the significance of the study. Lastly, it includes the limitations as well as the delimitation, definition of the terms and the overview of the chapters.

Chapter Two: Literature review and theoretical framework.

This chapter presents the literature search about the issues relating to the teachers' perceptions and practices of ESD in Life Sciences classrooms. The chapter illustrates both international and national literature and includes the theoretical framework of the study.

Chapter Three: Research design and methodology.

This chapter focuses on the methodology of the study. It includes the design and methodology of the research, the sampling processes and the selection of participants who are interviewed, the instruments and processes for data collection and analysis. It is then followed by a model outline for ensuring trustworthiness and ethical considerations.

Chapter Four: Presentation of the findings.

This chapter provides the results of the study. Here the findings are presented, translated and discussed.

Chapter Five: Conclusions of the study.

This chapter concludes this study and provides a summary of the findings. The findings in relation to the theoretical framework are also discussed. Chapter 5 includes the implications and the recommendations.

CHAPTER TWO

LITERATURE REVIEW AND THEORETICAL FRAMEWORK

2.1 INTRODUCTION

The aim of the study was to explore teachers' perceptions and practices of ESD in Life Sciences. The literature in this chapter presents current knowledge on teacher perceptions and attitudes towards ESD and their PCK. The first section of this literature emphasises the sustainability, the three pillars of sustainability, the purpose and practice of ESD, ESD in the South African context and within school education and in Life Sciences. The second section of this chapter reviews relevant literature concerning teachers' role in addressing sustainability issues, teachers' perceptions, attitudes and practices of ESD. Literature in this chapter considers studies from South Africa and international sources. This chapter concludes with the theoretical framework which underpins the study.

2.2 THE CONCEPT OF SUSTAINABLE DEVELOPMENT (SD)

Sustainability has been promoted by different political agendas and has been made a political goal worldwide (Burmmerister & Eilks, 2013). Internationally, sustainable development is perceived as an increasingly important goal for global well-being (Aksland & Rundgreen, 2020). International agendas such as the agenda 2030 for sustainable development are increasingly regulating the national education policies. However, these education policies can only be put into context if teachers are considered as key agents of change who advocate them in classroom practice (Chisingui & Costa, 2020). A sustainable approach is an approach that aims to understand the relationship among the three pillars of sustainability (environment, social

and economic) with an attempt to understand and realise the effects of our actions in the world.

2.2.1 Sustainable Development Goals

In order to achieve human development goals while protecting the ability of natural systems to deliver ecosystem services and the natural resources that underpin the economy and society, sustainable development is centered on this principle (Mensah & Enu-Kwesi, 2018; Shepherd *et al*., 2016). The idea of sustainable development is said to be more and more important as time goes on since natural resource availability does not keep up with population growth. This implies an imbalance between the population growth and the availability of the resources as resources get depleted faster than the environment can supply. As a result, there has been a global concern that has always been conveyed for the wise use of the available resources (Hylton, 2019).

Due to this concern, Millennium Development Goals (MDGs) and the Sustainable Development Goals (SDGs) were formed. The MDGs were introduced before the SDGs. The MDGs were able to accomplish a set of goals after they were rolled out for 15 years (Breuer, Janetschek, & Malerba, 2019). Even so, regardless of the MDGs effectiveness, not all the targets of the eight goals were accomplished by the year 2015 hence, the SDGs were introduced to proceed with the development agenda. According to the MDG progress report (2015), out of all the eight goals, there has been an incredible progress on the three goals in many countries such as decreased extreme poverty; increased primary school environment and improved access to clean water.

The main purpose of the SDGs according to the United Nation Communications Group (UNCG) and the Civil Society Organisation (CSO) (2017) is to ensure that by 2030 there is no poverty, the planet is protected, and the people get prosperity and enjoy peace. The SDGs are adopted by 193 countries and started to be applied in January 2016 with the purpose of encouraging economic growth, ensure social inclusion and environmental protection. The UNCG-CSO (2017) contend that with the support of the UN, the SDGs are intended to promote a spirit of partnership between governments, research, private sector, academia and civil society organisations (CSOs). The aim of

this partnership is to assure that good decisions are made now to enhance life for future generations, in a sustainable way (Breuer *et al*., 2019). Therefore, the purpose of sustainable development is to accomplish an environmental balance, economic growth and social progress.

2.2.2 Sustainability pillars

There are three fundamental pillars of sustainable development which are “economic sustainability”, “social sustainability” and “environmental sustainability”.

2.2.2.1 Economic sustainability

Economic sustainability entails a system of production that fulfils the present use of the resources without jeopardizing the needs of the future (Lobo, Pietriga & Appert, 2015). Since there is a perception that the supply of natural resources is finite, economists claims that there has been an unsustainable strain on the market's ability to distribute resources quickly (Du & Kang, 2016). Production, distribution, and consumption are the three fundamental tasks that need to be accomplished in an economy, but the accounting system that governs and assesses the economy with relation to these activities severely distorts values, which is unfavourable for the environment and society (Cao, 2017). According to Allen and Clouth (2012), the planet's finite natural resources are what sustain and support human life. Economic sustainability demands that decisions made must be equitable and fiscally sound, at the same time being considerate of the other features of sustainability (Zhai-Chang, 2019). Economic sustainability is also defined as the capacity of an economy to sustain a particular level of economic production over the long term. It also describes to decisions made in the most careful and sensible way possible regarding the other sustainability aspects. True sustainability is not encouraged when the economic aspects are not considered; all aspects of sustainability must be considered. The results are only positive when incorporating business practices with the environmental and societal aspects of sustainability (UNSD, 2018c).

2.2.2.2 Social sustainability

The definition of social sustainability given by Farazmand (2016) is a system of social organization that reduces poverty. The concepts of participation, environmental legislation, human and labour rights, cultural competency, social capital, health equality, accessibility, support justice, community development through public involvement and participation, responsibility, equity, community resilience, and human adaptation are all elements of social sustainability (Daly, 1992, cited in Wanamaker, 2018; Scopelliti *et al*., 2018). Kolk (2016) explained that guaranteeing that everyone's needs are addressed is not the goal of social sustainability. Instead, the objective is to create the circumstances that enable everyone to acknowledge their own needs if they choose to. Any obstacle that prevents people, groups, or communities from progressing in the direction of social sustainability is regarded as an obstacle that must be overcome (Pierobon, 2019). Socioeconomic sustainability, on the other hand, refers to the link between social conditions such as poverty and environmental devastation (Farazmand, 2016). The "social sustainability" idea states that reducing poverty shouldn't have an unintended negative impact on the environment or the stability of the economy. It should offer suggestions for reducing poverty while using the social system's already available financial and natural resources (Kumar, Raizada, & Biswas, 2014; Scopelliti *et al*., 2018). In addition, Lv (2018) and Pierobon, (2019) agree that social sustainability promotes peace, education, good health and stability around the world.

Guo (2017) contends that social sustainability covers a broad variety of issues, including those that advance peace, such as human rights, equality, gender equity, public participation, and the rule of law. The idea of social sustainability, which essentially states that future generations have a right to the same or higher quality of life as the present generations, generally supports the concept of intragenerational justice.

2.2.2.3 Environmental sustainability

The resolve to safeguard the environment by limiting risks is the foundation of environmental sustainability and human activities that result in negative environmental impact (Purvis, Mao & Robinson, 2018). It is based on how the natural world has

remained robust and fruitful in order to sustain human life. Given that it encompasses the biosphere, which is where we live, it is regarded as the world's largest pillar of the system. As the largest system, it is considered the largest actual problem because it is expected that the environment should provide natural resources indefinitely. When the environment's carrying capacity is limited, the social system's ability to provide for the general welfare likewise declines, and the economic system's ability to produce as many declines (Purvis, *et al*., 2018). This means that waste shouldn't be released into the ecosystem quicker than it can be absorbed by the environment and that natural resources shouldn't be used up faster than they can be restored (Evers, 2018). All civilizations must adjust to changing circumstances in order to be sustainable, say Campagnolo et al. (2018), in terms of managing ecosystems and natural growth limitations.

Sustainable development aims to meet current requirements without jeopardizing future generations' ability to fulfil their own needs. Consequently, the natural environment must continue to function and be useful for a long period in order to achieve environmental sustainability (Scopelliti *et al*., 2018). The optimum course of action would encourage both development rates and environmental balance. People should avoid any behaviour that can upset the homeostasis of the environment, and if they must happen, keep them to a minimum. Pollution and natural resource management are two examples of issues that relate to environmental sustainability. Environmental sustainability promotes the preservation and maintenance of our natural ecosystem while simultaneously aiming to reduce the negative effects of human activity on the environment (Mensah, 2019).

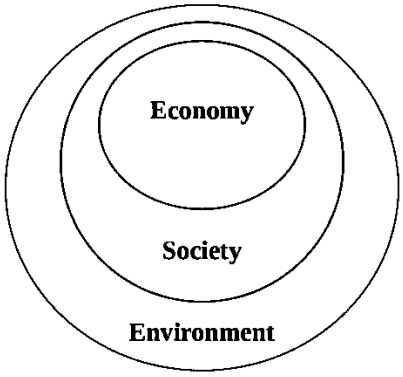


Figure 2.1: Environmental pillar is the largest pillar of the system. Adapted from Purvis et al. (2018).

2.2.3 Relationship among the three pillars

The discussion of scientific advancement in the future appears to be influenced by the idea of sustainability. According to Porter and Van der Linde (1995), the best options will likely continue to be those that meet societal demands, are economically and socially equitable, environmentally and socially sustainable, and socially and environmentally bearable (as cited in Mensah, 2019). Yang (2019) demonstrates that making the right judgments about sustainable resource management will result in long-term growth for a long-term civilization. A few examples of sound decisions on sustainable resource management that result in sustainable growth for a sustainable society are education, agricultural practices, energy management and equal opportunity (Montaldo, 2013).

It is implied that when the three pillars of sustainability are successfully implemented in practical contexts, everyone wins because natural resources are conserved, the environment is protected, the economy grows, and social life is enhanced by peace and respect for human rights (DESA, 2015). The three dimensions of sustainability are intertwined, and it is only through combining and applying them in real-world situations that they may provide a stable foundation for a sustainable future that benefits everyone. As a result, sustainable development is a mix of these three pillars, and it can only be properly achieved if they all work together. Basically, if one pillar is weak then the whole system is unsustainable.

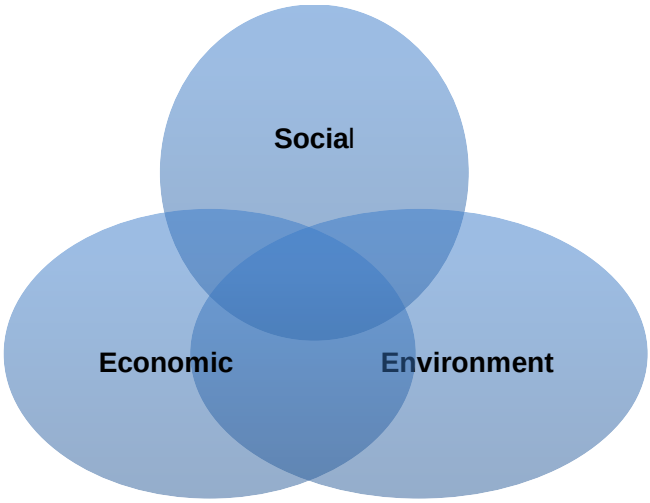


Figure 2.2: The three sustainability pillars are totally interdependent as shown in the figure. Adapted from Wanamaker (2018).

2.3 EDUCATION FOR SUSTAINABLE DEVELOPMENT (ESD)

Education for Sustainable Development (ESD) is a critical topic in learner education around the world because it attempts to provide students with the knowledge, skills, attitudes, and values necessary to ensure humanity's long-term survival (Doscher & Rocco, 2008). Teachers should understand the subjects that establish ESD, have a positive attitude toward it, and be aware of acceptable teaching approaches when tackling ESD concerns in the classrooms (Scopelliti *et al*., 2018). ESD is both a vision and a method for learning about our world's interconnection.

It motivates us to look for and take steps that, over time, bring about the process of realizing our own vision of a more sustainable future. To attain this, ESD requires that we concentrate on three interconnected priority areas: enhancing fundamental education, reformulating education to address sustainability, and enhancing public understanding of sustainability.

2.3.1 ESD Origin, Purpose, and Practice

According to the WCED (1987), it was acknowledged that to achieve sustainable development, there must be changes in people's values and attitudes toward the environment and development. The only way to bring about these changes in values and attitudes is through education. ESD refers to the integration of important sustainable development issues into teaching and learning (Mogren *et al.,* 2019)**.** It is all about lifelong learning and is a crucial component of receiving a good education.

The goal of ESD is to assist learners in developing positive attitudes, skills, and information necessary to make and act on informed decisions that benefit themselves, others, and future generations (Rosenburg, 2007). In essence, it seeks to address the relationship between the three pillars of sustainable development society, environment, and economy. It encourages abilities including critical thinking, scenario planning, and group decision-making. In addition, ESD encourages students to act responsibly and make educated decisions in the interests of cultural diversity, economic sustainability, and a just society for both the present and the future (DESA, 2015). The objective is to inspire and equip learners to change their behaviour and take action in support of participatory teaching and learning approaches and sustainable development.

Integrating essential topics into the curriculum, such as biodiversity, climate change, and production is important (Wanamaker, 2018). ESD instruction and learning should be designed to foster interactive, learner-centered environments that encourage inquisitive, action-oriented, and transformative learning. In the end, it is essential to be able to change oneself and the society one lives in, inspiring others to lead sustainable lifestyles, empowering individuals to be "global citizens" who can participate and take on active roles and facing and resolving global crises. Learners actively participate in building a more just, secure and sustainable society and global community. By encouraging learning and developing core competencies, the learning outcomes of ESD should improve core competencies like collaborative decision-making and taking responsibility for present and future generations and critical and systemic thinking (Yang, 2019).

Therefore, education is regarded as critical to both learning and a more sustainable future. Hence teachers must comprehend the concept of ESD and be aware of the various perspectives on ESD. Learners are taught to become engaged citizens who play a role in changing how our societies run through ESD, and youngsters are encouraged to see themselves as people who are actively constructing a better future. The subject content and the way ESD is taught reflect this purpose. Individuals can gain the knowledge, attitudes, abilities, and perspectives they need to take part in decisions about how to improve their quality of life through an integrated study of this dynamic interaction (Scopelliti *et al*., 2018; Ventakaraman, 2010).

2.3.2 Contextualisation of ESD in the South African context

The significance of ESD, the responsible implementation of science and technology with an eye for the environment and other people's health is emphasized. The NCS critical outcomes of the need for problem-solving abilities, teamwork, communication skills, ability to gather, use, and evaluate information, as well as the significance of the NCS critical outcomes of the need for information gathering, application, and evaluation, are also significant (Department of Education, 2002; DESA, 2015). Among the NCS's five key outcomes are social justice, a healthy environment, human rights, and inclusivity. The South African National Curriculum does not explicitly address the fundamental idea of ESD, but according to Winter (2009), environmental education has a significant impact on how the curriculum incorporates sustainability and other concepts related to sustainable development. Despite the jargon and rhetoric not always being incorporated, many elements of ESD are included in the NCS, with a focus on subjects like social responsibility, environmental education, and holistic education across academic boundaries (Department of Education, 2002; DESA, 2015). Sustainable resource use, preparing learners to take part in a democratic society that honors human rights, and promoting responsible environmental services are all concepts incorporated into the Life Sciences curriculum area (Winter, 2009).

Nonetheless, ESD discourse in South African education is still in its early stages, and as a result, it has had minimal impact on the curriculum. This is primarily due to a lack of comprehension of the ESD concept's uniqueness, as well as teachers' lack of

conceptualisation of ESD in the classroom practice (Leonard, 2012). In spite of the inclusion of general ESD concepts in the curriculum, there is still a lack of comprehension of how rhetoric promoting sustainable development should conflict with socio-political, economic, and environmental dynamics. According to Leonard (2012), if ESD is not based on confronting critical perceptions of an unsustainable environment, it will just be another ideology that is powerless to effect any change or offer a remedy.

The inability of school based ESD to encourage critical thinking among learners, according to Dzerefos (2020), is due to instructors' weak and limited knowledge base and information about their practices, instructional methodologies, and understanding of ESD. Leonard (2012) and Lombard (2015) found a shortage of adequate professional teacher education programmes in the South African context that stimulate critical and creative thinking, both of which are required to overcome the challenges of implementing ESD in South African schools which may include Life Sciences content workshops and subject advisors' interventions in teaching and learning of Life Sciences.

2.3.3 Integrating ESD in Life Sciences education

The use of ESD in science education is still in its infancy. The three pillars of sustainable development: society, environment, and economy as well as their interactions are the focus of ESD. It is proposed that appropriate education would enable future generations to better comprehend the linked nature of the economic, ecological, and societal transformations that are currently taking place (Maidou *et al*., 2019). For the development of a knowledgeable and qualified workforce, high-quality science instruction and the promotion of scientific literacy in learners at the school level are essential. Life Sciences is known as the scientific study of living things and how they function. According to Venkataraman (2010), ESD should not be taught in a directive, top-down style. Songqwaru (2012) encourages teachers to use democratic teaching methods, which encourage learners to take a more active role in their learning and gain a better understanding of the issues at hand. According to Lotz-Sisitka (2006) and Venkataraman (2010), inquiry-based methodology, critical learning through conversations and group work, and experiential learning, engaging with one another and their environment, can be achieved through participatory approaches in ESD.

Science's knowledge generation is an on-going process; as scientists enhance their knowledge and understanding, as well as people's perspectives change over time, scientific knowledge evolves (Barth, 2015).

When teaching Life Sciences, it is critical to assist learners in recognizing connections between related topics so that they can gain a comprehensive grasp of life's nature and interconnection. These connections must also be formed across grades as well. Maidou et al. (2019) suggest that teachers should be able to explore concepts and construct meaning and organize learning experiences based on their local circumstances, such as resource availability. The goal of studying Life Sciences is to gain scientific information and comprehension, as well as skills in the scientific process and an appreciation of science's role in society (South African. DoBE, 2011).

2.4 APPROPRIATE TEACHING APPROACHES FOR ESD INTEGRATION

According to Barth (2015), teachers should be expected to have academic and pedagogical competence in order to teach the concept of ESD, according to the recommendations. According to the majority of researchers, the most effective ESD teaching strategies are learner-centered (Tomas, Girgenti, & Jackson, 2017), experiential, participatory (Lysgaard & Simovska, 2016), praxis-oriented, place-based, interdisciplinary (Saka & Sahintrk, 2013), inquiry-based, and transformational (Biasutti, 2015; Biasutti & Frate, 2017; Girgenti, & Jackson, 2017). These teaching methods stimulate behavioural changes as well as changes in how people think about and react to processes as well as knowledge. These strategies, according to Biasutti (2015), are favoured because they educate learners how to think. Learner-centered methods include fieldwork, case studies, discussions as well as inquiry-based learning and experiential learning (UNESCO, 2012).

ESD promotes cooperative skills such as decision-making, critical thinking, and imagining future scenarios. As a result, ESD concepts necessitate a shift in how education is delivered today (UNESCO, 1992). It is critical that teacher education be

reoriented toward sustainability and gain more systemic learning and teaching models (Sterling, 2012). These methods depart from the traditional methods of teaching and learning (Jackson & Girgenti, 2017). Most teachers are aware that teaching ESD principles necessitates the use of specific teaching methods, such as learner-centered, action-oriented, and transformative-active instruction (Rieckmann, 2014). These interactive teaching and learning strategies inspire learners to take action to promote sustainable development.

2.5 ROLE OF TEACHERS IN ADDRESSING SUSTAINABILITY ISSUES

It is proposed that by the year 2030, education will have ensured that all learners have acquired the theoretical and practical knowledge required to promote sustainable development. Teachers have the power to shape the future by instilling in their students the concept of sustainable development (Mckeown, 2012). UNESCO (2004, 2005, 2006) recommends that new professional development models be developed expressly for the notion of ESD, which include key skills, action-based learning models, and cross-cultural approaches for teachers. In order to engage learners in topics like science, technology, and the nature of science as well as inquiry and scientific issues, it is crucial for science teachers at all levels to possess the competencies relating to necessary knowledge and skills, according to the National Science Teacher Association's (NSTA) report (NSTA, 2003).Furthermore, according to a study conducted by Bybee (2014), fundamental competences such as subject matter knowledge and pedagogical techniques are insufficient, and science teachers must also possess personal qualities such as a willingness to teach science and a personal interaction with pupils. Teachers are thought to be capable of preparing future generations to tackle the issues of current unsustainable development. As a result, teachers play an important role in creating the future. As a result, including ESD ideas into teacher education is critical.

Teachers who are knowledgeable must understand the crucial role that literacy plays in enhancing rather than displacing science instruction. Raising learners' knowledge of social and environmental issues is a key component of teachers functioning as change

agents, according to Timm and Barth (2020), who believe that learners can bring about societal change. Mensah (2019) contends that teachers should consider learners as either future members of society who require education in order to behave differently from the current generation or as intermediaries who have the power to influence change within their own families. According to Sund (2015), teachers in ESD should see themselves and their teaching methods as essential to energizing and inspiring their learners. Teachers in the studies by Evans et al. (2017) and Sund (2015) are confident that teaching ESD plays a significant role in fostering ESD and that specific external circumstances are essential for an ESD teacher's capacity to do so. However, the teachers who took part in Sund's (2015) study do not think they have any control over these outside factors, such as (a) a school with an ESD-friendly organizational structure and staff, (b) a principal who encourages ESD teaching activities, and (c) learners who are or might be interested in ESD. Timm and Barth (2020) claim that participant teachers are primarily concerned with the instruction level itself. Regarding their competencies, they were worried about having deep subject matter expertise (SME) and profound content knowledge (CK) as a prerequisite for being able to teach ESD.

The study by Mensah (2019) found that participant teachers recognize the value of pedagogical content knowledge (PCK), which helps them to choose themes and draft lesson plans that are in line with the prior experiences and interests of their learners. Additionally, a few of those participating teachers emphasize the idea that teaching ESD is more a matter of attitude than it is of knowledge and competence. Additionally, communication skills are a part of ESD practice because they are necessary when working with external organizations to include outside viewpoints and information into education (Mensah, 2019). Interacting with educators from different institutions is a part of this skill. Norden (2018) and Sund (2015) found that the participant teachers were able to filter their attributes as they mention that having an interest for ESD is indicative of a critical attitude regarding one's profession. They support the idea of ESD or are "keen to" and "want" to teach ESD. In order for the ESD track to be relevant, teachers must take tremendous tenacity into consideration, claims Norden (2018). In order to feel a feeling of ownership over the lessons they teach and the learning environments they create, he advised teachers to have high levels of self-efficacy while in the classroom.

It is important for teachers to understand that they are capable agents of change so that they can contribute to transforming educational institutions Timm & Barth, 2020). Mensah (2019) contends that for teachers to succeed in ESD, they must recognize the value of reflecting on educational objectives and ideas. According to Mensah (2019), teachers need to have a high sense of self-efficacy, be passionate about ESD, be excited about it, and be deeply convinced of its usefulness.

2.6 TEACHERS' PERCEPTIONS AND ATTITUDES TOWARDS ESD

According to Corney and Reid (2007), teachers' ability to address sustainability in their classrooms is dependent on their expertise as well as their ideas about subject matter and pedagogy. They suggest that teachers should cultivate a favourable attitude toward sustainability, as this may stimulate greater teacher involvement in ESD. Tomas, Girgenti and Jackson (2017) posit that teachers who have a favourable attitude toward the environment have a high level of self-efficacy for promoting ESD. Chunteng (2004) discovered that teaching ESD concepts requires a positive attitude toward ESD principles. Howlet et al., (2016) also claimed that teachers' attitudes have an impact on their lack of understanding and awareness of ESD. Gan & Gal (2018) explained that teachers in their study say they want to include ESD concepts into their lessons, but they require proper training to do so. Hence, it is apparent that most teachers agree that ESD should be included in teacher education beginning at the university level. Findings from Qablan (2018) revealed that participant teachers believe that incorporating ESD into the curriculum will have an impact on their capacity to teach about SD. Participant teachers also agree that beginning to teach about the notion of SD in early childhood education settings, such as primary schools, is critical (Qablan, 2018; Redmann *et al*., 2018). However, Redmann et al. (2018) found that teachers admitted that further education on environmental issues is required. Hence participant teachers agreed that it is crucial for teachers to acquire all the skills required to integrate ESD into their classrooms. According to Burgener & Barth (2018), teachers' perceptions about ESD influence how they prepare and teach their students for the future. Teachers in the

study conducted by Qablan (2018) believed that ESD knowledge, skills, and attitudes were not better addressed in sciences.

The findings of Redman et al. (2018) indicated there is a gap between what is learned and ESD results, and they believe that ESD integration will improve the relevance of sciences (Sund & Gericke, 2020). It necessitates a more in-depth examination of the skills that scientific educators and teachers are required to possess. Burgener & Barth (2018) suggest that participant teachers lacked the necessary expertise and skills to incorporate ESD with the use of transformative teaching and learning methods (Karaaslan & Teksoz, 2016). It is advised that transformative learning take place, in which real-life challenges and examples are used. PCK should be defined not only in terms of subject content and pedagogical expertise, but also in terms of ESD knowledge and competencies (Burgener & Barth, 2018). Maidau et al. (2019) realised that teachers require ESD specific PCK (ESD PCK), which includes knowledge of specific sustainable development concerns as well as pedagogical methodologies for integrating ESD into their classrooms. Hence, Maidau et al. (2019) suggests that science teachers should be able to connect subject matter and concepts to personal and societal challenges as articulated in ESD discourse, according to ESD PCK. Furthermore, they added that science teachers require direction on how to integrate and apply ESD and change-oriented teaching and learning experiences to life and community concerns into scientific instruction.

2.7 TEACHERS' PRACTICES OF ESD IN THEIR CLASSROOMS

Olsson, Gericke, and Chang-Rundgren (2016) contend that teachers need to be educated about the environment in order to instruct learners about SD. This is because lack of knowledge is regarded as one of the inhibiting factors. Because the environment, the economy, and society are all intertwined, economic or social actions may result in environmental issues. Furthermore, development must encourage environmental conservation in order to meet economic and social needs. The biggest issue that teachers face in interpreting and using the new curriculum, according to Sund (2016) is

that they do not have an adequate knowledge base. Accordingly, teachers who lack pedagogical knowledge, experience, and confidence usually use rote learning, expository teaching, and maintain strong control over classroom activity (Uitto & Saloranta, 2017). The importance of teacher expertise in enhancing learners' achievement has been established (Pearson *et al*., 2010). According to Pearson et al. (2010), teachers should use the same inquiry procedures in their professional development as they do with their learners.

Barth, (2015) and Aceska & Nikoloski (2017) argue that for education in South Africa to advance, teachers must participate in courses that will inform, inspire, and motivate them to change how they normally teach. They must also be able to mentor their learners in these activities. Nonetheless, for teachers to acquire new ways of thinking and teaching in their classrooms, this mentorship requires a significant conceptual shift. Rethinking teacher preparation, curriculum, and professional development is essential for such changes to occur (Pearson *et al*., 2010). Teachers' confidence, particularly in learner-centered teaching approaches, must be boosted, and teachers must be able to inspire critical and creative thinking in their classrooms. There is a shortage of skilled and knowledgeable teachers for ESD principles in science instruction, according to Maidou et al. (2019). He claims that many science teachers are not trained as science teachers, which leads to insufficient knowledge, a lack of key parts of science, and a lack of exposure to effective learner-centered teaching. Learners should be taught how to actively participate in shaping society in order to ensure a long-term future (UNESCO, 2014; Eilks, 2015).

In connection to general and scientific education, ESD offers guidance for educational research, classroom instruction at all levels, and expanding teacher preparation (UNESCO, 2014). It is important for teachers to have the sufficient content knowledge (CK), building skills (PCK), and attitude (enough willingness and drive) to meet the difficulties of sustainability. While the topic of what competences teachers need to become successful ESD teachers remains unanswered, the question of how well existing teaching and learning formats facilitate the development of these competencies also remains unanswered (Burgener & Barth, 2018; Evans *et al*., 2017). For science

teachers to be able to integrate ESD and act on it, they must first comprehend the issues of sustainable development and the concepts of ESD, as well as the principles and values (i.e., ESD content knowledge) and know the proper learning and teaching methodologies (i.e., the ESD pedagogy). ESD PCK is linked to the teachers' ability to connect subject information and concepts with issues of importance to society's development (Garcia-Gonzalez *et al*., 2020). This indicates that if teachers concentrate on ESD PCK, the subject's teaching and learning will contribute to the formation of environmentally conscious citizens in line with evolving conceptions of scientific literacy. As a result, the goal of Life Sciences as a science discipline must be to help shape a new generation of citizens that value and comprehend sustainable development.

2.8 INFLUENCE OF TEACHERS' PERCEPTIONS ON THEIR CLASSROOM PRACTICES OF ESD

Teachers are aware of ESD and have a decent understanding of the three pillars of SD, according to Adawiah and Norizan (2012), but they do not seem to understand how they are interrelated. Teachers are aware of how the three elements of ESD are relevant, but do not have a holistic grasp of it (Borg, Gericke, Höglund, and Bergman, 2014). Several surveys have found similar results, indicating that most teachers grasp the ideas of SD, however the ecological approach is the most widely recognized. Many scholars assert that teachers' grasp of sustainability varies, and even those with a solid comprehension do not comprehend how the SD components are interrelated. Many teachers' lack knowledge of sustainability issues is related to a lack of proper training during their studies (Cordina & Mifsud, 2016), which makes it difficult for them to integrate ESD in their classrooms. After taking an ESD course as part of their teacher education program, instructors' confidence in instructing about sustainability issues increased, according to Bezeljak et al. (2019). Many studies have shown that teachers with knowledge or understanding of the concept of sustainability may not necessarily be able to effectively teach about ESD issues (Aceska & Nikoloski, 2017), so it is critical for teachers to have knowledge of sustainability issues as well as pedagogical skills,

attitudes, and values to support teachers' confidence when integrating ESD in their classrooms (Bezeljak *et al*., 2019).

Teachers' duties are highlighted in efforts to integrate ESD into education on a policy level (e.g., UN Decades, SDGs, and GAP) (UNESCO, 2014). Nonetheless, ESD is not firmly established in teacher training or professional standards in most countries, and it is largely ignored (Evans *et al*., 2017). Teachers' competences and dedication to sustainability are crucial criteria for successful implementation of ESD in schools, according to research (Barth, 2015; Buchanan, 2012). In order to teach ESD in the Life Sciences, teachers must have a favourable attitude toward ESD, as well as specialized subject matter knowledge and knowledge of sustainable pedagogies.

For educational reform to be successful, instructors' views, past knowledge, and attitudes must be considered (Songqwaru, 2012). Unfortunately, information on secondary school teachers' ESD knowledge and attitudes in Life Sciences instruction is scarce (Burgener & Barth, 2018). Is it therefore vital to consider teachers' ESD knowledge, abilities, and attitudes in their teaching? It is also critical that they use participatory teaching and learning approaches that engage and inspire learners to modify their behaviour and act for long-term sustainability. Teachers' dedication, motivation, and novel ideas are essential for this change to ESD practices to take place (Evans *et al*., 2017). Teachers must be familiar with the topics covered in their curricula in order to identify possibilities for studying sustainable concerns in their classrooms (Songqwaru, 2012).

The study by Maidou et al. (2019) found that there is limited policy development, poor coordination, a lack of teaching support, and poor resources in many schools; teachers lack scientific understanding of ESD issues and there is still a misunderstanding of the nature of sciences and its purpose in ESD issues; and pedagogical knowledge becomes important when teachers must make disciplinary knowledge only accessible to their learners. According to Eilks (2015), teachers have good attitudes toward applying ESD, despite their inadequate awareness of ESD theory, pedagogy, possible resources, and classroom materials. Teachers are believed to instruct a topic in accordance with their understanding of the discipline's nature and its purpose, and that

the materials, instructional strategies, and resources they use have an impact on their value orientations toward the subject matter they instruct (Sund & Gericke, 2020). It is suggested that ESD issues, as well as long-term instructional techniques, should be included in scientific PCK. It is proposed that the concept of 'ESD pedagogical content knowledge (ESD PCK)' be viewed as an extension of Shulmans' (1986) concept (Garcia-Gonzalez *et al*., 2020).

2.9 ESD ACTIVITIES

ESD learning requires active learning, whereby a variety of activities are used both inside and outside the classroom. It is very important that teachers maintain the interest of their learners when teaching to help them engage actively with the concept of ESD (Antonius, Haines, Jensen and Niss, 2007). These active learning activities include problem-based learning (effective questioning, case studies and projects), collaborative learning (working in groups or pairs) and simulations (debates, games and competitions) (Wiggins and McTighe, 2011). Problem-based learning activities such as projects are more complex activities that extend over weeks or months (Wiggins and McTighe, 2011). These kinds of activities are given to learners to address a broader problem embedded in a real world. One teaching strategy that keeps learners interested and motivated while also improving their comprehension of science topics and methods necessary for the sciences is collaborative learning (Major, 2019).

A study conducted by Majola (2019) has shown that there is a significant improvement in performance where collaborative learning took place as there were discussions between the members of the group. Collaborative learning seems to be an effective approach for learning. These groups can be formed randomly or deliberately by the teacher or groups can be formed by learners. Groups function as pleasant sociological environments whereby group members work together with each other on the same problem through constant discussions (Srinivas, 2011). When solving more complicated issues, discussions are more beneficial so that when one is stuck, another person may be able to offer a proposal and others may be able to clarify. In this kind of exercise, the

teacher serves as a facilitator, asking questions that encourage reflection and learning. The teacher promotes discussion, assists learners in learning to collaborate, fosters communication skills among learners, encourages learners to see connections between the concepts, and gives learners the chance to apply their own knowledge and experience (Laal & Laal, 2012)

2.10 ESD ASSESSMENT

A key component of educational practice has always been assessment in its many forms. Learning is the focus of assessment. Assessment, a fundamental element of teaching and learning activities in schools, mediates the relationship between teachers and learners in the classroom (Amua-Sekyi, 2016). Assessment refers to all of the actions that teachers and learners engage in to collect information that might be used to alter teaching and learning. Depending on how the results are used, assessments have been divided into formative and summative categories. Since it is a part of the teaching and learning process and gives feedback to the teacher to help assess how well learners are learning, formative assessment is also known as assessment for learning (Tugel, 2018). Summative evaluation takes place at the end of the program to assess the level of learner achievement. It is known as learning evaluation and frequently takes the form of tests and exams. There are various techniques of evaluation, including group assessment, textual questions and written answers, oral questions and replies, and self-assessment (Maphalala, 2016). Some assessments such as project-based assessment are given to learners by teachers to work on a certain topic for a given specific time (Oyinloye & Imenda, 2019). Learners are given a topic on which to do an investigation. Group assessments are given to learners to work on, and the aim is to get good grades (Majola, 2019). Concept tests, marks, and academic reports produced through summative assessment are intended to assist teachers in making a final determination regarding a learner's achievement. According to Ssosse, Wagner and Hopper (2021) when assessing learners engaged in ESD practice, it is important to focus on the development of problem solving skills. Therefore, in order for teachers to judge whether learners have acquired the competencies and attitudes based on ESD

perspective, they should provide assessment that will help learners to reflect on their own learning, and increase their desire to learn and leads to new learning. Ssosse et al (2021) indicate that there are two most effective ways of assessing ESD, i.e., building up portfolios to file the results of learning activities and giving learners' worksheets to reflect on each activity and write down how they felt on each activity.

2.11 THEORETICAL FRAMEWORK

According to Gabriel (2008), a theoretical framework is the framework that a research's theory is built upon. It introduces and illustrates the logic behind why the research problem under study exists. This section discusses the theory that underpins the study and the rationale behind choosing this theory in the teaching of ESD in Life Sciences classrooms.

2.11.1 Pedagogical Content Knowledge theory

The study employed PCK as a theoretical framework. This framework enabled the researcher to search teachers' perceptions and practices of ESD in Life Sciences classrooms. PCK is a concept that is used to interpret the knowledge of teachers and is used to investigate the knowledge that makes one a good teacher (Rollnick & Mavhunga, 2017). It is the knowledge that the teachers employ in their teaching process. PCK was defined by Shulman (1987) as the themes that are most frequently covered in one's subject area, the best ways to portray those concepts, and the best analogies, examples, explanations, and demonstrations. Shulmans' concept of PCK is centered on two important views in teaching, that is: the representation and the understanding of content knowledge. Shulman (1987) states that the essential skill a teacher should possess is the capability to translate the knowledge taught to the learners in a way that could be well understood. Teaching should not only incorporate the teacher's skilful presentation of his/her knowledge but should include the ability to direct the learners to understand meaningfully the content of the knowledge (Rollnick & Mavhunga, 2017)

PCK is outlined as a concept of various elements connected with the transformation of content knowledge into pedagogical strategies, but it is required that PCK elements be discovered in a specific subject (Jing-Jing, 2014). PCK includes the prior conceptions that are brought to class by the learners, the knowledge of the subject from the teachers, and teaching that develops with time, the attitude and perceptions of teachers, and beliefs they have towards a subject which will also affect their teaching (Burgener & Barth, 2018). According to Shulman (1986), PCK includes specific knowledge for teaching a specific learning area, as well as being linked to the appropriate teaching of content; as a result, teachers must be aware of the various teaching strategies that will aid in teaching and learning, as well as the content teaching. PCK is defined by Rollnick et al. (2008) as the method teachers teach their knowledge of a curriculum subject as well as their attitudes toward teaching the specific learning area. Teacher attitudes were also included in the concept of PCK because attitudes can influence teachers' PCK. PCK, according to Rollnick et al. (2008), is a "transformative paradigm" in which teachers should be able to use new content and tactics daily in order to limit one-way transmission of knowledge to their learners and transform it in a way that maximizes understanding and learning.

Teachers' knowledge was split into seven categories by Lee Shulman (1986), including content, pedagogy, curriculum, objectives, goals, learners and learning, school environments, educational philosophies, and pedagogical knowledge. These seven groups of knowledge, according to Shulman, can be defined as a distinct body of information that distinguishes teachers from topic specialists. PCK is a trait of a teacher's professional knowledge, according to Shulman (1986). PCK is a hands-on expertise or skill used by teachers to apply appropriate pedagogical strategies to approach the learners required in class, and it complements but differentiates from topic knowledge (Shulman, 1986). PCK assists teachers in raising awareness of learners' misconceptions about a particular topic and enables teachers to use suitable pedagogical strategies to address the learners' needs in class (Shulman, 1986). Davis and Krajcik (2005) added to Shulman's (1986) definition of pedagogical content knowledge by stating that teachers require expanded and instructive field specific PCK.

Teachers will need PCK to teach ESD principles in the learning area of Life Sciences in this study.

2.11.2 PCK in Life Sciences (Teaching strategies and instructional methods)

Teaching the concept of ESD brings together many viewpoints on socially significant topics since it is possible to mix chemistry, biology, and physics, as well as perspectives from economics, social sciences, and the humanities (Rollniick *et al*., 2008). In order to promote ESD that extends beyond education about sustainable development, the approaches of ESD necessitate the use of a skills-oriented teaching paradigm (McKeown, 2006). As a result, it is apparent that teachers must have specific understanding in order to cope with ESD. Teachers must have specialized subject matter understanding in those Life Sciences-related concerns that will serve as the foundation for beginning to teach ESD in their Life Sciences classroom. They must also understand how to deal with sustainability, development, and their overall significance. Basic understanding of the terminologies, concepts, and models utilized in the sustainability debate is essential.

For understanding sustainability and sustainable development, a variety of definitions and models have been established (Burmeister *et al*., 2012). Sustainability should be viewed as a holistic concept that encompasses ecological, economic, and societal aspects. It is critical for teachers to understand the various orientations of Life Sciences education that suit ESD objectives in order to successfully deploy ESD in Life Sciences. Teachers will require acceptable ideas for connecting ESD with Life Sciences curricula, taking into consideration learners' prior knowledge of sustainability, and they will need to be able to apply a suitable repertory of pedagogies for incorporating ESD-based teaching into Life Sciences classrooms (Burmeister & Eilks, 2012). In order to achieve meaningful ESD reform in science, it is critical to invest in scientific teacher education in terms of their knowledge, attitudes, and beliefs.

2.11.3 Science PCK model

In science, Magnusson et al. (1999) identified a PCK model to analyse the concept of PCK for specific subject matter. This PCK model emphasizes the elements of PCK for science teaching. Magnusson et al.'s model emphasizes that there is a two-way interaction among the components of PCK and the way in which the two-way interaction assists in shaping PCK elements as a whole concept (Peng, 2013). Teachers are required to incorporate all PCK elements for decision making in teaching. This science model described the five PCK components:

1) **Orientation to teaching science**- nine orientations: process, academic rigour, didactic, conceptual change, activity-driven, discovery, project-based science, inquiry, and guided inquiry.

2) **Knowledge of science curriculum** - specific science curricular and specific goals and objectives.

3) **Knowledge of learners' understanding of science** – requirements for learning and areas of difficulty.

4) **Knowledge of instructional strategy** – science specific strategies (for any topic) and strategies for specific science topics.

5) **Knowledge of assessment of scientific literacy**- dimensions of science learning to assess and methods of assessment of science learning.

Magnusson et al.'s model of science teaching makes it simple for the integration of teacher knowledge. This model is used in many studies to understand teachers' knowledge. The science model was used in the study to understand how teachers teach the concept of ESD in their Life Sciences classrooms. It enabled the research to explore teachers' knowledge in teaching ESD, the skills they possess, the beliefs they have towards ESD, and the teaching methods and strategies they use when teaching the concept of ESD in Life Sciences.

Figure 3 below shows the theoretical framework that was used in the study. The framework highlights the teachers' role when integrating the concept of ESD in their Life

Sciences classrooms. It shows the teachers PCK and how it influences their beliefs about ESD or vice versa, and how the teacher knowledge and beliefs influence their teaching in their classrooms.

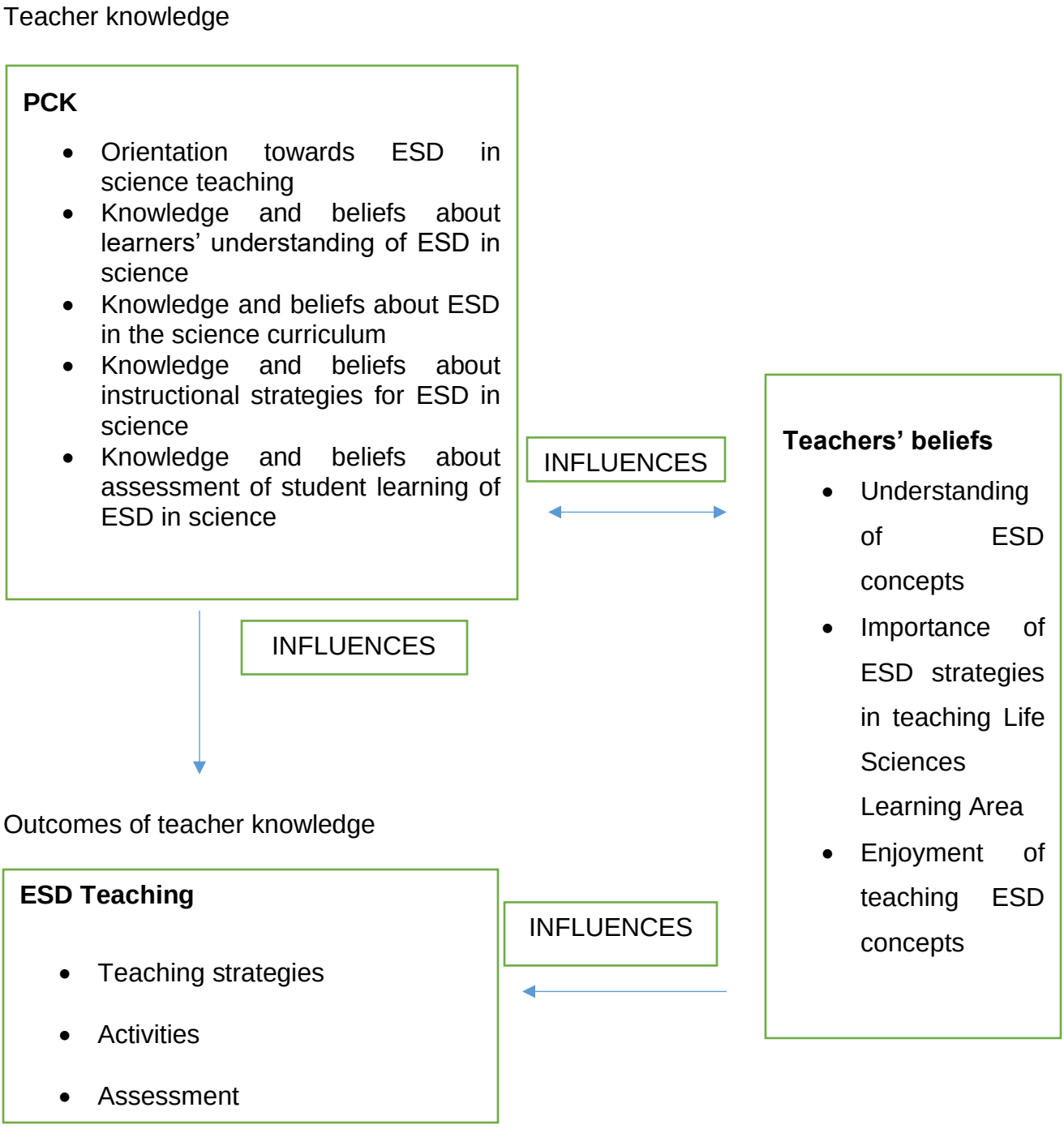


Figure 2.3: Summary of theoretical framework adapted from Magnusson, Krajcik & Borko (1999) and Rollnick, Bennett, Rhemtula, Dharsey & Ndlovu (2008).

2.12 CONCLUSION

This chapter began with a literature review regarding the concept of sustainable development and education for sustainable development. The three sustainability pillars as well as their interconnectedness were described in detail. The chapter further discussed teachers PCK with the focus of the concept of ESD and on Life Sciences as a subject. The teachers' perceptions, beliefs and attitudes towards ESD from other studies were also considered. The chapter advanced to present a theoretical review of recent research on ESD and teachers' PCK in order to comprehend teachers' knowledge, attitudes, and instructional strategies.

CHAPTER THREE

RESEARCH DESIGN AND METHODOLOGY

3.1 INTRODUCTION

Research methodology, as defined by Kothari (2004), is a strategy for systematically addressing the research problem. In it, we examine the typical approaches used by the researcher to analyse the research problem and the rationale behind such approaches. This chapter will present the research paradigm, research approach, research design, sampling, data collection, and data analysis that were employed to carry out the study.

The chapter will start off with outlining the main topic of the current study, which will be followed by a thorough description of the interpretivism research paradigm. A discussion of the paradigm will be followed by a presentation of the study's research strategy and design. The current study used an exploratory case study design and a qualitative research methodology. Data collection methods included semi-structured interviews, non-participant classroom observation, and document analysis. The three data gathering techniques were used for triangulation and were able to produce appropriate data to address the study's research goals. Data collected was analysed through thematic data analysis.

The current study explored teacher perceptions and practices of ESD in Life Sciences classrooms. It specifically explored how teachers perceive the concept of ESD, how they integrate ESD in Life Sciences classrooms and how their perceptions influence the practice of ESD. To achieve this, the study aimed to address the following main research question:

What are the teachers' perceptions and practices of education for sustainable development in Life Sciences classrooms?

To answer the main research question of the study, the following research sub-questions were addressed:

1. How do the teachers perceive education for sustainable development teaching in Life Sciences?
2. How do the teachers facilitate education for sustainable development in Life Sciences classroom?
3. How do the teachers' perceptions of education for sustainable development influence classroom practices?

The main aim of the study was to explore teachers' perceptions and practices of education for sustainable development in Life Sciences classrooms.

To achieve the aim mentioned above, the study focused on the following objectives:

4. To explore teachers' perceptions of education for sustainable development in Life Sciences classrooms.
5. To explore how teachers facilitate education for sustainable development in Life Sciences classrooms.
6. To examine how teachers' perceptions of education for sustainable development influence classroom practice.

3.2 RESEARCH PARADIGM

An interpretivist paradigm was used because interpretivism stresses different forms of reality (Hartley, 2010). It focuses on the experiences of people, understanding and the nature of knowledge hence I focused on the views, perceptions and ways of teaching. Guba and Lincoln (1994) contend that because social conceptions are subjective and flexible, only interaction between the researcher and the participants will allow for the elicitation and improvement of individual conceptions. The use of an interpretive approach enabled me to understand the world from an individual's views through the experiences of teachers. This approach follows a worldview whereby the perceptions are shaped by peoples' experiences (Maree, 2010). According to Thomas (2009),

paradigms are shared beliefs within a specific field of study, the way that scholars think, and the guidelines for conducting research. Mugo (2011) also argues that the purpose of an interpretative paradigm is to establish how people comprehend the setting in which they live and work. This study aimed to explore teachers' perceptions of ESD development in their daily teaching classrooms and explore how their perceptions influence their classroom practice. This was done through semi-structured interviews that allowed participants to voice their experiences in teaching education for sustainable development in Life Sciences classrooms. The interaction with teachers during semi-structured interviews enabled teachers to share their experiences through their voices and gave the researcher access to data of the integration of ESD in their Life Sciences classrooms. The goal of the study was to interpret the teachers' experiences using semi-structured interviews and classroom observations because the participants were teachers who actually taught Life Sciences. This choice of an interpretative paradigm was motivated by the fact that it recognises the multiple interpretations as being equally valid.

3.3 RESEARCH APPROACH

A qualitative research approach was employed in the study. Baytek et al. (2011) state that it is a process that makes inquiries to understand the behaviour of humans. This research method helped the researcher to explore the teachers' perceptions and practices of ESD in Life Sciences classrooms using a PCK lens. Creswell (2014) states that in a qualitative research approach, the words and opinions from the participants are analysed to understand the phenomenon. Through this research method the researcher describes peoples' experiences about a particular phenomenon (Creswell, 2014; Frankel & Wallen, 2009; Giorgi, 2009). Creswell (2007) states that in a qualitative research approach, the researcher gets a chance to study individuals and accumulate their views and experiences. The researcher serves as an inquirer who attempts to get meaning through understanding and promotes opinions to the way we purview the world (Shank, 2006). The study relied on qualitative data hence it was important that data be

drawn from Life Sciences teachers to understand not only their experiences but also the factors that influenced the experiences.

Researchers accumulate information from the perspective of the participants in the research through qualitative methods such as observation of participants and interviews (Lester, 1999). The narratives were made of what is told by the teachers regarding their experiences in teaching ESD in Life Sciences classrooms. Yin (2003) expresses that a qualitative approach refers to research that involves a practical and detailed investigation of a phenomenon that occurs in a real-life setting. The goal of this qualitative approach was to develop multiple interpretations of existing Life Sciences teacher perceptions and practices by exploring teacher perceptions of ESD, the teaching strategies teachers employed when integrating ESD and the influence of their perceptions on ESD practice. Through one-on-one semi-structured interviews with participants, classroom observations and document analysis (lesson plans), the researcher was able to directly gather data from them (Mohajan, 2018).

Through an in-depth review of the topic, the researcher was able to gain an understanding of the phenomenon under study, in relation to the meaning's participants ascribed in their classrooms. To fully comprehend the study, a detailed report on teacher perceptions and practices of ESD was necessary, which was made possible using the qualitative research approach (Khaldi, 2017). By methodically employing suitably assertive, reliable, and ethically appropriate techniques, the researcher showed a great deal of flexibility in his pursuit of data generation and analysis on teacher views and practices (Ronoh, 2017).

3.4 RESEARCH DESIGN

A case study is described by Bromley (1991) as a systemic investigation into an event or a group of connected events with the goal of characterizing and understanding the phenomena of interest. The study used an exploratory case study design, which is characterized as a case study intended to explore circumstances when the intervention being evaluated has no obvious, singular set of outcomes (Yin, 2003). An exploratory

design allowed a researcher to explore an area about which he/she has little or no knowledge (Yin, 2014). It is an exploratory case study as it provides an in-depth exploration of “what” and “how” the phenomenon under study is carried out in their Life Sciences classrooms (Creswell, 2009). Johnson and Christensen (2008) contend that a case study is holistic as it exists in real-life. A case study is used to describe and examine a person individually (e.g., his or her activities), a group of people (e.g., teaching staff), individual institution or a problem, processes, phenomenon, or event in a particular institution (Sagadin & Bertoncelj, 1991).

This design was used because the aim of the study was to explore teachers’ perceptions of ESD and how ESD is practiced in Life Sciences classrooms. The data gathering technique associated with this case study was one-on-one semi structured interviews, classroom observations as well as document analysis of lesson plans. The intervention of this research is the ESD curriculum innovation, i.e., the implementation of a curriculum innovation to help teachers practice ESD successfully when teaching Life Sciences. Teachers need to be well equipped with the knowledge and the concept of ESD for them to practice it in their classrooms. Because it allowed for an in-depth investigation of the varied daily practices of Life Sciences teaching practices, an exploratory case study methodology produced rich data of great depth (Crowe *et al*., 2011). The following benefits were provided to the researcher by the exploratory case study design. (Hill, 2017):

- A researcher was provided with a great flexibility during data collection,
- A researcher had an opportunity to investigate deeper into the instructor methods used for ESD integration
- The researcher was able to gain deeper understanding of teacher perceptions and practices and how their perceptions influenced their practices (Justus, 2017).

In order to align with the main research problem, the exploratory case study approach helped to provide a comprehensive and in-depth understanding of teacher perceptions and practice (Harrison *et al*., 2017).

3.5 PARTICIPANTS SELECTION (SAMPLING)

3.5.1 Study setting

The study was conducted in Phuthaditjhaba which falls under Thabo Mofutsanyana District of Education in the Free State. Phuthaditjaba is a rural area that consists of both public schools and private schools. Data were collected from teachers in circuit 10 of Thabo Mofutsanyana district. The researcher chose Thabo Mofutsanyana district in Phuthaditjhaba because she had taught in the district for five years in secondary (public) schools. The desire to conduct the study and the identification of the problem were driven by this experience. The researcher was interested in exploring how teachers perceive and practice ESD in their Life sciences classrooms and how their perceptions influence their practice in this rural area.

3.5.2 Study population

A population is defined as a group of people, objects, species, etc. that contains the elements of anything you want to study (Mothokwa, 2011). It is a group of individuals that are known to have similar characteristics and can participate in the study (Asimah *et al*., 2017). The study consists of three grade 10-12 Life Sciences teachers from Phuthaditjhaba in the Free State with more than two years of teaching Life Sciences in the Further Education and Training (FET) phase. These teachers were at school in circuit 10 of Thabo-Mofutsanyana district.

3.5.3 Participant selection

Sampling was defined by Gentles, Charles, Ploeg, and McKibbon (2015) as the choice of particular data sources from which data are gathered to satisfy the research objectives. Etikan and Bala (2017) state that the researcher should judge the participants who he/she believes will supply only useful information to meet the goals of the study. The participants for the study were purposefully sampled. According to Alvin (2016) only teachers who satisfy the requirements of the study and meet the needs of the criteria should be approached because they are believed to bring the best information that is needed for the study. Hence, they should be selected with the

purpose of sharing information that will be of benefit and who are willing to share such information (Etikan & Bala 2017). The researcher required participants who would be able to offer the necessary data in order to collect the information for the study and to address the research questions. For this study, the population comprised of Life Sciences teachers of circuit 10 in Thabo Mofutsanyana district. Three teachers from Phuthaditjhaba were selected based on the following criteria:

- They taught Life Sciences in secondary school (grades 10-12)
- Their number of years of teaching Life Sciences, i.e., at least two years of teaching experience incorporating ESD in their teaching

Participants were chosen according to these criteria and were believed to provide detailed and reliable information for which the researcher is looking. The reason the researcher chose participants according to these criteria was because of the aim of the study which is to explore teachers' perceptions and practices of ESD in Life Sciences classrooms hence only teachers who are qualified to teach Life Science are fit for the study and only those who have been teaching and practicing ESD for more than three years can provide sufficient information required for the study. According to Patton (2002) there is no fixed principle regarding to sampling size in a qualitative study. Hence the three selected participants represented a population of Life Sciences teachers and provided adequate information needed to produce reliable and fair results. All reasonable precautions were made to ensure protection of the participants. Letters were sent to the selected participants' schools explaining the aim of the study and all consent forms were issued and signed.

By purposive selection, the researcher was able to explore the research questions in great depth. The researcher also works in the same circuit as the participants so it was easy to identify participants that will provide relevant information needed for the study. Two of the participants were Departmental heads (Post level 2) of the department of Life Sciences and one participant was a post level 1 teacher teaching grade 12 only.

3.6 INSTRUMENTATION AND DATA COLLECTION TECHNIQUES

Because it produced the data needed to answer the study questions, data collection is a crucial component of research. Three methods were employed in this qualitative study to gather data. The three techniques are semi-structured one-on-one interviews, classroom observations, and lesson plan document analysis. I'll give a brief description of the significance of the study's data collection techniques.

3.6.1 Semi-structured interviews

Through interviews, the researcher can gather an extensive and varied set of data in a less formal setting. Unlike questionnaires where specific information is acquired, interviews allow for an extensive examination of the interviewee's opinions, experiences and feelings. According to Sproull (1995), the advantages of interviews include:

- Learning information directly from the people involved.
- Gives the researcher the chance to go further and learn why people behave in certain ways.
- Enables information to be clarified as it is presented.
- It provides possibilities to clarify and confirm previously gathered data and to explain difficult facts.

The interviews consisted of a set of predetermined questions. This strategy was used to gain required information about the perceptions and practices of ESD the teachers have in their Life Science classrooms. According to Seidman (2013), interviews are appropriate for understanding and exploring the experiences of other people with an interest in opinions about the experience they have with the phenomenon under study. Creswell (2007) also states that although interviews are costly and time consuming, they are the most relevant method to use to collect data. Semi-structured interviews allowed flexibility for follow up questions and allowed the researcher to discuss topics in detail and probe for more clarity where answers were not clear. This data collection method was relevant for this study as only three Life Sciences teachers were interviewed.

When there are only a few participants in a study, as there were in this one since only three were chosen, semi-structured interviews are the best option. Semi-structured interviews, according to Stewart, Treasure, and Chadwick (2008), consist of a few core questions that outline the topics to be covered in research but also give the interviewer and participant an opportunity to examine a concept in greater depth. Three Life Sciences teachers were interviewed in the present study. The participants were allocated 30-40 minutes duration for the recorded interviews. Interviews were conducted telephonically as participants' schedules were tight due to grade 12 extra-classes. This was also for participants to be comfortable so that they provide the information that was required for the study. Permission was obtained from the participants to record the interview with the use of an audio tape. Interviews addressed the main question and the question of how teachers perceive ESD teaching in Life Sciences. The researcher managed get information about the perceptions teachers have about the concept of ESD and how they have been teaching it.

3.6.2 Classroom observations

Classroom observations were the second strategy that was used for data collection for the purpose of triangulation. Croll (1986) defined an observation as an attempt to characterize a process that is happening at a certain time. When doing lesson observations, the researcher observes an event first-hand, notes their perceptions, and assesses the significance of the observed behavior (Somekh, 2011). The advantage of observations is that the researcher is in contact with the field and the participants they are observing. They let the researcher to observe the participants' experiences, activities, and interactions with the environment first-hand, producing precise descriptions of those events. In addition, observations provide an opportunity for the researcher to compare what is written in documents or said during conversations to what takes place. Patton (2002) opines that observations are important tools to gather data because they allow the researcher to get an understanding that could be missed if they depended on other descriptions of the setting.

The reason for choosing class observation as a second strategy is because the researcher wanted to know the teachers' perceptions towards ESD teaching and their

PCK and compare how the responses from the teachers' interviews are reflected in their teaching in classrooms. In the present study, all three participants were observed teaching ESD and only one classroom observation was conducted for each teacher. The researcher received permission from the principal to visit teachers in their classrooms to observe their lessons. Classroom observations addressed the question of how teachers facilitate ESD and how their perceptions influence classroom practices. The researcher was provided an opportunity to see how teachers teach the concept of ESD as well as their attitude towards ESD. Only the activities connected to what the teachers did and said while integrating ESD were captured on audio and field notes. The data from lesson observations are presented as Vignette pictures that capture episodes of classroom practice. A vignette is a qualitative research technique that presents a plausible description of a situation and can be used to encourage conversation with individuals or groups on a particular subject (Bennet, 2016). They reveal participants perceptions, values, social norms or impressions of events.

According to Maree (2014), there are many advantages of observation in qualitative research such as:

- The gathering of information necessary to interpret the occurrence seen involves the researcher directly.
- The researcher is allowed to see what people do, rather than what they say they do.

3.6.2.1 Non-participant observer

During classroom observations, the role of a researcher is to observe the lesson and not take part in it. Non-participant observation according to Liu and Maitlis (2010) is where the researcher observes individuals or groups without getting involved in the activity performed by the participant. The researcher in this method collects data without having to interact directly with their participants (Williams, 2008). It involves observing a lesson without actively participating in the lesson. Harvey (2012) stated that the role of a researcher during observations is to observe social behaviour at first hand, without

joining in. Therefore, the researcher in this strategy has an observational role, a non-participant who will not intervene or participate in the teaching.

3.6.3 Document analysis

Document analysis was another strategy that was used in the study which is examining lesson plans designed by the Life Sciences teachers. Bowen (2009) defined document analysis as a systematic procedure for evaluating or assessing a document that could be either printed or was electronic material. To get meaning, comprehension, and develop verified knowledge, the data collected must be evaluated and interpreted, just like with any other approach (Corbin & Strauss, 2008). Three lesson plans were analysed. One of the advantages of collecting documents is that all the information that appears on the lesson plans are from the teachers as they are the ones who created them (Creswell, 2007). Lesson plan analysis provided information of how the teachers plan to integrate the concept of ESD in the teaching, the teaching strategies they use, how they engage learners in their teaching as well as how they assess them. To analyse lesson plans, texts that are ESD related in teachers' lesson plans and observation notes were identified. The identified texts that reflected any of the ESD concepts or teachers PCK were highlighted and coded and placed under categories.

3.6.4 Pilot testing

Before conducting this exploratory study, a pilot test is usually conducted to assess the procedures and usability of the data collection processes. Pilot studies are described as a subset of feasibility studies aimed to assess whether the study can be done and to test the aspects of study design and processes to be implemented in the exploratory study (Kim, 2010). According to Doody & Doody (2015), pilot tests are usually carried out to assess the technique's practicality, the validity of the questionnaires and interviews, as well as how they interact in a particular context. It is also thought to reveal potential ethical and practical problems. The researcher's objectives in carrying out a pilot study were:

- To define and redefine the instruments used to collect data (Janghorban, Roodsari & Taghipour, 2014).

- To assess how usable the interview protocol and classroom observation guide was (Fraser *et al*., 2018).
- To determine any possible challenges related to the collection of data and analysis.
- To train the novice researcher and provide an opportunity to increase their confidence in conducting qualitative research (Williams-McBean, 2019).

One Life Sciences teacher from Thabo Mofuntsanyana district participated in a pilot testing. The teacher was teaching grade 10 and 11 in a school situated in Phuthaditjhaba. An interview was held before classroom observation. The participant enabled the researcher to realise the order of questions and the appropriateness of the question items. The participant was able to answer all the questions as listed in the interview protocol. Therefore, there were no changes made to the interview protocol and enabled the researcher to answer the research questions of the study. One lesson was observed from the participant and one lesson plan was provided by the participant and was analysed. The pilot testing was beneficial and was able to prepare the researcher for the actual data collection of the study.

3.7 DATA ANALYSIS APPROACH

Creswell (2009) states that the researchers' role is to learn how and why things take place in a specific way. Data analysis, according to Kawulich (2004), is a method a researcher employs to support a narrative and its interpretation. During the process, data are organized, reduced through summarization and categorization, and themes in the data are found and connected. Data analysis, according to Mohajan (2018), is a dynamic process that entails fusing together the data that has been acquired, finding themes, and defining key concepts or meaning units, as well as other materials gathered from the literature. In this qualitative study, the contributions made by the participants were analyzed using a qualitative data analysis approach in order to comprehend the significance of the qualitative data (Mohammed, Ragab, & Arisha, 2016). The use of a qualitative data analysis enabled the researcher to learn more about the perceptions and practices of ESD from the participants and acquired a deeper

knowledge of the real teacher perceptions and practices in their classrooms (Mohammed *et al*., 2016). According to Mohammed et al. (2016), there are different types of data analysis approaches: thematic analysis, content analysis, performative analysis, structural analysis, discourse analysis and interactional analysis. Jamieson (2016) states that the most employed data analysis approaches are thematic analysis and content analysis. In the present study, thematic and content data analysis are the strategies used. Large quantities of texts are systematically categorized and coded as part of content analysis with the goal of finding participant use of words (Mohammed et al., 2016). According to Kalpokaite and Radivojevic (2019), there are similarities between content analysis and document analysis. They found that both methods identify themes, patterns and profiles.

Content analysis was an approach used to identify texts that are ESD related concepts in teachers' lesson plans and observation notes. The identified texts that reflected any of the ESD concepts or teachers PCK were highlighted and coded and placed under categories. Data from the exploratory interviews were used to answer the first and third research questions that are based on teachers' perceptions and the influence of their perceptions in their classroom practice and the data collected from the classroom observations answered the second question based on the integration of ESD in their classrooms. Content analysis, according to Kalpokaite and Radivojevic (2019), differs from thematic analysis in that it employs deductive strategies to identify data that will support the existing theoretical or conceptual knowledge, whereas thematic analysis employs inductive strategies to analyse data, resulting in the development of theory.

3.7.1 Thematic data analysis

Creswell (2009) states that the researchers' role is to learn how and why things take place in a specific way. Thematic data analysis is the strategy that was used to analyse data in the present study. According to Braun and Clark (2006), thematic data analysis is a technique for finding, analyzing, and reporting patterns (themes) within data. The theoretical conceptual frameworks and literature research conducted in chapter 2 influenced the themes. As a result, the information gathered for the study was arranged in accordance with pertinent themes that addressed the stated research questions. A

smartphone was used to record the interviews with the teachers. To transcribe the interviews (from an audio to text) an App called Otter was used. The audios and transcripts were saved in a memory stick. The transcripts were sent to the participants to confirm if what is written is what came from them and is expressed the way they intended. This was done to establish authenticity of the results (Hatch, 2002; Creswell, 2009). The data were analyzed thematically as words that come from the participants. The researcher was able to connect and interpret data by recognizing patterns, themes and categories (Johnson & Christen, 2008). A pattern was formed when a word emerged many times in the data and a group of the same words called a theme was formed. The themes were therefore set into categories which established a connection among the information (Creswell, 2009). When themes have been identified, the researcher categorized the information and analyzed the patterns of the information. The themes were prepared and used in the final report. Descriptive field notes were summarized from the classroom observations as well as the lesson plans from the teachers to develop themes and categories. Themes were generated and organized based on the sub-questions of the study to understand teachers' perceptions and practices of ESD in Life Sciences classrooms.

3.7.2 Thematic analysis sequence

According to Maguire and Delahunt (2017), there is a six-step approach to thematic data analysis. The six-steps can be divided into three steps. The first step is where data that includes verbatim and transcription of audio files is compiled. In this step, the researcher familiarised herself with data that were acquired to know and grasp the meaning behind the data collected. The second step is where coding took place. It is whereby the researcher dismantled the data and formed categories. Here the researcher used raw data and identifies themes, codes and concepts. And the last step is whereby the emerged codes from the data were used to form themes. The detailed six-step approach is discussed below and represents figure 3.1.

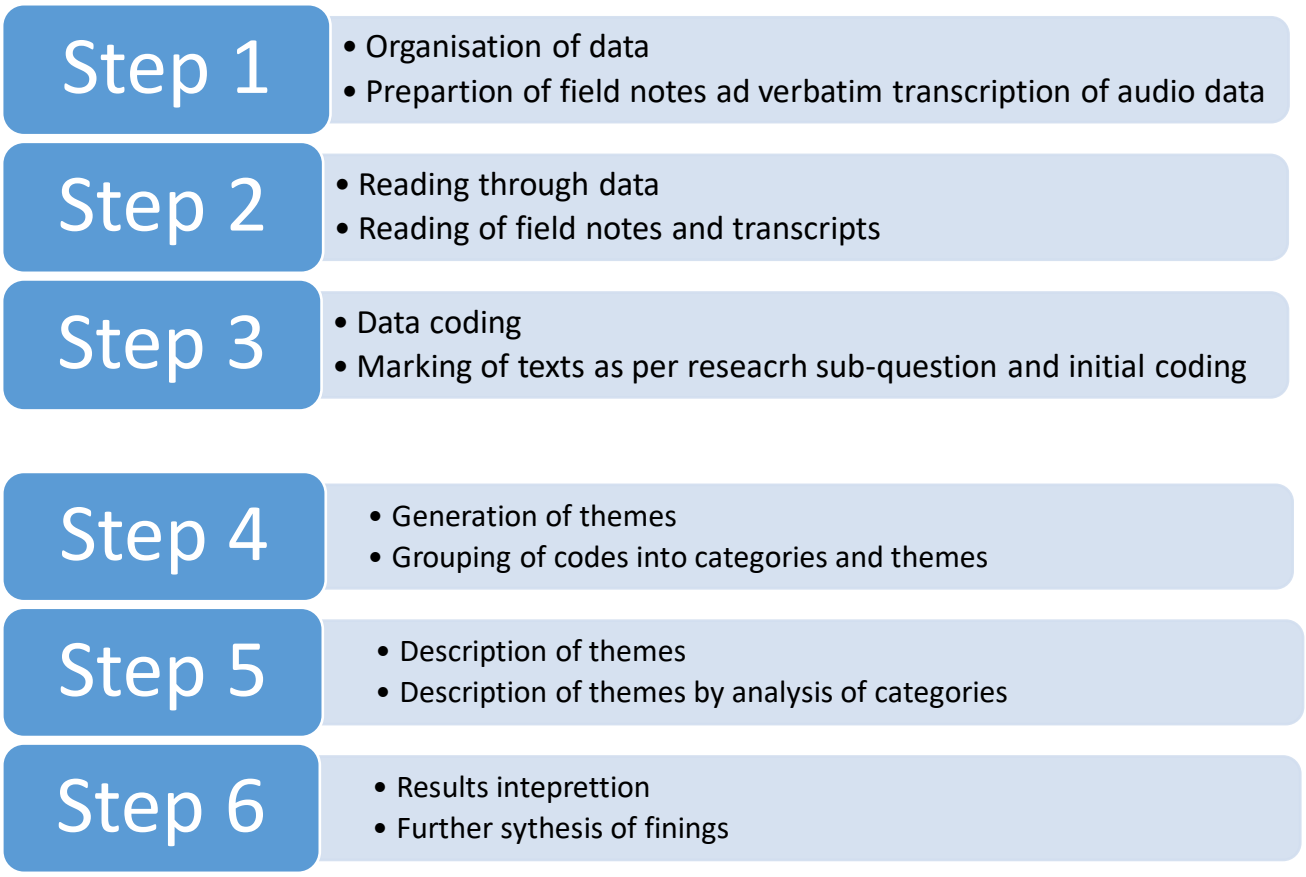


Figure 3.1: Six-step thematic analysis approach. Source: Maguire and Delahunt (2017)

3.7.2.1 Organisation of data

At this stage, the collected data were prepared and organised by the researcher. The audio data from the semi-structured interviews and classroom observations were transcribed into text verbatim (Jamieson, 2016). An app called Otter was used to transcribe the data from both semi-structured interviews and classroom observations of each participant. The field notes of data collected from each participant were typed and read. This was done to for texts and other aspects of editing (Jameison, 2016).

3.7.2.2 Reading through data

The researcher went through each script that had been transcribed in this step in order to interpret the information gathered and understand its overall significance. By observing the similarities and contrasts among data sets, the researcher was able to

create an overall idea of the themes and categories at this point. The researcher took care to read over the data without introducing any personal bias (Jamesion, 2016).

3.7.2.3 Data coding

This step involves the formation of segments of data sets in each script and defines their meanings (Jameison, 2016). The scripts from both semi-structured interviews and classroom observations were highlighted with coloured highlighters into segments and were arranged per research sub-question and each category or theme had its own specific colour. The analysis of the lesson plans yielded more data, and new categories arose, then data were recorded to ensure constant comparison and new themes were developed (Theron, 2015).

3.7.2.4 Generation of themes

The previously defined categories and themes were read, clarified, and given new names in accordance with their primary concepts (Jasmeison, 2016). To help with the main research question, they were then organized into codes that captured the overall essence of each category (Maguire & Delahunt, 2017). The researcher made sure that the themes were relevant to Life Sciences teachers' activities and attitudes of ESD.

3.7.2.5 Description of themes

The themes and categories generated will be discussed in detail in chapter 4. A summary of the themes and categories will be presented in figure 4.2 and table 4.1. During this step, the researcher looked for patterns between themes and used the relevant literature to interpret the data (Theron, 2015). The data collected from semi-structured interviews and classroom observations were combined with data from lesson plans with the aim of finding the link and interaction between the themes and their categories (Maguire & Delahunt, 2017).

3.7.2.6 Results interpretation

The data were analysed with the aim of answering the main research question: What are teacher perceptions and practices of ESD in Life Sciences classrooms? To answer

this question, a further analysis of the findings will be reported in chapter 4 and will be discussed in chapter 5 of the present study (Maguire & Delahunt, 2017).

3.8 VALIDITY AND TRUSTWORTHINESS

Noble and Smith (2015) contend that it's important to assess the quality of all research. According to Mahajan (2018), in qualitative research, the study's reliability and validity are examined to determine its overall quality. The researcher used data collection tools and a methodology for her investigation. To make sure that the questions posed were in line with the purpose of the study, the appendix list includes the semi-structured interview guide and the classroom observation procedure (Kaindume, 2018).

3.8.1 Validity

Validity is described as truthfulness and authenticity by Merriam (2009). In a qualitative study, validity implies the application of various strategies including member checking, peer examination, triangulation of data, and flexibility (Merriam, 2009). Brantley (2009) claims that the validity of a qualitative study aids in establishing a connection between the data and the phenomenon. Researchers who use qualitative techniques present accurate, reasonable, and fair descriptions of the viewpoint of the people who have experienced a specific phenomenon on a daily basis. In a qualitative method, internal validity means the researcher is expected to show that the results are credible from the participants' view (Brantley, 2009). External validity means the power to transpose the results of one study to the other setting (Brantley, 2009; Merriam, 2009).

In the present study, triangulation was used to increase the validity of data interpretations. Triangulation means that two or more methods of collecting data are used to express human behaviour (Cohen *et al*., 2007). According to Honorene (2017), the goal of triangulation is to produce a detailed, informative and balanced picture of the phenomenon under study. In the present study, the researcher employed semi-structured interviews, classroom observations and document (lesson plan) analysis as triangulation to strengthen the study's credibility and build trustworthiness (Mohajan,

2018). The three data collection techniques were used in the study to collect information and answer the research sub-questions. The lesson observations and the lesson plan analysis were used to cross-verify the data collected in the semi-structured interviews. The researcher also used field notes, transcribed observations and teachers' evaluation questions to follow the recontextualization process. The process of validity was ongoing throughout the study. The validation process ensured that the researcher minimises biasness (Mohajan, 2016) and the corroboration of the findings ensured that there were no conflicting findings.

3.8.2 TRUSTWORTHINESS

In a qualitative research, credibility aims to maintain the debate that the findings are "worth paying attention to" (Cuba & Lincoln, 2005: 34). The process by which the researcher presents acceptable, transparent, and appropriate representations of assumptions and data analysis procedures is known as "trustworthiness". According to Nowell et al. (2017) the researcher should ensure that data analysis is conducted in an exact, consistent and thorough manner to establish the study's reliability. I ensured trustworthiness by describing in full the process that will be undertaken to add on the internal validity of the study. Trustworthiness was used in the study to demonstrate that the theme analysis's findings are deserving of consideration (Nowell et al., 2017). In this qualitative study, trustworthiness was assessed using the four connected and interdependent techniques of credibility, dependability, transferability, and conformability (Lemon & Hayes, 2020).

3.8.2.1 Credibility

According to Moser and Korstjens (2018), credibility is concerned with the truth-value part of the qualitative investigation. In the current study, the researcher made sure that the study's conclusions were based on participant data and correctly interpreted as their original points of view (Anney, 2016). Persistent observation, triangulation, and member verification are just a few of the techniques used to assure the validity of a qualitative study (Moser & Korstjens, 2018). In this study, I employed member checking for the credibility of the results. During member checking, participants can give their input on

the accuracy of the interpreted interviews. The member checking process involves participants checking the accuracy of the interpreted data provided in their interview. According to Carlson (2010), member checking is an efficient manner of determining if the data analysis is congruent. It gives the participants the chance to edit, clarify, and elaborate the interpreted themes and patterns that the researcher had recorded. In addition, to ensure the credibility of the study, three data collection tools were used at different times (Moser & Korstjens, 2018). Semi-structured interviews were triangulated with classroom observations and document (lesson plan) analysis (Anney, 2014).

3.8.2.2 Dependability

According to Nowell et al. (2017), the researcher had to make sure that the data analysis was logical, traceable, and well-documented. According to Moser and Karstjens (2018), dependability emphasizes the study's consistency component. All the processes and the phases of research are clearly explained in the study such as the choice of methodology (paradigm), the study design (exploratory case study), research approach (qualitative approach). Furthermore, a detailed explanation of how data was collected using semi-structured interviews, classroom observations and document analysis was provided. Thematic data analysis was also described in detail. By reporting themes that were consistent with the information from the transcripts, the researcher in this study ensured the consistency and dependability of the findings (Hadi & Closs, 2016). The researcher ensured that she avoids any personal influence during classroom observations by not being involved in the planning. The researcher was a non-participant during classroom observation; the participants conducted their normal lessons according to the annual teaching plan recommended by the CAPS document (Jameison, 2016).

3.8.2.3 Transferability

External validity, according to Nowell et al. (2017), refers to the extent to which the study's conclusions may be extended to different contexts, which implies that the work's findings can be used to benefit a larger population. According to Nowell et al. (2016), the results of a qualitative research study can only be implemented on a case-by-case

basis and cannot be generalized to the entire community. In the present study, only three Life Sciences teachers participated, therefore, the findings may not be applicable in other contexts (Jamieson, 2016). The researcher provided all the details of the study methodology to establish transferability by clearly describing the purposeful selection process of the participants of the study (Moser & Korstjens, 2018). The purposeful sampling followed a criterion that was applied uniformly to all the participant teachers that had taught Life Sciences for more than two years and that they integrated ESD in their lessons.

3.8.2.4 Confirmability

Confirmability in a qualitative study indicates that the findings of the study are not biased and have no interest and perspectives of the researcher but rather function solely of the respondents and conditions of the inquiry (Moon, Brewer, Januchowski-Hartley, Adams and Blackman, 2016). In this study, to achieve confirmability, the qualitative research data collection methods that were used were clearly described. In order to demonstrate that the stated findings are solely based on data acquired from the participants who taught Life Sciences, the purposeful sampling technique of participants was thoroughly explained. By ensuring that her findings and interpretations were based on accurate data and contained statements from participants, the researcher further highlighted how the interpretations of the data relate to the conclusions reached (Anney, 2014). Moser and Korstjens (2018) states that confirmability can only be established once credibility, transferability and dependability have been provided.

3.9 ETHICAL CONSIDERATION

In the current study, the researcher made sure to follow guidelines for ethics in order to respect the participants' dignity and publish a thoroughly researched study (Akaranga & Makau, 2016). There was a total of three participants in the study from Phuthaditjhaba, Thabo Mofutsanyana district. Firstly, I began by applying for ethical clearance from the University of the Free State Ethics committee and permission was obtained. Then application was made to the Head of the Department of Basic Education of the Free

State Department (Thabo Mofutsanyane district) to grant me a permit for collecting data from schools. Letters to the gatekeepers of the schools were sent to ask permission to conduct research in their schools and permission was obtained. All selected participants received participation letters requesting them to participate in the study voluntarily.

To establish trust with the participants, they were ensured of anonymity and confidentially. Participants were assigned pseudonyms for confidentiality. The pseudonyms for interview participants were participant 1, participant 2, etc. This anonymity encouraged participants to openly discuss their information and experiences with the research in all honesty and truth (Farrimond, 2017). Participants understood that by sharing their experiences with the researcher will not cause any harm. Consent and agreement forms for participating in the study were supplied to all the participants. All participants signed willing and opted to be part of the study with an understanding that the participation is voluntarily. No data was collected from the learners, only participating teachers were allowed to share their information. According to Parveen and Showkat (2017), there are principles that the researcher should abide by when conducting a study. The principles include respect for participants which relates to advocacy for and the safety of the participants during the entire research process. The researcher ensured that great care was given to the participants when conducting the study and ensured that their rights were not violated. These rights include respecting their religions, values, cultures and economic status (Parveen & Showkat, 2017). Participants were protected as reasonable precautions were made (Akaranga & Makau, 2016). The participants were informed of their ability to decline or withdraw from the study at any time, and their confidentiality was guaranteed. All the data collected from the participants were saved and protected as hard copies were locked in a cupboard while electronic copies were saved in a memory stick and lock with the hard copies in a cupboard. The information supplied by the participants is only accessible by the researcher and the supervisor. Akaranga and Makau (2016) state that participants should be informed about the goal of the study and the advantages of participating. The aim of the study was explained clearly at the beginning of the interviews. The participants knew and understood that there were no financial benefits involved when

they partake in the study to avoid deception. Even though there were barely risks, the researcher made sure that participants were aware of them (Parveen & Showkat, 2017).

The researcher also ensured that no data used in the study is fabricated and falsified; the conclusions made were entirely based on the information provided by the participants (Akaranga & Makau, 2016). To avoid misinterpretations by the researcher, the transcripts were sent to the participants for review and to confirm that what is on the transcripts is exactly what they said and do corrections if necessary. During classroom observations, the researcher ensured that she focuses only on how ESD is integrated in their classrooms. The researcher ensured that the data reported was truthful and avoided data duplication.

3.10 LIMITATIONS AND DELIMITATIONS

3.10.1 Limitations

The present study was a qualitative research approach; as a result, the findings cannot be applied to a larger teacher population as the number of the sampled participants was quite small and unique. Because the study was conducted in Thabo-Mofutsanyane district located in Phuthaditjhaba, three qualified professional teachers with experience in teaching ESD topics in the Life Sciences made up the small sample of participants in the study. According to Mohajan (2018), in order to address bias issues, the viewpoints of the researcher and the participants must be outlined. Since the researcher is also a Life Sciences teacher, to counter the effect of biasness, the data collected were triangulated as three data collection methods were employed.

3.10.2 Delimitations

The first delimitation is related to the interviews that were limited only to qualified professional teachers who had two years of teaching experience or more teaching ESD in Life Sciences classrooms in Phuthaditjhaba. The participants were not limited by age or gender, but the study was limited to only one district. The study intended to understand teachers' perceptions and practices for teaching ESD in Life Sciences using

a PCK framework. Therefore, the study only interviewed three teachers from schools in Phuthaditjhaba. The number of the participants was influenced by the time the data was collected for the study. Cropley (2015) states that in qualitative methods, it is necessary to be in contact with the participants to persuade them to give up their time. The data were collected during the third term of the schools' calendar when teachers are busy with the preparations of the final examinations, as a result, most teachers could not participate in the study while some withdrew. The participants represented Life Sciences in different grades (10-12). All the teachers who participated in the study taught grade 12 hence they could not have enough time to conduct interviews face-to-face but rather suggested that telephonic interviews be conducted when they get home after work.

3.11 CONCLUSION

This chapter examined a qualitative research methodology that was conducted in the study and the significance of this method for exploring teachers' perceptions and practices of ESD in Life Sciences classrooms. Selected participants participated in semi-structured interviews as well as classroom observations and lesson plan analysis for triangulation. The study's data collection was analyzed using a thematic approach. All data gathering instruments that were used are explained clearly how they helped to achieve and answer the research questions of the study.

CHAPTER FOUR

PRESENTATION AND DISCUSSION OF FINDINGS

4.1 INTRODUCTION TO THE DATA

The aim of this chapter is to present the findings and analysis of the data collected. Qualitative data was collected using semi-structured interviews, classroom observations and document analysis (lesson plans) of Life Sciences teachers who taught from grade 10-12 in Thabo-Mofutsanyana district, Phuthaditjhaba. The data was analyzed thematically from the texts that were generated from the participants. The data presented here addresses the following objectives of the study:

- To explore teachers' perceptions of education for sustainable development in Life Sciences classrooms.
- To explore how teachers facilitate education for sustainable development in Life Sciences classrooms.
- To examine how teachers' perceptions of education for sustainable development influences classroom practice.

4.2 DEMOGRAPHICS OF THREE PARTICIPANTS

Three qualified Life Sciences teachers were purposefully selected from three different schools in Phuthaditjhaba. The three selected teachers teach Life Sciences from grade 10-12. Pseudonyms such as P1 (Participant number 1) were used for participants to ensure confidentiality.

Participant P1 was a female teacher aged 58 years old. She is a post level 2 teacher (a Departmental Head of Life Sciences and Life Orientation). She has been teaching Life Sciences for 25 years and has been a Departmental Head for 15 years. She has a BA education degree and a B.Ed honours degree. She is working in a semi-private school located near town and is currently teaching grade 10 and 12 Life Sciences. She also taught Life Orientation in grade 10 and 11 for 5 years in a different school before she was appointed as a Departmental Head.

Participant P2 was a 28-year-old female teacher with two years of teaching experience. She is a post level 1 (PL1) educator. She works in a school located in town that caters for a diversity of learners from different areas. The school caters for grade 12 only (semi-college) whereby only learners who are upgrading or have failed their matric are accepted. The teacher is teaching only Life Sciences and has 5 classes. She has a BA education degree and a B.Ed honours degree.

Participant P3 was a 36-year-old female from a school located in Phuthaditjhaba close to town. She is a newly appointed post level 2 educator PL2 (Departmental Head of Life Sciences) with eight years of teaching experience. She has a BA education degree and a B.Ed honours degree. The teacher is teaching Life Sciences grade 10-12. The school caters for a diversity of learners from different areas.

4.3 THE THEORETICAL FRAMEWORK

The theoretical framework of the study was adapted from Magnusson, Krajcik and Borko's (1999) PCK model for science education and consists of the following five components:

1. Orientation towards ESD in Life Science teaching,

2. Knowledge and beliefs about learners' understanding of ESD in Life Science,

3. Knowledge and beliefs about ESD in the Life Science curriculum,

4. Knowledge and beliefs about instructional strategies for ESD in Life Science,

5. Knowledge and beliefs about assessment of learners learning of ESD in Life Science.

This model enabled the researcher to understand teachers PCK which includes the prior conceptions that are brought to class by the learners, the knowledge of the subject from the teachers, and teaching that develops with time, the attitude and perceptions of

teachers, and beliefs they have towards a subject which affect their teaching (Burgener & Barth, 2018).

4.4 OVERVIEW OF THEMES

The data gathered during the study was examined to see if it would provide adequate information and to confirm if it would answer the research questions of the study. The themes generated from the study to address the research questions are:

1. Teachers' perceptions of ESD in Life Sciences
2. Facilitating ESD in Life Sciences classrooms
3. The influence of teachers' perceptions on practicing ESD in Life Sciences

The themes were then sub-divided into subthemes and categories in order to give a clear description of the data from the findings of the study. The main data source of the findings was from the participants' semi-structured interviews which enabled the researcher to get information directly from the participants to construct meaning from their responses and their experiences. The data presented includes verbatim quotes extracts of documents to give a reader the first-hand experience of the findings. Non-participant classroom observations and lesson plan analysis were also conducted for the purpose of triangulation to provide insight of how teachers integrate the concept of ESD when teaching Life Sciences in their classrooms versus what they have provided in their interview's responses. The data from lesson observations are presented as vignettes pictures that capture episodes of classroom practice.

4.5 SUMMARY OF THE THEMES

Figure 4.1 and Table 4.1 below provide a summary of the themes, sub-themes and categories generated from the data to help understand and get a clear picture of the data collected from the participants of the study.

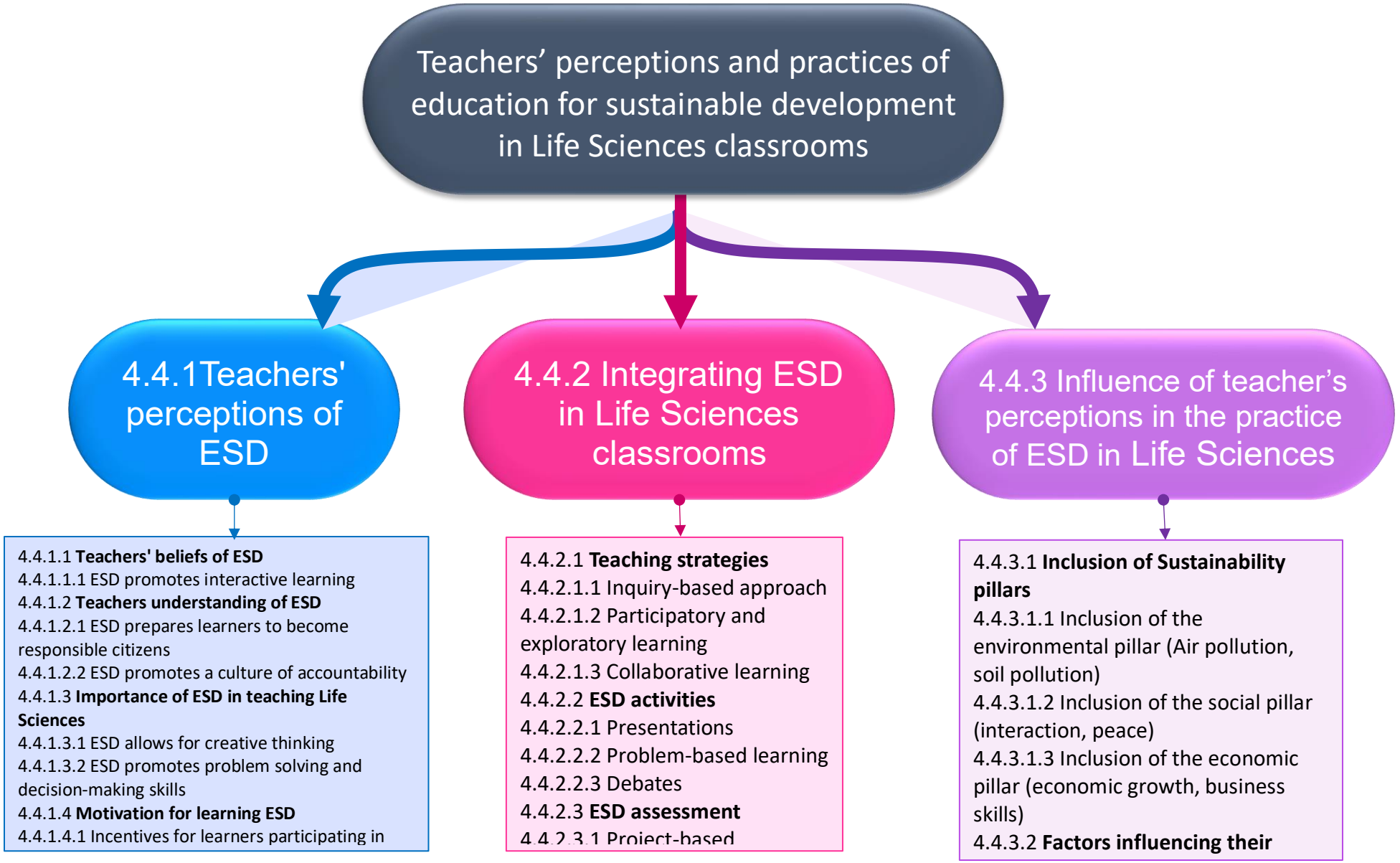


Figure 4.1: Teacher's perceptions and practices of ESD in Life Sciences classrooms

Table 4.1: Research questions and a summary of themes, sub-themes and categories

RESEARCH QUESTIONS	THEMES	SUBTHEMES	CATEGORIES
1. How do teachers perceive education for sustainable development in Life Sciences classrooms?	**Theme1** Teachers' perceptions of ESD	**Subtheme 1.1** Teachers' beliefs of ESD	**Category 1.1.1** ESD promotes interactive learning
		Subtheme 1.2 Teachers understanding of ESD concepts	**Category 1.2.1** ESD prepares learners to become responsible citizens
			Category 1.2.2 ESD Promotes a culture of accountability
		Subtheme1.3 Importance of ESD in teaching Life Sciences	**Category 1.3.1** ESD allows for creative thinking
			Category 1.3.2 ESD promotes problem solving and decision-making skills
		Subtheme 1.4 Motivation for learning ESD	**Category 1.4.1** Incentives for learners practicing in ESD

2. How do teachers facilitate education for sustainable development in Life Sciences classroom?	**Theme2** Integrating ESD in Life Sciences classrooms	**Subtheme 2.1** Teaching strategies-Learner-centered approaches	**Category 2.1.1** Inquiry-based approach **Category 2.1.2** Participatory and exploratory learning
			Category 2.1.3 Collaborative learning
		Subtheme 2.2 ESD activities	**Category 2.2.1** Presentations
			Category 2.2.2 Problem-based learning
			Category 2.2.3 Debates
		Subtheme 2.3 ESD assessment	**Category 2.3.1** Projects-based assessment
			Category 2.3.2 Group assessment
			Category 2.3.3 Concept test

3. How do teachers' perceptions of education for sustainable development influence classroom practices?	**Theme3** The influence of teachers' perceptions in the practice of ESD in Life Sciences classroom.	**Subtheme3.1** 3.1 Inclusion of the environmental pillar of ESD	**Category 3.1.1** Air pollution, soil erosion
		3.2 Inclusion of the social pillar of ESD	**Category 3.2.1** Interaction, peace
		3.3 Inclusion of the economic pillar of ESD	**Category 3.3.1** Economic growth, business skills
		3.4 Factors influencing the integration of ESD	**Category 3.4.1** Lack of teacher development/ support programs **Category 3.4.2** Lack of resources **Category 3.4.3** Time constraints **Category 3.4.4** Annual Teaching Plan (ATP) packed

4.5.1 Teachers Perceptions of ESD In Life Sciences Classrooms

This theme discusses the teachers' perceptions of ESD in their Life Sciences classrooms. Magnusson et al.'s science model was used to discuss teachers' perceptions from the data gathered from the interviews as well as classroom observations.

Figure 4.2 below provides a summary of theme 1 with its subthemes and categories to help understand the theme better.

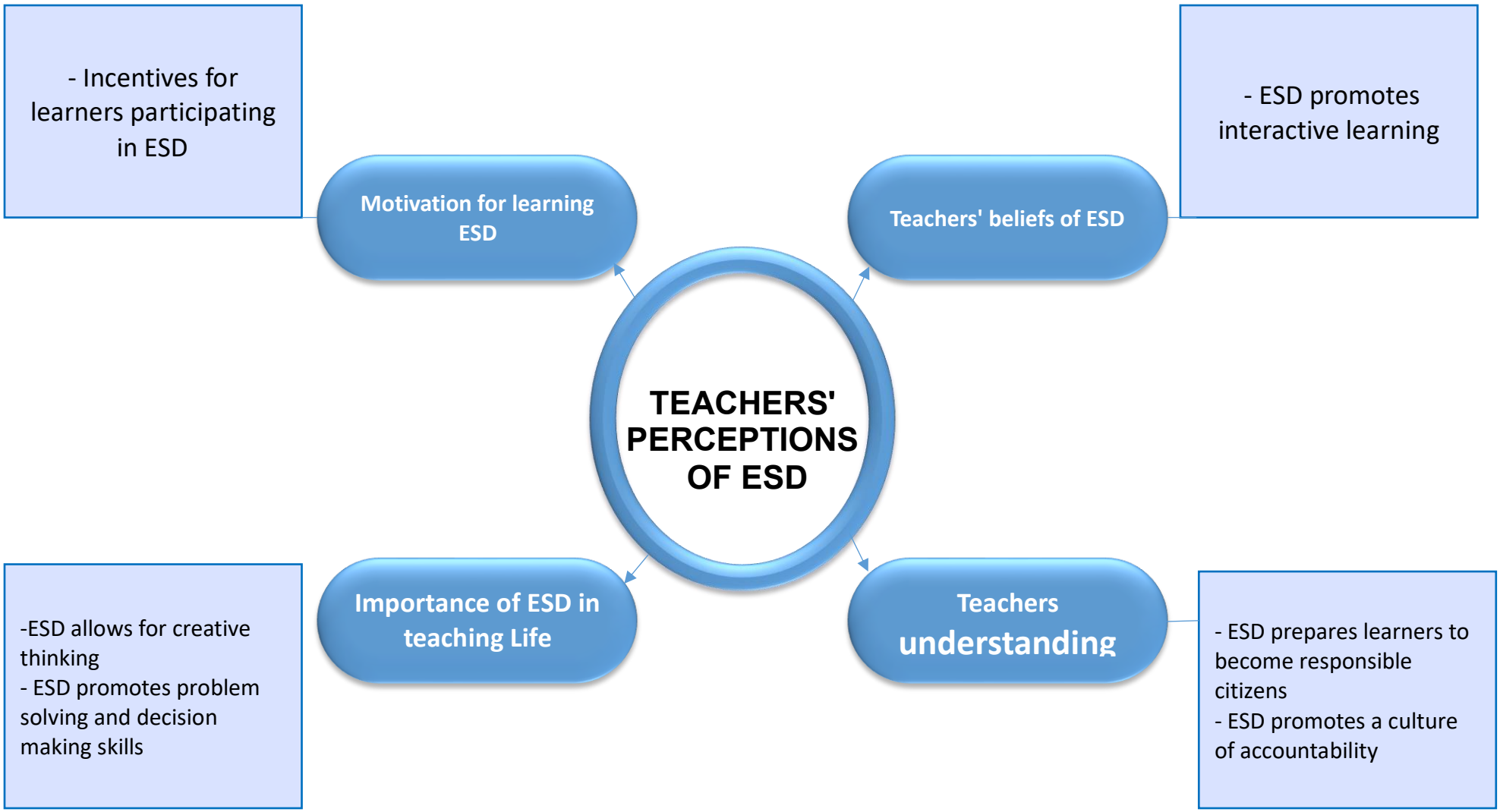


Figure 4.2: A summary of theme 1 with its subthemes and categories to help understand the theme better

4.5.1.1 TEACHERS' BELIEFS OF ESD

4.5.1.1.1 ESD promotes interactive learning in classrooms

Two of the three participants believed that learners learn best when they learn from each other than when they learn from the teacher. Through interactive learning, learners were able to engage with each other through group work, asked each other questions and create solutions on their own. Participant P3 shared

> "*Interactive learn afford learners an opportunity to discuss and share their knowledge with each other as well as their experiences. This helps a lot when they are given challenging situations and have to come up with solutions, you'll find them sharing their knowledge from their communities with each other".*

During interactive learning, learners were grouped by the teacher. Participant P3 ensured that all learners took part in discussions and contributed positively to the lesson by sharing their knowledge. Participants shared that when learners interact with each other through group work or pair work; they share most of their common community challenges and try to come up with the solutions. Participant P1 also had similar views as participant P3 as she said:

> *"uhmm, in my classes, I usually prefer that learners interact with each other by learning on their own through having discussions so that they can contribute their knowledge to the lesson".*

Interactive learning is believed to be an effective teaching and learning method for science subjects as learners get to discover things on their own through inquiry. Additionally, interactive learning supports SDG number 4, which highlights the importance of inclusive, equitable quality education and the promotion of opportunities for lifelong learning for everyone (United Nations, 2018). This shows that when participants teach this concept, they consider inclusivity and equitable access in addition to providing learners with lifelong learning opportunities for all learners through

interactive learning. Both participant P1 and P3 agreed that interactive learning helps learners acquire skills such as working in teams and improve their communication skills.

Participant P1 stated:

> *"Learners benefit a lot from interactive learning because they learn communication skills and get to understand team work better. I always make sure that when learners work in groups all learners are included in discussions by asking them questions and give them opportunity to reflect and respond".*

Participants also mentioned that these interactive teaching and learning strategies inspire learners to act in a way that supports sustainable development. Hence their confidence in learner-centered teaching approaches must be boosted, so that they will be able to inspire critical and creative thinking in their classrooms. The findings are also in line with the findings from UNESCO (2014) and Eilks (2015) that learners should be taught how to actively take part in shaping society to ensure a long-term future.

4.5.1.2 TEACHERS' UNDERSTANDING OF ESD

4.5.1.2.1 ESD prepares learners to become responsible citizens

Participants' understanding of the importance of teaching ESD it to prepare learners to become future responsible citizens. They believed that learners should be able to take responsibility towards their actions. When they were asked about the importance of incorporating ESD in their life sciences lessons, participant P1 shared:

> *"It is very important that learners are taught about ESD since it prepares them to be responsible for their actions. Learners should understand the importance of taking care of their environment as well as the animals"*

Participant P2 also held the same views and said:

> *"The aim of ESD is to ensure that learners are well prepared for their future and are responsible citizens. That is why I think ESD is necessary to teach our*

learners about this concept so that they do not only focus on the today but also think for their future".

Participant P3 also shared:

"I always emphasize in my classrooms that they are the future generation so if they cannot take care of their environment now, they will have nothing in future. Teaching learners about responsibility helps them to understand that the resources we have, should last them long as the future generation. Should they get depleted earlier, they will live their lives struggling due to their actions. They really need to be informed."

Participants' views are the same as that of Schild (2016) as their interpretation is that ESD's goal is to prepare citizens who have the appropriate skills and values to act responsibly, guided by the principles and goals of sustainable development.

4.5.1.2.2 ESD promotes a culture of accountability

When participants were asked about the importance of learning about ESD, they mentioned that it affords learners to learn about the challenges they face in their communities and understand the consequences of their actions, so that they will be able to account for their actions and help each other from making bad decisions. Participant P1 shared:

"In my classrooms I usually teach learners about accountability because they need to be able to account for their actions. This helps them to understand that each decision they take has a consequence whether good or bad. For example, my classrooms are usually clean because I have taught them that they need to take care of their environment so if I find any dirt in the classroom, they will account for it. Same as the school garden, it should be taken care of".

Participants addressed the SDGs by teaching their learners about becoming responsible citizens in their Life Sciences classrooms as they aim to equip learners with

the ability to use the acquired knowledge and skills in everyday life by making informed decisions to improve the quality of life. Participant P3 shared that:

> *"I observe my learners most of the time to see if this concept of sustainability is practiced not only in the classrooms but even during break times outside the classroom. The reason is because they know that they will account for their actions should they not practice it and trust me, accounting is not easy for them, so they just do what needs to be done".*

Participant P1 added,

> *"In my Life Sciences classroom ESD is very important because it is integrated in a way that promotes the culture of accountability on the part of the leaners, provided they don't want to please the people around them because sometimes they do things based on what the other learners think about them. In most cases, they are afraid of coming out and doing what is right".*

Participants are of the view that the goal of the SDGs is to improve the quality of life and ways of achieving a sustainable world. It is also believed that science becomes more relevant to learners' lives when the SDGs are incorporated in their classrooms as it contributes to the achievement of the goals of SDGs.

4.5.1.3 IMPORTANCE OF ESD IN TEACHING LIFE SCIENCES

4.5.1.3.1 ESD allows for creating thinking

When participants were asked about the integration of ESD in Life Sciences, they shared that ESD should not be integrated in Life Sciences only but in all subjects. The main reason for this belief is that all learners should be able to take responsibility for their actions. They need to understand that for every action, there is a consequence. Participant 1 shared:

> "*There must be an integration of this concept in all subjects because if you go to commerce classes, you'll find that they do not care about their environment*

whereas science learners care about their environment. So, if they are not taught about how to take care of their environment, they will destroy it".

The findings from the participants align with UNESCO (2015) where it was suggested that the entire science and technology curriculum as well as other subjects should include ESD, which should be interdisciplinary and holistic and should not be represented as a separate topic. The findings are also in line with the findings from Kavai, Williams and Tsakeni (2022) who also found that lecturers from South Africa and Sweden also believed that ESD is a concept that should be integrated across the school curricula and each subject should play a role in the teaching of ESD.

Two participants believed that the concept of ESD can be incorporated in all the topics of Life Sciences, but one teacher believed that it can only be incorporated in certain topics. Participant P3 stated:

"*I incorporate it more on the topics such as human impact on the environment and human population (grade 11), history of life (grade 10) and negative feedback of the level of oxygen and carbon dioxide (grade 12).*

Participant P1 responded:

"*There can be many topics in Life Sciences where it is integrated, but the one that is outstanding to me is ecosystems where learners learn about the interaction between the living organisms and the non-living".*

Participants have also revealed that the subject of Life Sciences promotes most of the SDG as many of them are incorporated already in the Life Sciences content such as the SDG 2, 3, 4, 6, 12, 13, 14 and 15 (see Appendix) which seem to be the topics existing in Biology as a discipline (United Nations, 2018). These topics include food security, improved nutrition, sustainable agriculture, healthy lifestyles, sustainable water management and sanitation, climate change, sustainable consumption and production of materials, sustainable use of oceans, seas and marine resources, and sustainable ecosystem management (Tsakeni, 2018), this shows that some of the SDGs exist as topics in Life Sciences as a Science subject. However, participants believed that not all Life sciences topics can incorporate the concept of ESD.

Participant P3 shared:

> *"I feel like it is not possible to incorporate ESD in all Life Sciences topics. Yes, most of them even appear as the ESD concepts such as in strand 3 and 4 but as for others I don't think it's possible. I have not even tried because I do not see how possible it is for me to incorporate the concept in some topics".*

The findings are in line with the findings from Kavai et al., (2022) who revealed that some lecturers felt that it was difficult to incorporate ESD into some Biology content as some topics are taught for conceptual understanding. It was indicated that there were some topics in which it would be easy to include ESD while some topics like genetics are difficult to incorporate ESD because they are taught conceptually. It was also noted that with topics like biodiversity and ecology, it is much easier to incorporate ESD.

However, Participant P3's view is different as she suggested:

> *"ESD should be a subject on its own so that all learners can be taught about it and continue to study this concept throughout their careers so that they can realize its impact in their lives".*

This perception correlates with the findings from Kavai et al., (2022:141-142) as two participants from South Africa indicated that "sometimes it is difficult to include ESD in Biology content that focuses mostly on conceptual understanding".

When participants teach Life Sciences, they ensure that learners recognize connections between related topics so that they can gain a comprehensive grasp of life's nature and interconnection. They also emphasized that these connections are formed across grades as participants were able to construct meaning of ESD. The findings are supported by Teise and leRoux (2016) who also agreed that a young nation facing an uncertain future will be unprepared if we simply raise awareness about sustainable development without challenging the economic status quo. Participant P3 stated that:

> "*When I teach the concept, I give them practical examples that they see or live with every day, that are applicable and happening at home not things far from their lives*".

This shows that participants practice transformative learning in which real-life challenges and examples are used. It was observed during classroom observations that teachers do not plan to teach about ESD. This was evident from their lesson plans that there is no planning for ESD when they prepared for their classes. This finding is the same as that of Kavai et al., (2022) that although teachers believe that ESD is more applicable to Life Sciences as a discipline, it was observed that the integration was neither deliberate nor planned for.

4.5.1.3.2 ESD promotes problem solving and decision-making skills

Participants were able to unpack how this concept is related to the topics in Life Sciences and the need for this concept to be integrated in Life Sciences. Although participant P2 has knowledge about this concept, when they were asked about the aim of ESD she mentioned:

> "*Personally, I think this concept is important because having addressed ESD in the lesson afford learners the ability to be aware and knowledgeable about the sustainability challenges that we are currently facing and how we can overcome those*".

Participant P1 also shared the same sentiment as participant P2, that ESD aims to provide learners about the knowledge related to the environmental challenges they encounter as she said:

> "*Basically, the aim is to channel learners in a way that they grow to be responsible generation that cares for their world by engaging towards environmental factors that have bad impact and how we contribute to such. They learn to make the right decisions of their environment*".

While participant P1 also shared the same views that ESD should be taught to learners so that they can have knowledge of how to look after their environment as she mentioned:

> "*I think this must be installed into the learners so that they should learn to take care of their environment. This means that they will be trying to maintain the resources that we have".*

Participants believed that it is important that learners be taught about ESD concepts because as soon as they become aware of the challenges they have in their communities they will also acquire the problem solving skills to deal with those challenges. Participant P2 stated:

> "*I think the aim of ESD is to help us preserve our environment and take care of it, and to ensure that we teach learners about the importance of taking care of the environment. Learners gets to learn about problem solving skills as they get to discuss the issues they face in their communities*".

Participants shared that when ESD is incorporated in Life Sciences learners do not only learn about their environmental challenges but also learn about the safety of the environment so that they can take good decisions of their environment. Participant P3 also shared:

> "*It is important to incorporate ESD in Life Sciences because the things we do today have an impact on the environment so if learners are taught about ESD there will be differences in our environment so that they will start changing their behaviour*"

They have also highlighted the importance for learners to be taught about ESD from primary schools not only in high schools. They believed that good decisions should be taken from an early stage so that they can practice these skills as they grow up. Participant P1 stated:

> *"Actually, learners are supposed to be started at a very early age about this concept so that they learn to make right decisions on their own without being told what to do in different situations".*

This is in line with the findings from Qablan, 2018; Redmann et al., (2018) where teachers also agreed that beginning to teach about the notion of ESD in early childhood education settings, such as primary schools, is critical.

Participants also understood that ESD promotes cooperative skills such as decision-making, critical thinking, and imagining future scenarios. Participant P3 stated:

> "*Learners need skills and knowledge of how to control some of the issues we face and come up with solutions*".

According to Eilks (2015), ESD should foster learners' ability to think critically and solve problems in order to meet the issues and difficulties of sustainable development. The research findings also advised that it should feature participatory decision making, giving learners the opportunity to be involved in the decision-making process.

4.5.1.4 MOTIVATION FOR LEARNING ESD

4.5.1.4.1 Incentives for learners practicing ESD

In order to encourage learners to participate in ESD, participants reward learners who took care of their classrooms as well as their environment. Participant P1 shared:

> "*There must be incentives towards the learners who are trying to make sure that the environment is clean".*

Participant P3 also felt the same way and shared that:

> *"I think we should award those learners who do not litter the environment, who plant trees in the school garden. That will help other learners to see and realize the importance of ESD and would want to take part in taking care of the environment. I was so impressed by this other boy in 2017 I forgot his name; he planted trees in the backyard of the school. Every morning I would see him watering them and when I asked him why he planted the trees he answered that he understands the importance of the trees since they provide us with oxygen so I am trying to ensure that we do not run out of oxygen and he wants to take care*

of the environment. I used to encourage him more by giving him rewards such as money or candies".

Incentives are believed to motivate learners to be more productive and creates the feeling of achievement. Rewards are used to improve learners' achievements. Incentives can motivate learners to become more interested in activities and motivate them to continue their involvement in these activities. Participant P3 also shared:

"Now that I have been rewarding that boy, many learners have joined in taking care of the environment. They have been cleaning up, taking care of the laboratory, working together with the school cleaners in the school yard to pick up papers because they know they will be rewarded but most importantly not doing it for rewards but for our environment, that's how I encourage my learners to participate in ESD activities".

Participants explained that giving rewards to learners shows that their hard work is appreciated. They believed that it encouraged learners to feel better about the work they do which also promotes feelings of pride and happiness.

This section speaks of the knowledge of learners' understanding of ESD and knowledge of ESD in sciences curriculum of the Magnusson's et al science model that was used in the study as a theoretical framework. Different participants' perceptions are discussed about the concept of ESD.

4.5.2 Integrating ESD In Life Sciences Classrooms

This theme captures the integration of ESD in teachers' Life Sciences classrooms. It presents data of how teachers integrate ESD, the strategies and approaches they employ when teaching in their Life Sciences classrooms. The data generated in this theme was dominated by the observation notes from classroom observations and teachers' lesson plans rather than the interviews as some strategies were not mentioned during the interviews but were practiced in their lessons.

Figure 4.3 below provides a summary of theme 2 with its subthemes and its categories generated from the data collected from the participants.

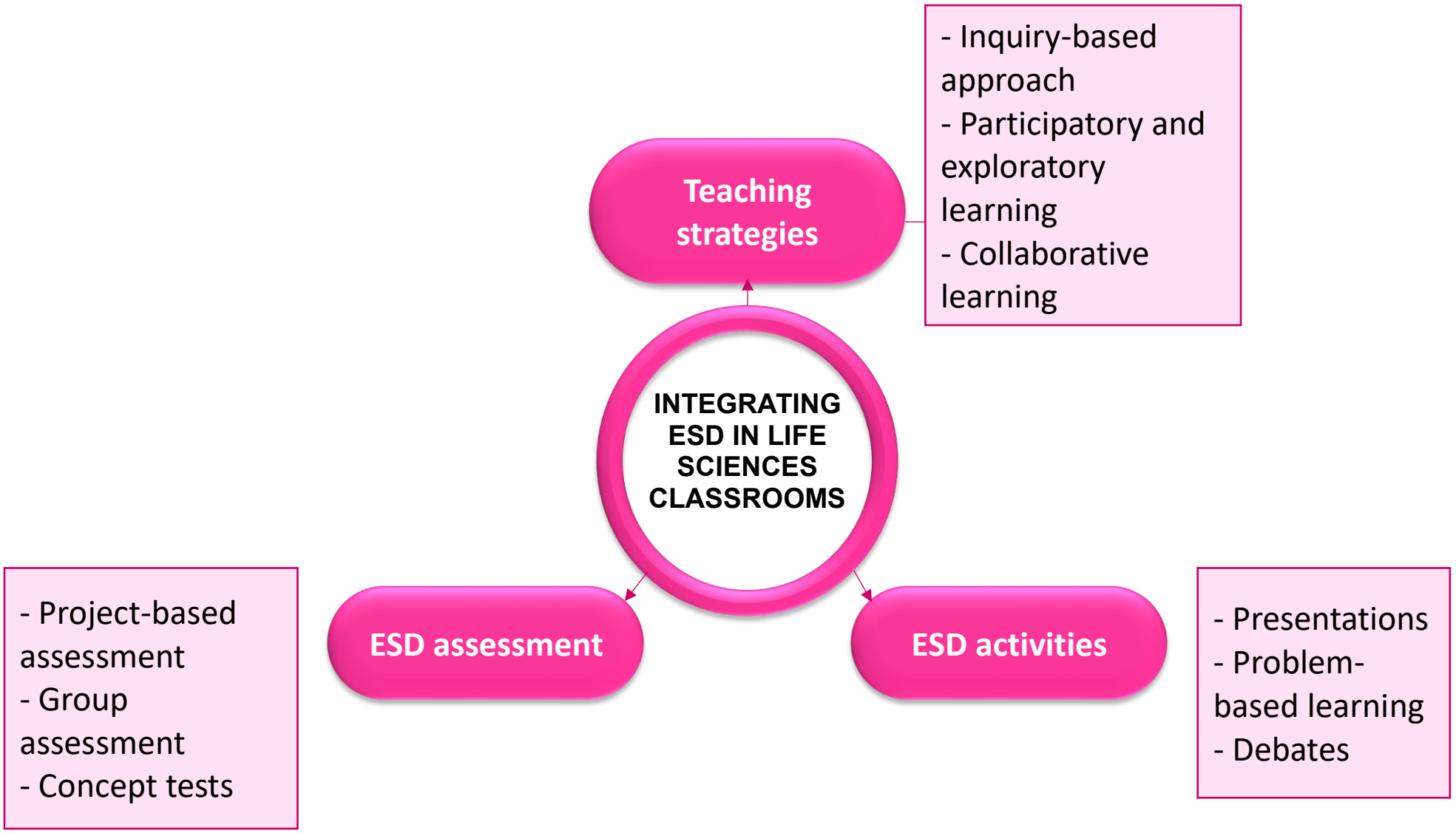


Figure 4.3: Integrating ESD in Life Sciences classrooms

4.5.2.1 TEACHING STRATEGIES

4.5.2.1.1 Inquiry based approach

When participants were asked about the teaching strategies and approaches, they use in their classrooms, it was revealed that they apply different teaching methods when teaching the concept of ESD. But they believed that the best way learners can understand this concept and relate to it is if they are taught in a way that is practical, where learners can participate so that it can relate to their personal lives. Participants believed in constructivism learning which is a learner-centered approach. It is an active approach where learners work independently and in groups where they construct their own interpretations of the information given using their experiences and test the new information against what they already know.

Participant P1 emphasized that:

> *"ESD is a practical concept and the best way for it to make sense to leaners is if they practice it every day".*

Participants mentioned that when they teach their learners, they used approaches such as field trips, outdoor learning, watching videos; they brought materials to classrooms such as newspapers, and charts. Participants used an inquiry-based approach as a stimulus, to find learners' preconceptions of the topic. They thought it ought to be used as a strategy to encourage desire, conversation, and involvement in the classroom.

Participant P3 shared that:

> "*I divide my learners into pairs or groups and give them activities to work on. They usually help each other to answer the questions and if they do not understand they call me so that I can assist them. I have seen them discussing important facts which I believe I wouldn't have explained them better than they do. Interacting with each other helps".*

The participants expressed that this approach led to their learners being enthusiastic and very interested in the subject.

Vignette on participant P3 lesson based on gaseous exchange

It was revealed that participants used open-ended questions to engage learners in discussions in their classrooms. Participants allowed their learners to create their own idea and thoughts and shared them in their classrooms. The observations in the classroom showed that the teachers were able to promote discussions and maintained control of those discussions, where each learner in the classroom had an opportunity to engage with the teacher or their peers.

When participant P3 was teaching gaseous exchange to her grade 11 class, she used an inquiry-based approach for introducing a lesson as she started by asking learners what the cause of air pollution could be.

Participant P3: which two gases are involved in the process of gaseous exchange?

Learner 1: oxygen and carbon dioxide

Participant P3: good. And which gas should be inhaled and which one should be exhaled?

Learner 2: we inhale oxygen and exhale carbon dioxide.

Learner 1: is carbon dioxide really bad to our lungs? During covid-19 we used masks and I though we inhaled it back.

Participant: yes, very bad. Carbon dioxide is a dirty gas which should be excreted from our system. We did not inhale it back. I mean doctors and nurses perform operations in hospitals for hours wearing masks so we can't say they inhale it back.

Participant P3 asked: What causes air pollution and how can we reduce it?

Learner 4: the cars we use

Learner 2: burning coal, we should stop burning coal

Participant P3: that's true. A high amount of air pollution is caused by the burning of fossil fuels as well as the use of transportation. Remember, when we studied the process of photosynthesis, we mentioned that carbon dioxide is a requirement and oxygen is a product. We need oxygen therefore we need to plant more trees so that we can get more oxygen. And stop burning coal; instead we should use replace it with other alternatives such as solar you know and use other modes of transport such as bicycles that will help so much.

Through this introduction of the lesson based on gaseous exchange, the teacher asked learners the causes of air pollution and how to prevent it. She touched on the environmental pillar of sustainability by encouraging learners to plant more trees. She emphasized to the learners that air pollution is caused by human activities such as the burning of coal. She dwelt more on burning coal as the main cause of global warming and as a result this harms our health due to the smoke that we breathe that is not good for our lungs.

Figure 4.4: Teacher assisting learners in groups

When her lesson plan was examined, none of the pillars were indicated including the introduction in her lesson plan. This shows that she does not prepare for ESD. In the interview she mentioned that she preferred that learners be given questions; work on their own to discover answers while teachers only guide them to the correct answers as a teacher who believed that ESD is a practical concept. She gave learners group assignments to work on. The lesson plan shows the plan for the entire topic of gaseous exchange. The lesson observed was based on lesson 8 as an introduction to the process and resources used were all listed in the lesson plan.

TOPIC: Gaseous Exchange			
TERM	3	**WEEK**	3
DURATION	4 hours	**WEIGHTING**	32 Marks (21%)
SUB-TOPICS	• Ventilation of lungs • Homeostatic control of lungs		
RELATED CONCEPTS/ TERMS/VOCABULARY	Inhalation, exhalation, alveoli, ventilation, diaphragm , external-intercostal muscles, diffusion gradient, homeostasis , bicarbonate ions, oxyhaemoglobin, carbhaemoglobin		
PRIOR-KNOWLEDGE/ BACKGROUND KNOWLEDGE			
• Structure of gaseous exchange • Adaptation of ventilation system			
RESOURCES			
Textbook, ATP, Examination Guidelines, Model of breathing system, Charts, Previous Exam Papers			
ERRORS/MISCONCEPTIONS/PROBLEM AREAS			
• Inhalation and exhalation • Diaphragm and diagram			
METHODOLOGY			
LESSON 8 • Explain the following terms: ✓ inhalation ✓ exhalation • Construct a model to show inhalation and exhalation			
LESSON 9 • Use charts and diagrams to demonstrate how gaseous exchange occurs in the alveoli and in the tissues.			
LESSON 10 • Describe the transportation of gases (Oxygen and Carbon dioxide) around the body.			
LESSON 11 • Describe how the breathing rate may be modified to meet the changing needs of the body.			
ACTIVITIES/ ASSESSMENT			
• Describe inhalation and exhalation • Describe the homeostatic control of breathing • Analyse and interpret data on the number of red blood cells and the effect of exercise on breathing/pulse rate			
SUMMARY			

Figure 4.5: Participant P3 lesson plan

4.5.2.1.2 Participatory and exploratory learning

Nikoloski (2017) highlighted that participatory teaching and learning is an appropriate method that is required as it motivates and encourages learners to change their behavior and take action in favor of sustainable development. It was observed that participants in the study also shared the same view that it is only when learners participate in sustainable development will changes in the environment be seen. They believed that learning should not occur in a passive way where learners are being

taught but cannot apply it. Participant P3 also suggested exploratory learning as the best approach as she was taught ESD through exploring. She shared:

> *"I usually come with materials to the class, or most of the time I spend teaching in the laboratory even if we are not going to do an experiment. The reason is that when I teach about the human skeleton, I need the skeletal system to be right next to me so that they can see it and label them and even touch them. I have seen this method working because they see what I am talking about or sometimes I ask one of the to facilitate the lesson as others will be answering the questions asked by the facilitator".*

She added:

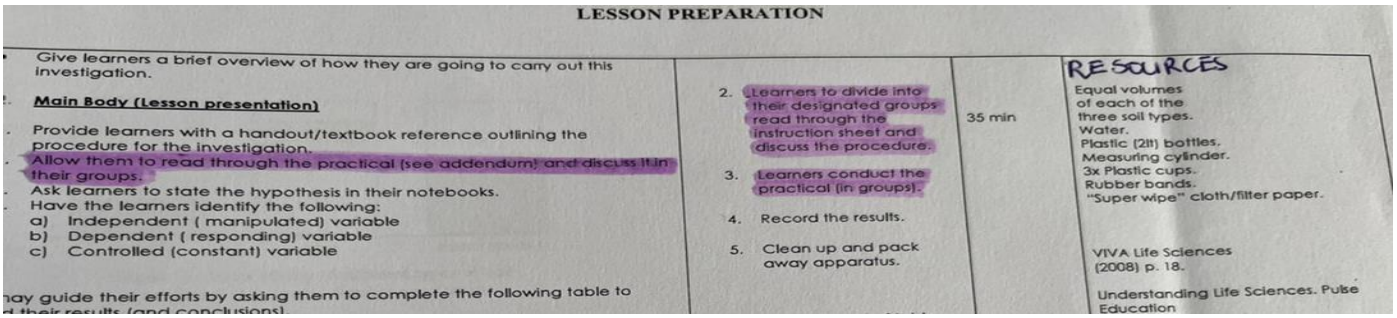
> "*When I was a learner even at university, we used to travel to many different places such as museums, national parks, aquariums and fields to assess the environment and the impact people have on it*".

Participant P2 is also added that is it very important to teach a lesson in such a way that it makes so much sense to them, do practical examples and allow learners to explore for. She said:

> "*My understanding is that when I teach learners, I must teach them a lesson that will have an impact in their personal lives so that they can take care of their environment, so they should be allowed to explore and see what we are teaching them to that they can have a better understanding*".

This is supported by Venkataraman (2015), who stated that approaches which are participatory can be achieved through inquiry-based methodologies, through discussions and group work, as well as experiential learning where they engage with one another and their surroundings. Participants mentioned the skills that learners will learn through the integration of ESD in Life Sciences such as decision-making skills and problems solving skills. The finding is in line with Biasutti (2015), who attested that these teaching methods stimulate behavioral changes as well as changes in how people think about and react to processes as well as knowledge.

The findings also correlate with the findings from Kavai et al., (2022) as participants indicated that it is important to teach ESD through strategies which allow learners to actively participate in constructing the knowledge so that their learning can be effective. They have agreed that the method that works best is through participation so that they apply their knowledge when participating in groups when engaging with each other.



LESSON PREPARATION

Give learners a brief overview of how they are going to carry out this investigation.

Main Body (Lesson presentation)

Provide learners with a handout/textbook reference outlining the procedure for the investigation.
Allow them to read through the practical (see addendum) and discuss it in their groups.
Ask learners to state the hypothesis in their notebooks.
Have the learners identify the following:
a) Independent (manipulated) variable
b) Dependent (responding) variable
c) Controlled (constant) variable

ay guide their efforts by asking them to complete the following table to

2. Learners to divide into their designated groups read through the instruction sheet and discuss the procedure.
3. Learners conduct the practical (in groups).
4. Record the results.
5. Clean up and pack away apparatus.

35 min

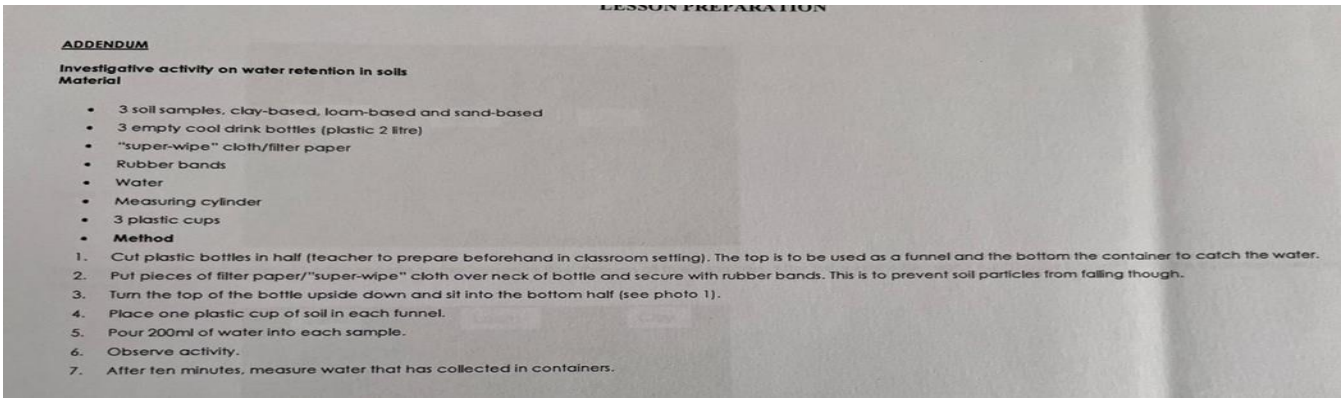
RESOURCES
Equal volumes of each of the three soil types.
Water.
Plastic (2lt) bottles.
Measuring cylinder.
3x Plastic cups.
Rubber bands.
"Super wipe" cloth/filter paper.

VIVA Life Sciences (2008) p. 18.

Understanding Life Sciences. Pulse Education

Figure 4.6: lesson plan showing resources to be used by learners in groups

The lesson was based on the different types of soils, so the teacher was facilitating an investigation of the properties of the soil. It is also evident from the lesson plan that the teacher had planned that learners will conduct the practical in groups. All the resources for the investigation were included in the lesson plan. Exploratory and participatory learning motivates learners to become active citizens, encourages critical thinking, debates, and alternative acts while fostering a sense of democratic citizenship (Gonzales et al., 2020).



LESSON PREPARATION

ADDENDUM

Investigative activity on water retention in soils
Material

- 3 soil samples, clay-based, loam-based and sand-based
- 3 empty cool drink bottles (plastic 2 litre)
- "super-wipe" cloth/filter paper
- Rubber bands
- Water
- Measuring cylinder
- 3 plastic cups
- **Method**

1. Cut plastic bottles in half (teacher to prepare beforehand in classroom setting). The top is to be used as a funnel and the bottom the container to catch the water.
2. Put pieces of filter paper/"super-wipe" cloth over neck of bottle and secure with rubber bands. This is to prevent soil particles from falling though.
3. Turn the top of the bottle upside down and sit into the bottom half (see photo 1).
4. Place one plastic cup of soil in each funnel.
5. Pour 200ml of water into each sample.
6. Observe activity.
7. After ten minutes, measure water that has collected in containers.

Figure 4.7: lesson plan showing method of how learners will conduct the investigation

The lesson plan shows exactly how the investigation will be conducted by learners. It is only when learners are involved in making decisions for their future will they learn about the current issues and the consequences of their actions in the environment. This requires teachers to be very creative and committed and show motivation to their learners. Tsakeni (2018) supports the findings that learners are exposed to experiential learning if educational approaches, such as project-based learning, experimental activities, and investigations, are implemented. It is believed that these teaching methods will help learners acquire ethical principles and responsible citizenship. It is also advised to use place-based pedagogies to introduce learners to the implementation of SD in real-world settings.

Vignette on participant P1 lesson based on the types of soil

Participant P1 presented her lesson on different types of soil, examples of which she brought to class. She sent learners to the school garden to collect their own loamy soil as well. Apparently, some learners found plastic in their soil and asked their teacher about the effect this plastic could have on the plants.

Learner 1: ma'am, we just found plastic in the soil. Were our plants going to be able to grow?

Participant P1: yes, they were going to be able to grow but plastic releases harmful chemicals that could be very harmful to plant.

Learner 2: can we consider this soil eroded since it has chemicals from plastics?

Learner 3: I think we should, the soil is bad already for the growth of our plants.

Learner 2: it shows that the soil is not taken care of. We have been told many times to ensure that we keep garbage away from the garden. It also shows that the soil does not receive enough water and can be considered an eroded soil because we won't be able to plant vegetation on such soil and is not fertile.

Learner 3: the soil can be bad again because of natural processes whereby the topsoil is lost because of the rain

Learner 2: but that is not always the case, somehow, we are the cause of the bad soil.

Participant P1: that's correct; some human activities cause soil erosion, activities such as farming.

Learners: but Ma'am, I thought farming is a good practice

Participant P1: yes it is, but we should practice good farming methods that ensure that the soil is not left vulnerable to erosion but is taken care of at all time.

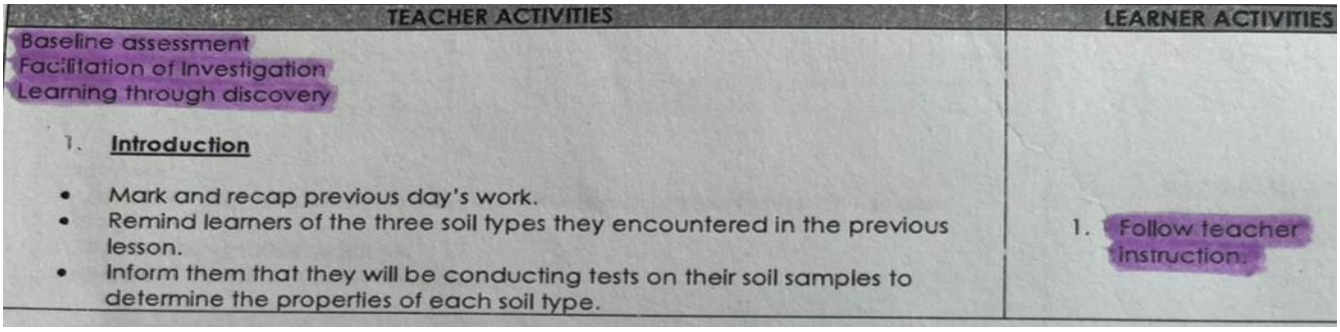
Throughout the lesson, the participant kept on encouraging group members to engage and participate in the lesson by performing this investigation on their own. The teacher in her classroom acted as a facilitator as learners were learning by themselves. She ensured that all learners actively participate in their groups by asking for feedback from each group. She mentioned in her interview that she usually takes learners out of the classroom to their small garden where they plant their vegetation. The intention of the having that garden is to teach learners how to take care of their environment through gardening and encouraged them to sell those vegetables as their business. This lesson of a small garden also teaches them about the economic pillar where learners learn that not everything should be bought. She also mentioned the economic pillar this has taught learners to plant vegetation even at home. She further explained that through selling food from their gardens, they will learn the skill of businesses. This statement was also made by participant P3 when she explained that when it comes to an economic pillar:

> *"I always encourage learners to start their own businesses even at school so that when they finish their matric, they can consider having their own instead of waiting for job employment as the standard of living is too high these days".*

Figure 4.8: learners performing experiments in groups

When the lesson plan was analyzed, participant P1's lesson plan was clear and detailed about her activities that she plans to do in her classroom. It is also clearly stated that

there will be a baseline assessment. The learning approach for this lesson will be learning through discovery and the teacher acts as a facilitator of the investigation while learners follow instructions.



TEACHER ACTIVITIES	LEARNER ACTIVITIES
Baseline assessment Facilitation of investigation Learning through discovery 1. **Introduction** • Mark and recap previous day's work. • Remind learners of the three soil types they encountered in the previous lesson. • Inform them that they will be conducting tests on their soil samples to determine the properties of each soil type.	1. Follow teacher instruction.

Figure 4.9: lesson plan indicating the forms of assessment and orientations to the lesson

Participants believed that learners learn best when they discover things by themselves. Participant P3 mentioned that she preferred to have an outdoor class or a fieldtrip to make learners better understand this concept of ESD. The findings are supported by Schild (2016) who recommends place-based pedagogical approaches as it is believed to change learners' behaviour and their thoughts in everyday life. These methods allowed learners to apply local sustainable development and environmental issues to comprehend global environmental issues. It also indicates that learners will follow the teachers' instructions as the teacher facilitates the investigation.

4.5.2.1.3 Collaborative learning

Participants have indicated the value and the importance of collaborative learning as an approach that is very effective. Participants preferred that learners work in groups for them to understand the concept of ESD. It was also evident from their lesson plans that they value group work. Although participants did not mention more about group work during their interviews, it was evident from classroom observations that it is a strategy that is more practiced in their classrooms. Participant P1 understood that learner-orientated learning provides learners the opportunity to make their own decisions while

learning. Participant P3 also agreed that a lesson conducted by learners is much better than the one conducted by the teacher because ESD is practical. She stated:

> "*It is a very practical concept so it requires that you bring materials to the classroom and show learners, even learners should also come with materials such as papers or crates with soil and plants so that it becomes practical*".

Vignette on participant P2 lesson based on evolution

The lesson was based on the introduction to evolution and the evidence of evolution. The teacher wrote notes of a summary of evolution on the chalkboard. While learners copied the notes, she introduced the topic. She used an inquiry-based approach to introduce the topic as she asked learners questions to get their prior knowledge of the topic.

Participant P2: what is the meaning of evolution?

Learner 1: evolution is the process of the development of different organisms from other organisms

Participant P2: that's good, anyone else?

Learner 2: it is the gradual changes that occur in different species over time

Learner 3: ma'am I think evolution explains how organisms came to being, like how the earth is developed as well as how different species evolved,

Participant P2: well, you are all correct. Evolution is basically the changes in heritable traits of biological populations over successive generations. It is a process that gives rise to diversity.

Participant P2: can you give examples of evolution

Learner 4: natural selection by Charles Darwin

Participant P2: very good. We are going to focus on Darwin's theory of natural selection which is known as the survival of the fittest as well as Lamarckism' law of inheritance of acquired characteristics. On your tables I left examples of species that evolved, and I want you to discuss their changes over many generations. Some groups have peppered moth, finches on the Galapagos island, flightless birds and brightly colored peacocks. You will work in groups or pairs

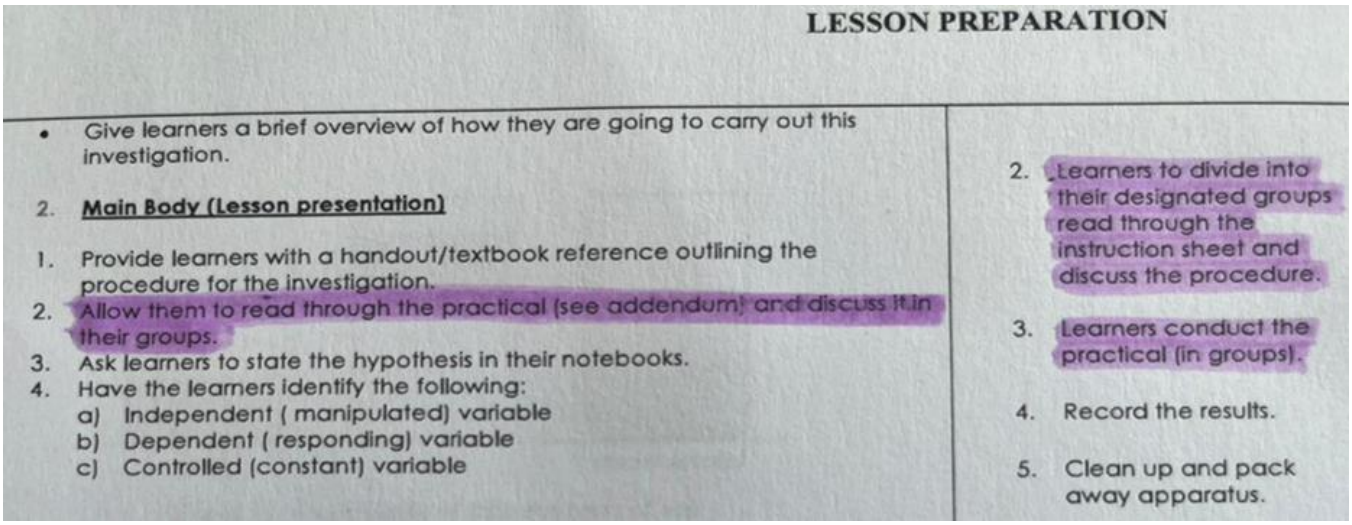
Participant P2 divided learners into groups and encouraged them to work together to

Participant P2 divided learners into groups and encouraged them to work together to discuss and write solutions by themselves. The participant believed that the benefit of this strategy is that all learners get included in discussions and allows every one of them to participate at every stage of the learning process as she was facilitating the lesson. Her positive attitude towards ESD had a positive impact on learners as they enjoyed the lesson and participated with enthusiasm. They have shown that working in groups is a practice of the social pillar where leaners are taught about the importance of participation not only in their classrooms but also in their communities. The participant during the discussions was moving around the classroom asking questions and guiding learners. Participants also believed that group work teaches them about peace and interaction which is an essential part of the social pillar. They also believed that learners also get to be taught about how to reflect on their personal actions individually before they decide in a joint function.

Participant P3 indicated that with experience you get to know the ATP and the assessment guideline by heart such that they get used to how the concept/topics relates to each other as well as the concept of ESD. Therefore, they do not include the concept of ESD when they are planning as their lesson plans does not show any information related to ESD although they successfully practice it in their classrooms. Findings from Kavai et al., (2022) indicate that participants described instructional methods that they used in the classroom as one participant expressed that class discussions could be used as an integrated platform to stir conversations to include ESD issues by encouraging sustainability conversation in every topic.

Figure 4.10: learners working in pairs

Participants mentioned that the benefit of this approach is that learners get to enjoy the learning process as they are encouraged to relate it to their own experiences. They understand the relevance of the lesson by putting new knowledge into practice. Instead of learners memorizing, they learn to think and understand what is required from them and acquire the most important skills. They added that the strategy also helped learners to develop social skills as well as the ability to communicate effectively. In this approach the participant is an active agent, facilitating and guiding the learners to tackle problems and create solutions together. The CAPS document also refers to these abilities as the NCS critical outcomes, stressing the importance of knowledge and abilities like teamwork, critical thinking, communication, and information gathering, application, and evaluation as a means of demonstrating responsibility for the environment and the health of others (DESA, 2018).



LESSON PREPARATION

- Give learners a brief overview of how they are going to carry out this investigation.

2. **Main Body (Lesson presentation)**

1. Provide learners with a handout/textbook reference outlining the procedure for the investigation.
2. Allow them to read through the practical (see addendum) and discuss it in their groups.
3. Ask learners to state the hypothesis in their notebooks.
4. Have the learners identify the following:
   a) Independent (manipulated) variable
   b) Dependent (responding) variable
   c) Controlled (constant) variable

2. Learners to divide into their designated groups read through the instruction sheet and discuss the procedure.
3. Learners conduct the practical (in groups).
4. Record the results.
5. Clean up and pack away apparatus.

Figure 4.11: lesson pan indicating that learners worked in groups

This section of data collected speaks to the knowledge about instructional strategies in ESD as well as the orientations towards ESD of the Magnusson et al.'s (1999) sciences model as the theoretical framework of the study. Different teaching approaches and methods participants used to incorporate the concepts of ESD in their Life Sciences classrooms are discussed and how their learners are orientated towards ESD.

4.5.2.2 ESD activities

4.5.2.2.1 Presentations

Participants preferred that learners do presentations as an activity when learning. This is usually when learners are working in pairs or groups where one learner will be selected to do a presentation. Participant P3 shared:

> *"I encourage my learners to do presentations of awareness about our environments, whereby learners talk about different types of pollutions, talk about how to preserve different species".*

Learner-centered methods include fieldwork, case studies, discussions, role play, reflective accounts, and critical reading and writing activities, as well as inquiry-based learning and experiential learning (UNESCO, 2016). According to the learner-centered

approach, learners are seen as active individuals who contribute their own knowledge, ideas, education and past experiences and in return have an impact on how they learn and take in new information.

Classroom observation of participant P1 after the discussion of the water holding capacity led to the first group that was ready to do a presentation. She mentioned that:

> *"Presentations afford learners an opportunity to interact with the whole class, give feedback on their findings and also, teaches them communication skills because they all get an opportunity to present, it's not always the same person".*

Figure 4.12: learners doing a presentation of the water holding capacity of different types of soils

Participants have mentioned that presentations helped learners learn a topic thoroughly as they will be able to explain in detail their findings with discussions of how they got their results. Presentations also provided learners with presenting skills which is important in the workplace. Most scholars agree that the best ESD teaching approaches are learner-centered (Tomas, Girgenti, & Jackson, 2017), experiential, participatory (Lysgaard & Simovska, 2016), inquiry-based, and transformational (Biasutti, 2015; Biasutti & Frate, 2017; Girgenti, & Jackson, 2017). Hence participants are aware that

teaching ESD principles requires the use of specific teaching methods, such as learner-centered, action-oriented, and transformative-active instruction.

4.5.2.2.2 Problem-based learning

Problem-based learning is one of the effective learner centered approaches that works best in teaching and learning as learners solve real problems and skills they can put in place when they face challenges. When teachers pose a problem to their learners, they think about any challenge that learners face in their communities. The aim of posing a question is to enable learners to develop skills such as problem-solving skills. Learners responded to the problem posed by identifying creative and innovative solutions. Participants have indicated that it is one activity that allows learners to reflect on their communities and think about how they can assist where possible. Participant P1 shared:

> "*I prefer that I give my learners challenges most of the time, like I would pose a problem and ask them to come up with solutions. This is a strategy that has worked for me for years to ensure that my learners learn problem solving skills."*

Posing a problem also enabled them to understand and share their community challenges and think about the solutions for those problems.

Participant P2 agreed that posing a problem enabled learners to be also aware of the situations around them. She said:

> "*When I pose a problem to my learners, I know that they will quickly discuss the solutions with their peers and share with the rest of the class. I heard most of them discussing how they help to clean up their communities by forming youth organizations that collect papers, bottles, boxes and other stuff in the afternoons".*

4.5.2.2.3 Debates

Participants find debates one of the effective learning activities that learners enjoy the most as they have indicated the benefits of this activity such as the skills learners gain from debates. Debates helped learners stay fully engaged with the topic and come out of the debate informed on the issue. They have shared how debates have encouraged most of their learners to participate in ESD activities which led them to taking good care of their environment. Participant P3 shared:

> *"Years back, we used to have competitions for the school garden, and I remember that when we make a rubric we used to check how spacious is the garden and how they take care of their vegetation and how clean it is and if the plants are growing properly".*

She also said:

> *"Those competitions made learners understand that plants are living organisms and needs to be take care of including their environment. Learners learnt about the different types of soils and checked the impact of pollution on the environment and there are winners for good presentations".*

Participant P2 also agreed with what participant P1 stated that debates have made their learning more effective, she said that:

> *"My kids love competitions so much. I think if there's one activity, they enjoy the most is competitions, I know it's because the team that did an outstanding work gets rewarded, they now take care of their environment due to the things they learn when they debate with each other. For example, sometimes I would give them a topic such as the importance of taking care of our environment".*

4.5.2.3 ESD assessment

Participants believed that it is very important to assess learners about this concept or else it will seem useless to teach them about it if they do not get its real meaning and its application in real life. Participant P1 mentioned that after assessment, she believed

that it is very important to reward those leaners who practice the concept in their classrooms. She mentioned that those leaners who lead by example, who pick up papers at schools to ensure that the environment is always clean should be rewarded. This in return will make others want to do the same thing and be rewarded. Although it is important for learners to be taught and understand this concept, participant P3 suggested that teachers should be the first to practice it in and outside their classrooms so that they can lead by example. The participants stated that it is useless for learners to be taught the concept when it cannot be practiced.

Participant P1 stated:

> "*Assessment ensures that the information was transferred to the learners and also assessment itself is assessing the level of understanding by the learner*".

Because she believed that this concept is practical, she also added that by going to the school yards they will have their own gardens to take care of and be given marks based on how they are taking care of them.

4.5.2.3.1 Project-based assessment

According to the participants, giving learners projects helped them to interact with their environment in many ways. Participants give learners projects related to ESD so that they can learn more about the pillars of sustainability. Participant P2 states that:

> *"I think when it comes to the environmental pillar, I'm really doing justice because most of the projects I give to my learners are more related to it especially with when it comes to the environmental studies. I have been giving my learners projects where they must collect resources and materials from their communities for those specific topics such as abiotic factors and I am always impressed with the things they bring along to the school. They also collect papers so that they can be recycled in one of the companies to make toilet papers. They are not aware that through these projects they are cleaning and saving our environment".*

Participants mentioned that projects are very helpful such that those learners struggling with a certain topic can associate with others and learn from them. Participant P3 said:

> *"When I give them projects, I usually expect them after three weeks or so because they know I'm expecting everybody to take part. Most of our learners come from good families so they do not struggle with resources when it comes to projects, so I ensure that I group them in a way that accommodates others. Projects sometimes forces them to meet up at home or do the work after school hours because or lesson periods are too small, I cannot give them time to do them in class, but I believe projects are effective assessments techniques teachers should use to assess their learners".*

4.5.2.3.2 Group assessment

Participants have also highlighted how easy it is to assess learners in groups compared to individually. The expectation from group work is that learners work together on a specific task and help each other. Participant P2 stated:

> *"When learners are given a group assignment, I'm expecting them to get good scores because they will combine their brains and explain to each other where they do not understand. I believe that working in groups makes it easier for them to come up with solutions and argue if the answer is not correct".*

Participant P1 also mentioned:

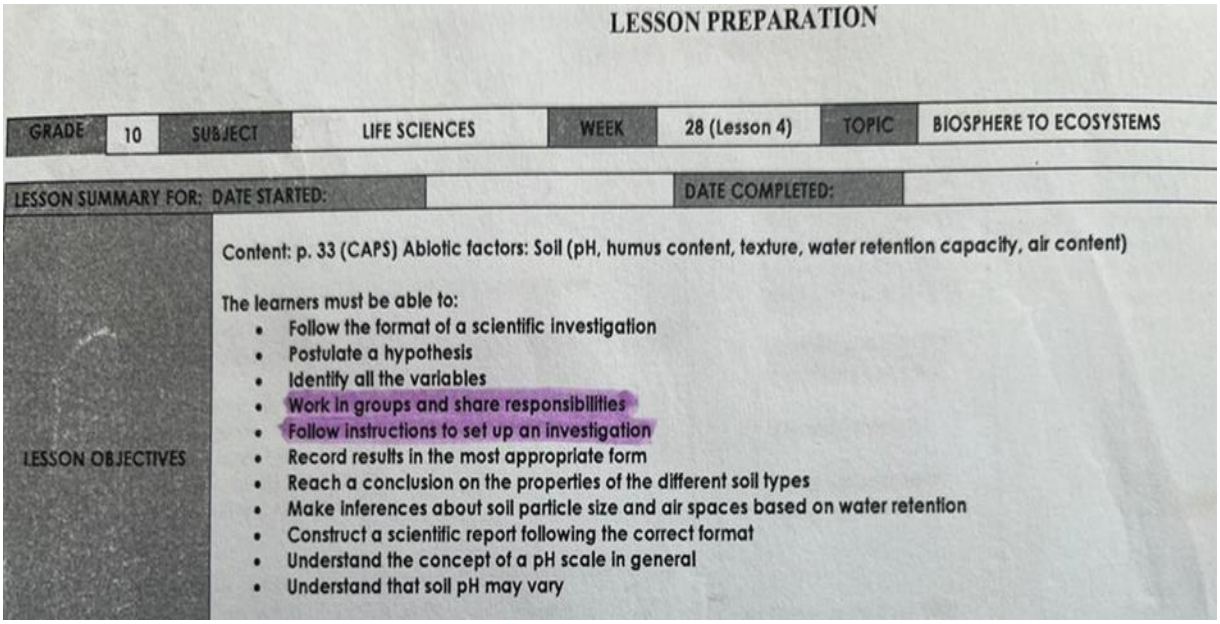
> *"Working in groups help as learners develop a sense of ownership when working with their peers and provide feedback to each other and learners are able to make adjustments and improvements and changes on what they understand".*

Group assignments allowed teachers to assess learners in groups so that they can work collaboratively and receive a common grade and feedback as learners are divided into groups according to different levels of learners' understanding. Participants believed that when they work in groups, learners get motivated and develop skills such as

teamwork and communication skills. Learners working in groups were able to plan and manage their time and be able to work with understanding through discussions and explanations. The aim is to encourage learners to contribute to group interactions, share knowledge and promote learning at group level.

Participant P1 added:

> *"I like that when learners have group assignments, they can hold each other accountable. At the end of the assignment or project, they are required to write who contributed what on the task so that they know they should all participate. So, they learn how to delegate roles and responsibilities as they understand that they will be graded for that task so they are all responsible for that score.*



LESSON PREPARATION

GRADE	10	SUBJECT	LIFE SCIENCES	WEEK	28 (Lesson 4)	TOPIC	BIOSPHERE TO ECOSYSTEMS
LESSON SUMMARY FOR: DATE STARTED:				DATE COMPLETED:			

LESSON OBJECTIVES

Content: p. 33 (CAPS) Abiotic factors: Soil (pH, humus content, texture, water retention capacity, air content)

The learners must be able to:

- Follow the format of a scientific investigation
- Postulate a hypothesis
- Identify all the variables
- Work in groups and share responsibilities
- Follow instructions to set up an investigation
- Record results in the most appropriate form
- Reach a conclusion on the properties of the different soil types
- Make inferences about soil particle size and air spaces based on water retention
- Construct a scientific report following the correct format
- Understand the concept of a pH scale in general
- Understand that soil pH may vary

Figure 4.13: lesson plan showing lesson objectives

Lesson objectives were clearly stated and included the social pillar that learners will work in groups and share responsibilities.

4.5.2.3.3 Concept tests

Concept tests according to the participants are an effective way of checking if teaching occurred especially when learners apply what they were taught individually. Participant P3 stated:

> "*I give them different forms of assessments, could be formal or informal tests, presentations, debates or observe them during break if they do practice the concept of ESD they were taught in class*".

Participants emphasized the importance of including formative and summative assessments. The findings are the same as the findings from Kavai et al., (2022) that lecturers give their students formative and summative assessment, out-of-class activities as well as projects.

Participant P2 believed that concepts tests are more effective than group work assessments because learners here are usually assessed individually with no help from the others even though learning might have occurred in groups. Participant P2 said:

> *"It is best to give learners activities to assess and see if really, they understood the topic that was taught. I really love setting and giving them tests, mostly informal test to evaluate their understanding and if they do not, they can be given more time on the topic".*

Participant P2 also said:

> *"Short tests provide me with quick feedback regarding the learners understanding of the concept that was taught in classroom and to track their progress and identify areas that needs more attention".*

Participants also believed that concept tests are summative assessments because they require more dedication, time and preparation compared to other forms of assessments but are important for assessing learners individually.

This section speaks to the knowledge about assessment of learning ESD of Magnusson's et al.'s (1999) science model as a theoretical framework of the study. It discusses the different activities participants give to their learners to assess the concept of ESD as well as different assessment forms they give to their learners to ensure that they understand and enjoy the concept of ESD.

4.5.3 The Influence of Teachers' Perceptions on Practicing ESD In Life Sciences Classrooms

This theme discusses the influence of teachers' perceptions on practicing ESD in Life Sciences classrooms. The incorporation of the three sustainability pillars is discussed fully in this section as well as the challenges that teachers have regarding the integration of ESD in their Life Sciences classrooms. Figure 4.16 below gives a clear summary of theme 3 together with its subthemes and categories to help understand the theme better.

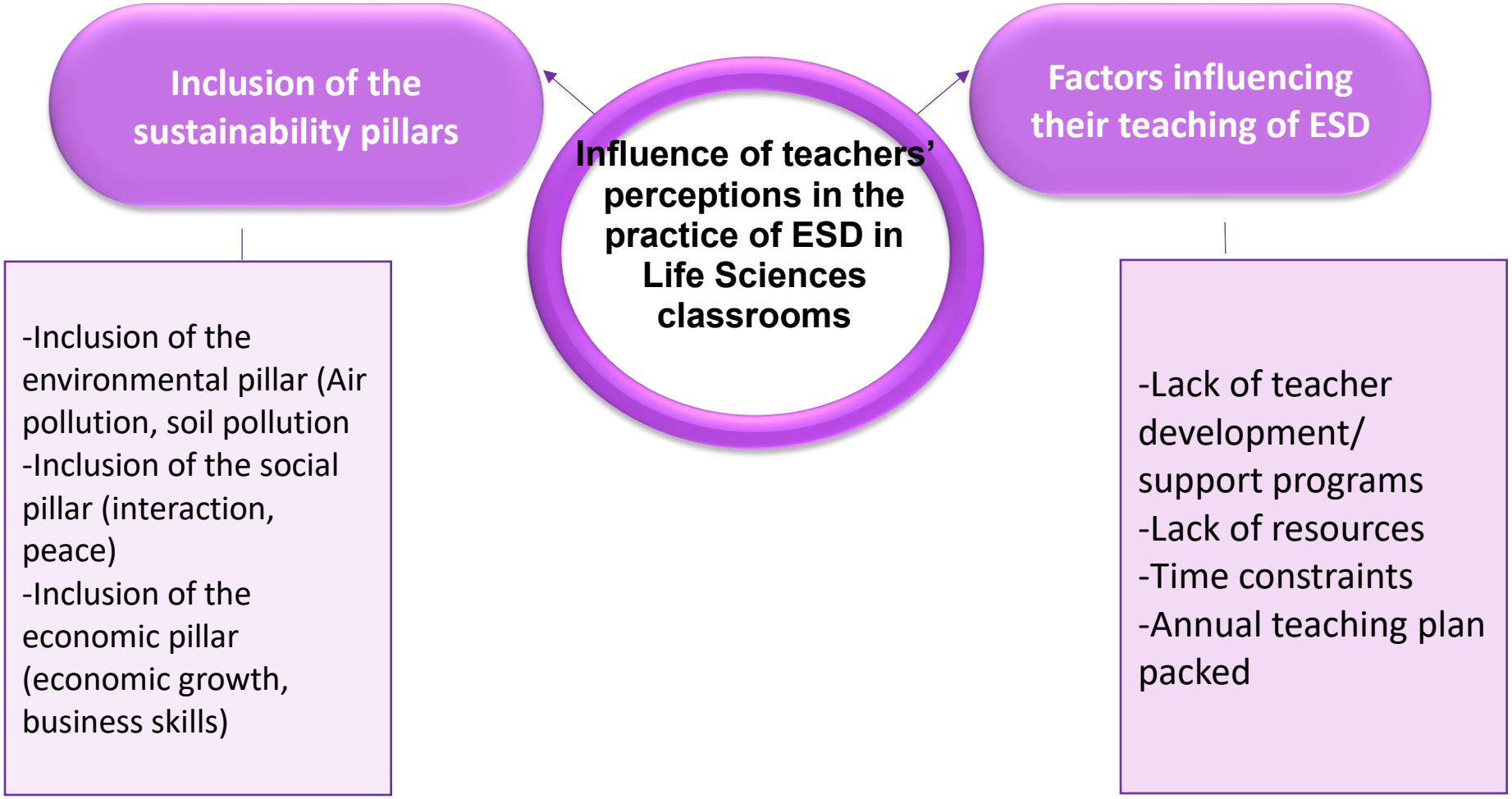


Figure 4.14: Influence of teachers' perceptions in the practice of ESD in Life Sciences classrooms

4.5.3.1 Inclusion of the sustainability pillars

Participants have good perceptions of ESD and are willing to practice it and two of the three teachers were able to practice it successfully in their classrooms. It is believed that teachers' perceptions influence their teaching. Findings from Burgener and Barth (2018) also revealed that teachers' perceptions about ESD influences how they prepare and teach their learners for the future.

When participants were asked about their knowledge of ESD, they mentioned sustainable development as an important concept before focusing on their perspectives and experiences with ESD. They explained how important it is to understand sustainable development first before incorporating ESD in Life Sciences classrooms. The interviews revealed that participants have good perceptions about ESD and believe that it is a very important concept that learners need to be taught about. Participants' knowledge of this concept as well as their beliefs about this concept is good.

4.5.3.1.1 Inclusion of the environmental pillar

The most well understood and practiced sustainability pillar is the environmental pillar. Participants understood the importance of the environmental pillar and the reason it seemed to be the most incorporated pillar in most Life Sciences content than the other two pillars. Participants shared that the most important pillar is the environmental pillar. Participant P3 shared:

> *"The environmental pillar of sustainability is the most important pillar according to my understanding because it is the one that is incorporated more in Life Science topics".*

Participant P1 shared the same views as participant P3:

> *"Topics in strand four, the environmental studies, such as biosphere, biomes, ecosystems, biodiversity, population ecology and human impact on the environment present an opportunity to integrate all the three sustainability pillars"*.

Participant P1 acknowledged that she needs more development on the environmental pillar than the other pillars because she feels it is the biggest pillar as she stated:

> "*I think when I study the environment; the environment accommodates all other pillars because if our environment is our primary concern, then there won't be any sustainability at all".*

This finding is in line with that of Purvis et al (2018), who commented that the environmental pillar is the biggest pillar and more practiced than the other pillars. The environmental pillar seemed to be the most practiced than the social and economic pillars. Participant P1 emphasized that there is no sustainability without the environmental pillar as there is a relationship between the three pillars which is in correlation to Wanamaker (2018) who also attested that the biggest pillar of the three is the environmental pillar which also connects the other pillars. Participant P2 also mentioned:

> *"I think when it comes to the environmental pillar; I'm really doing justice because most of the projects I give to my learners are more related to it especially with when it comes to the environmental studies. I have been giving my learners projects were they have to collect resources and materials from their communities for those specific topic such as abiotic factors and I am always impressed with the things they bring along to the school. They are not aware that through these projects they are cleaning and saving our environment".*

There seemed not to be a balance between the three pillars when they incorporated it in their classrooms. Participants confessed that there are many topics in Life Sciences that incorporated sustainability issues as a way of implementing ESD. However, participants were not confident about the incorporation of the three sustainability pillars simultaneously in their classrooms.

Participant P2 commented:

"*I honestly need to be developed on the three sustainability pillars altogether*".

However, she felt the environmental pillar is incorporated in most topics of Life Sciences when she is teaching such as the human impact in the environment, ecosystems and population growth.

Figure 4.15: learners interacting with the environment (collecting soil)

Participants always defined sustainable development from a point of the environmental pillar because when asked about their understanding of sustainable development, their responses were based more on the environmental pillar and the social pillar to some extent. It was also observed that out of all the pillars, the environmental pillar is integrated more in Life Sciences than any other pillars. This implies that the environmental pillar is more supported by the topics under the ecological dimension of the Life Sciences curriculum as the ecological dimension is based on the ecosystems which consists of biotic and abiotic factors and the life supporting systems. The aim of the ecological dimension is to promote conservation of the ecosystems. This leads to

learners having positive attitudes towards environmental sustainability which improves their knowledge and leads them to being responsible future citizens.

4.5.3.1.2 Inclusion of the social pillar

When participants were asked about the social pillar of sustainable development, they mentioned that learners need to be taught about the importance of participation in their communities as well as decision making. When participants have an opportunity to integrate the concept of ESD, the social pillar is discussed when they talk about resource security to promote, maintain and restore access to basic resources such as food and land. Participant P1 stated:

> *"Learners needs to acquire the skills of participation especially in their communities so that they can take good decisions that will benefit them in future".*

Participants also mentioned that it is necessary to empower learners to act in order to improve their health and environment; and to achieve healthy and sustainable societies.

She added:

> *"Learners needs to understand their human rights and practice them of course with together with their responsibilities, they should understand the importance of equality, safety, access to basic resources and community engagement like I have mentioned that they need to participate in their communities".*

Participants promote the social pillars in their classrooms by ensuring learners take part in conversations or decision-making exercises about how to conserve natural resources.

Participant P2 mentioned:

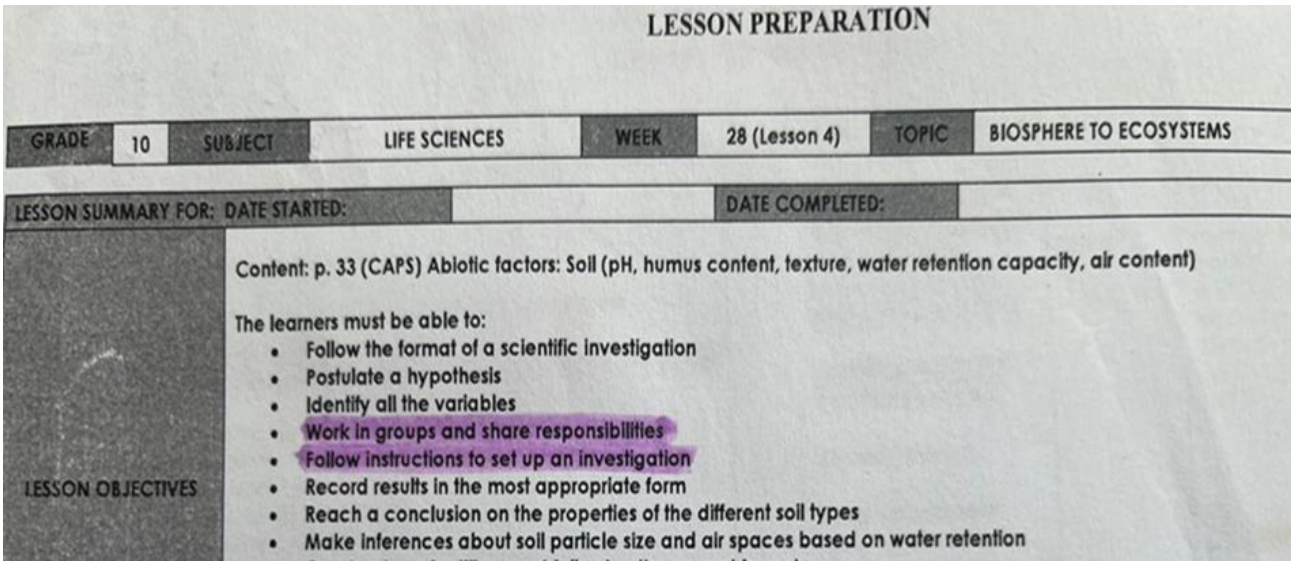
> *"I think when I divide learners into groups, I am actually practicing the social pillar of sustainability. I think it is important that learners learn the skill of socializing. It is only when they share that they learn from each other. I need them to learn about diversity and volunteerism especially in their homes".*

The social pillar is also integrated by engaging learners in school and community projects to learn about how to participate in their communities such as being involved in creating solutions to the challenges their communities face.

Participant P3 shared:

> *"I'm always encouraging my learners to participate in community programs whereby youth have discussions on how to clean their community, you know those community programmes".*

Participants have indicated through their teaching approaches that they promote the social pillar in their classrooms through group work so that learners get used to working together, sharing ideas and engaging in discussions.



LESSON PREPARATION

GRADE	10	SUBJECT	LIFE SCIENCES	WEEK	28 (Lesson 4)	TOPIC	BIOSPHERE TO ECOSYSTEMS
LESSON SUMMARY FOR: DATE STARTED:				DATE COMPLETED:			

LESSON OBJECTIVES

Content: p. 33 (CAPS) Abiotic factors: Soil (pH, humus content, texture, water retention capacity, air content)

The learners must be able to:

- Follow the format of a scientific investigation
- Postulate a hypothesis
- Identify all the variables
- Work in groups and share responsibilities
- Follow instructions to set up an investigation
- Record results in the most appropriate form
- Reach a conclusion on the properties of the different soil types
- Make inferences about soil particle size and air spaces based on water retention

Figure 4.16: lesson plan showing objectives where learners will work in groups and share responsibilities

The practical work that was also performed by participant P1 also presented an opportunity to integrate the environmental and social pillars as learners were required to

examine the quality of the soil and the impact of human activity on the soil before they started with the experiment.

Figure 4.17: learners working in groups of 5 and the teacher facilitating the discussions

4.5.3.1.3 Inclusion of the economic pillar

The data gathered shows that the economic pillar is the pillar that is less practiced compared to the other two pillars. It was evident in this study that integrating the economic pillar is a challenge, but it can only be achieved when discussing the cost of living in grade 10 environmental studies and the economic growth in the grade 11 human population. The findings from Tsakeni (2018) also revealed that the opportunity for integrating the economic pillar is not explicit. However, participants also believe that it can be implied from other pillars such as in the topic of environmental studies.

Participant P1 indicated that the idea of having a school garden presents an opportunity to integrate ESD. She stated that:

> *"You help learners develop a small garden and make sure that you teach them to take care of it every day. This is going to teach learners that even if I'm not employed, if I take care of the garden, it can feed me, it can bring an income into my house".*

Although she indicated that learners consider gardening as a punishment, she strongly believed that learners get to learn about their environment, how to take care of it as well as other natural resources and their families. Learners also learn about the skill of business when they get to sell vegetation from the garden which presents an opportunity for an economic pillar.

Participant P3 indicated that:

> *"I only address the economic pillar of sustainability when I talk about how expensive the cost of living is in the current age. Learners should be aware that with time, most things won't be affordable, so they need to work hard"*

Participants were aware of ESD and had a thorough understanding of the three pillars of ESD, but they do not seem to understand how they are interrelated. This finding correlates to the findings of Borg et al., (2014) whose study found that teachers are aware of how the three elements of ESD are relevant, but do not have a holistic grasp of it. Participant P2 also mentioned:

> *"I have no idea how the economic pillar is integrated as I did indicate that I need development in all the three pillars of sustainability"*

Several surveys have also found similar results, indicating that most teachers grasp the ideas of SD, however the environmental approach is the most widely recognized. The environmental challenges presented by the chemistry curriculum, according to Tsakeni (2018), present potential for integrating social, civic engagement, and educational objectives and less of the economic pillars into teaching and learning. This implies that the challenge of incorporating the economic pillar is not faced only in Life Sciences but

also in other subjects. Participants have noticed that the economic pillar of sustainability is not visible compared to the other two pillars in the subject of Life Sciences. This means that only two dimensions of ESD, environmental and social, were clearly visible.

Only one participant P1 seemed to understand how the three pillars connect but also emphasized that the environmental pillar is the biggest pillar there she believed that she and other participants could be more equipped with the knowledge of the environmental pillar, then other pillars will fall into place.

4.5.3.2 Factors influencing their teaching i.e., Barriers to teaching ESD

When participants were asked about the challenges they face when teaching this concept of ESD, they mentioned that the biggest challenges that they face in their Life Sciences classrooms is lack of knowledge of the concept due to lack of teacher development programmes, lack of resources, time constraints (timetables packed) as they felt that ATP channels them.

4.5.3.2.1 Lack of teacher development programmes

Participants lacked the knowledge of the concept of ESD which leads to the difficulty in integrating it successfully in their Life Sciences classrooms. Participant P2 stated very clearly that:

> "*I personally do not integrate the concept of ESD in my lessons because I am a little bit under knowledge about ESD concept".*

These findings correlate to those of Maidou et al. (2019) where it was revealed that there is a shortage of skilled and knowledgeable teachers for ESD principles in science instruction. Their findings also revealed that many science teachers are not trained as science teachers, which leads to insufficient knowledge, a lack of key parts of science, and a lack of exposure to effective learner-centered teaching. Howlet et al. (2016) are of the view that teachers' attitudes have an impact on their lack of understanding and awareness of ESD. This is primarily due to a lack of comprehension of the ESD concept's uniqueness, as well as teachers' lack of conceptualization of ESD in the

classroom practice. Despite the inclusion of general ESD concepts in the curriculum, learners still don't comprehend how sustainable development should confront socio-political, economic, and environmental dynamics.

Participant P1 shared that:

> *"I need more developmental programs on this concept of ESD in order for me to fully implement it. The department needs to organize these programs because this concept is important as it prepares the upcoming generation."*

Uitto & Saloranta (2017) also support the findings that teachers who lack experience, confidence, and general pedagogic content understanding usually use rote learning, expository teaching, and maintain strong control over classroom activity.

Participants shared that the reason they do not have sufficient knowledge about this concept is because they were not trained/taught enough about this concept as a result, they feel the need for development.

Participant P2 also added that:

> *"We were not trained or taught enough about this concept from the university that is why I feel that we lack in it and cannot integrate it the way we should".*

The findings are also supported by Riekmann et al. (2018) that it is necessary to have teacher training in both the university setting and on the job in the form of continuous professional development to enable appropriate implementation of ESD at all levels. The findings from Gonzales et al. (2020) also support these findings that their interdisciplinary character is truly a challenge for many educators.

Not only do they lack knowledge but also the strategies or appropriate method they would employ in their classrooms and the findings which are in line with those of Karaaslan and Teksoz (2016). Their findings also confirmed that teachers lack the necessary expertise and skills to incorporate ESD with the use of transformative teaching and learning methods. The inability of school based ESD to encourage critical thinking among learners, according to Dzerefos (2020), is due to teachers' weak and

limited knowledge base and information about their practices, instructional methodologies, and understanding of ESD.

Participants suggested that development is needed for them to be fully equipped with this concept of ESD. Participant P3 shared:

> *"I think teachers need workshops where they will be trained about how we can teach ESD or how to incorporate it in classrooms and be given time and also specialize with it. I think it will help a lot*".

Participants therefore suggested that there should be workshops where district officials will be involved as well as the subject advisors of different subjects. The findings from Lombard (2015) also indicated that there is a shortage of adequate professional teacher education programmes in the South African context that stimulate critical and creative thinking. Cordina and Mifsud (2016) in their study also found that many teachers' lack of knowledge of sustainability issues is related to a lack of proper training during their studies. Participants also shared that not only do they lack knowledge of this concept; they also lack motivation to practice it. Participant P1 stated:

> *"We have never been motivated to practice this concept, not from any content workshops we have been attending so far".*

Workshops are important and are required to overcome the challenges of implementing ESD in South African schools which may include Life Sciences content workshops and subject advisors' interventions in teaching and learning of Life Sciences.

4.5.3.2.2 Lack of resources

Participants have indicated during the exploratory interviews that the challenge they have is lack of resources which hinders them from practicing the concept of ESD. They have mentioned that the concept of ESD is more practical and requires teaching approaches that will allow learners to explore and practice it in their classrooms. They have indicated that as much as they understand the importance of ESD they do not have enough materials to teach the concept. Participants shared that it is important that

when ESD is being taught, learners should explore and do things practically. But due to lack of materials and resources, their lessons are more passive which makes it hard for learners to relate the concept to their personal lives.

Participants have indicated that the best approach to teaching ESD is when learners are engaged and participate in a lesson but lack of resources as a challenge hinders the integration of ESD. Participant P3 shared that,

> "*Some of the things we just do them theoretically, we do not have them. For example, we usually tell learners about the melting of ice glaciers but we do not have it here and mention that it is in Antarctica*".

Hence participants believed that it is very difficult to teach learners without resources because they cannot relate to what you are teaching about except via their textbooks. Lack of teaching materials does not only make the teaching difficult for teachers, but makes learners not enjoy the concept as stated by participant P3 that,

> "*I try to make practical examples that learners can relate to, that are applicable to their everyday lives so that they can enjoy the lesson".*

Participant P3 indicated that when she was taught about ESD they used to go on fieldtrips and excursions but now she is unable to take her learners for such activities because the school does not have funds. Participants also believed that lack of functional laboratories in their schools is also a hindrance because if they had laboratories with resources, they would facilitate the integration of ESD where learners will get to explore on their own compared to a classroom setting as participant P2 stated:

> *"The challenge I face in most cases is that the information most of the time is outdated and we do not have labs that are functional as well*".

This suggests that participants do want to practice the concept of ESD, but lack of resources contributes to the difficulty of integrating ESD. Participants also shared that the teacher education was not adequately preparing teachers for the incorporation of

ESD in their classrooms. Participants believed that for them to effectively integrate ESD in their classrooms it also depends on their learners' attitudes.

Participant P3 also shared:

> "*The problem we face in schools is that we treat it as if it's just theory. Life Sciences should be taught in a lab not in the classroom because we are talking about life and science so the conceptual factor is that we teach it in the classroom. Even the practical part of Life Sciences is not practical but its theory because we do not have equipment's and materials. Even our learners are getting used to doing practical's in a way that we do theory and that makes them have negative attitudes towards the concept*".

Hence all their lessons are carried out in their classrooms and only sometimes outdoors.

4.5.3.2.3 Time constraints

Participants P1 and P3 indicated that time is one of the challenges that hinders them from integrating ESD. They have mentioned that the integration of ESD requires a lot of time especially if they want to incorporate all three sustainability pillars simultaneously during their lessons. They have also indicated that even if they try to use different approaches to teaching ESD such as outdoor lessons, to prepare for such lessons takes time. Participants shared that their school timetables last from 07:00 hours to 14:45 hours and sometimes there are unplanned activities such as assembly that lasts longer, which reduces their teaching time.

Participant P1 shared:

> *"We only have eight hours of teaching, any other time is extra time which is also not enough because we have some activities the school participate on which mostly are unplanned so they take most of our time".*

They mentioned that their periods are 50 minutes at most and sometimes less depending on days of the week (such as on Thursdays for sports) so it is not enough to practice ESD while teaching a certain Life Sciences topic. Participant P3 shared:

> "*The challenge I face is that ESD and Life Sciences has a lot of content, but the time is never enough*".

She also complained that:

> "*Even the practical part we are given an hour so you as a teacher will have to decide that 30 minutes will be for theory and the other 30 minutes will be for practical which is not enough*".

Although they felt they are incorporating ESD when they teach it is not enough because time limits them. Participant P3 shared that usually when she decides to do outdoor learning, it usually takes about two to three days. Even after those days, she felt she did not do justice to the curriculum as some topics could not be done in details or in a satisfying way. Hence, they complained that time does not allow them to integrate ESD when teaching as a result they suggest that it should be a subject on its own where it will be allocated a time to be taught to all the learners. Participant P1 indicated how packed her timetable is. She shared:

> *"As a departmental head, I am expected to have a maximum of 5 classes but i have 6. This makes it harder for me to give myself and my learners enough time to practice this concept of ESD. I believe that if I had more free periods for admin work, I would have been able to spend more time with my learners especially with their garden as I am the one responsible for it".*

She mentioned that lately she has been using hours after 14:45 to check on their garden.

4.5.3.2.4 Annual Teaching Plan

Participants have complained that the Annual Teaching Plan (ATP) they are provided by the Department of Basic Education has limited them on what to teach in their classrooms. They felt that the ATP channels them too much on how each concept should be taught, for how long, and which method to use and as a result it becomes a challenge of integrating ESD. Participant P1 expressed that:

> *"If the ATP allowed us an opportunity to integrate ESD, we would definitely practice it daily in their classrooms but the time allocated for each topic in Life Sciences is very much limited and makes it very hard for us to explore other concepts".*

They have relied too much on an ATP such that it becomes a challenge to even take learners on to the field trips because most topics seems to be class based according to the ATP whereas they also want to explore other approaches. Participant P3 shared:

> "*It is hard to know how to teach a certain topic in the classroom because there is a gap between theory and practical in Life Sciences. Even the pacesetter does not accommodate the practical part*".

It was also evident from their lesson plans that the concepts of ESD are not included although they seem to practice them in their classroom such as when participant P1 was asking learners to identify the causes of soil erosion which was not mentioned in the lesson plan. It is very obvious that participants were unable to relate their subject matter and concepts of critical issues to the advancement of society. This is in line with Kavai et al., (2022) that lecturers have also highlighted that as much as they believed that ESD can be integrated in most Life Sciences content, there are no policies that inform them how the integration could be implemented. They have indicated that the integration of ESD is possible, but time is always limiting them.

4.6 SUMMARY OF THE DATA

Participants were aware of the concept of ESD and understood the importance of this concept being integrated in the Life Sciences classrooms. It was revealed that participants have good perceptions and attitudes towards ESD and apply different strategies to ensure that learners understand the concept and can relate it to their personal lives and apply it in their everyday practices at home and at school. It was also revealed that the opportunity of integrating ESD in Life Sciences is mostly through the environmental pillar as it is more understood by participants and incorporated in most of the topics in Life Sciences.

4.7 CONCLUSION

The data collected described the teachers' knowledge of and experiences with ESD. Data revealed that participants' have good attitudes toward integrating ESD, despite their inadequate awareness of ESD theory, pedagogy, possible resources, and classroom materials. It was also revealed that the opportunity to integrate ESD in Life Sciences relates to the environmental and social pillars and to a lesser extent the economic pillar. Approaches such as inquiry-based learning, exploratory and active learning are used to integrate ESD in Life Sciences and are practiced ensuring that learners understand the concept. Different forms of assessing ESD concepts were also discussed. The most common challenges described by the participants was lack of knowledge of this concept, access to resources that will enable them to deliver lessons more dynamically, not enough time as the Life Sciences ATP is packed and does not allow them to integrate other concepts but only channels them to teach what is mentioned there to have a bigger effect on the learners they teach.

Data presented speaks to the Magnusson's et al.' sciences model as a theoretical framework of the study. The first theme discusses knowledge and beliefs about learners' understanding of ESD in Life Science and the knowledge and beliefs about ESD in the Life Science curriculum. The second theme captures the data related to the

orientation towards ESD in Life Science teaching as well as knowledge and beliefs about instructional strategies for ESD in Life Science. The third theme discusses the knowledge and beliefs about assessment of learners learning of ESD in Life Science.

CHAPTER FIVE

FINDINGS AND RECOMMENDATIONS

5.1 INTRODUCTION

The aim of the study was to explore teachers' perceptions and practices of Education for Sustainable Development in Life Sciences classrooms. This final chapter of the study begins with the summary of how the study was conducted. The summary of the main findings and their significance as well as the findings in relation to the theoretical framework adapted in the study are also discussed. The discussion of the findings and the interpretations are linked to the literature reviewed in chapter 2 and the procedures and methods of data that were collected and analyzed are linked to methods described in chapter 3 of the study. The objectives of the study are aligned to the themes generated from data collected to answer the research questions. The last part of the chapter discusses the limitations, implications and recommendations of the study. The recommendations made in the study are based on the challenges that participants face for the integration of the concept of ESD.

5.2 SUMMARY OF THE RESEARCH STUDY

The study explored teachers' perceptions and practices of ESD in Life Sciences classrooms. The study unveiled teachers' perceptions of ESD, the different strategies and methods they employ when integrating ESD in their Life Sciences classrooms as well as the influence of their perceptions of ESD in their classrooms. According to Lombard (2015), it is important for Life Science teachers to possess adequate and sufficient knowledge of how to incorporate the concept of ESD so that they can contribute to learners' understanding, which depends on the teaching strategy that the teachers use to effectively present scientific principles. To explore teachers' perceptions

and practices of ESD, a qualitative approach was employed (Ronoh, 2017). A qualitative approach was suitable for collecting data on individual participant and document their perceptions and practices of ESD using a single exploratory case study design (Creswell, 2008). The study design provided an in-depth exploration of "what" and "how" ESD was implemented in the Life Sciences classrooms (Creswell, 2009). For this exploratory case study, extensive and in-depth data were gathered using semi-structured interviews, non-participant classroom observations, and document analysis (lesson plans) (Harrison et al., 2017).

The aim of the study of study was to answer the main research question: What are teachers' perceptions and practices of ESD in Life Sciences classrooms?

To answer this main research question, three research sub-questions were formulated. Table 5.1 below shows the sub-questions as well as the relevant instrument used to collect data.

Table 5.1: Research questions and instruments used to collect data

Research questions	Research instrument
How do the teachers perceive education for sustainable development teaching in Life Sciences?	Interviews Document analysis (Lesson plans)
How do the teachers facilitate education for sustainable development in Life Sciences classroom?	Interviews Classroom observations Document analysis (Lesson plans)
How do the teachers' perceptions of education for sustainable development influence classroom practices?	Interviews Classroom observations Document analysis (Lesson plans)

Table 5.1 listed all the sub-research questions and the instruments used to collect data. Individual interviews were conducted as primary data collection instruments with participants telephonically. Classroom observations were also conducted to validate teachers' practices of ESD integration in the classrooms. Lastly, document analysis of

lesson plans was also conducted to analyze participants' lesson plans to see how they plan to integrate the concept of ESD in their classrooms.

The findings of the study will be discussed in the next sections. The data were collected from three Life Science teachers based in Thabo-Mofutsanyane district in Phuthadithjaba who taught grades 10-12. The results collected from the semi-structured interview, classroom observations and lesson plan analysis were combined to produce a full, triangulated explanation of ESD integration in the Life Sciences classrooms.

5.3 KEY FINDINGS AND THEIR SIGNIFICANCE

5.3.1 Teachers' Perceptions of ESD in Life Sciences Classrooms

5.3.1.1 Teachers' beliefs of ESD

Participants shared different perceptions of ESD in Life Sciences. They believed that ESD promotes interactive learning where learners can interact with each other during the lesson while learning instead of passive learning where the teacher is the one who mostly does the teaching. Participants perceived ESD as a concept that prepares learners to become responsible citizens. They expressed that through ESD learners will be able to make good decisions about their environment and take part in contributing positively towards it. They also said that ESD promotes a culture of accountability for learners' actions. Participants also perceived ESD as a concept that allows for creative thinking and promotes problem solving skills in Life Sciences. They opined that learners who take part in ESD should be rewarded so that other learners can see and learn from them that practicing ESD is a good thing.

Participants P1 and P3 shared the same sentiment that learners learn best when they learn from each other rather than when they learn from the teacher. They believed that when they interact with each other they share some of the information the teachers might not share with them. During interactive learning, teachers divided learners into groups where they were able to engage with each other, ask each other questions and create solutions on their own. Interactive learning ensured that the teacher interacted

with learners while learners interacted with each other in the form of groups or pairs. Participants shared that when learners interact with each other through group work or pair work; they usually share most of their common community challenges and try to create the solutions. The findings are also in line with the findings from UNESCO (2014) and Eilks (2015) that learners should be taught how to actively participate in shaping society in order to ensure a long-term future.

5.3.1.2 Teachers' understanding of ESD

Participants expressed that it is important to teach learners about the concept of ESD as it prepares them to become future responsible citizens. Participants shared that learners should be able to take responsibility for their actions and believed that learners need to be informed about their actions as every action has a consequence. Participants shared the same views as Schild (2016) as they have articulated that the main goal of ESD is to prepare citizens who have the appropriate skills and values to act responsibly, guided by the principles and goals of sustainable development. Hence it is essential for Life Science teachers who apply ESD in their classrooms to recognize possible orientations of science teaching that accommodate the objectives of ESD and develops citizens who acquire knowledge regarding the environment and be able to deal with sustainability issues that the country is facing.

According to Kioupi & Voulvoulis (2019) sustainable development ensures that people understand the composite features and man-made environments developing from the interactions among biological, social, cultural, economic and physical views. It enables people to participate in environmental management and resolve sustainability issues. Participants said that it is important for learners to learn about ESD because it affords learners an opportunity to learn about the challenges they face in their communities and understand the consequences of their actions, so that they will be able to account for their actions and prevent each other from making bad decisions. Participant P1 shared that in her classrooms it is very important for learners to learn about accountability. She believed that learners need to understand that for every bad action they do, they need to be accountable. She mentioned that it teaches them to be responsible so that they do not repeat the same mistakes repeatedly. According to Hylton (2019) and Saner et al.

(2019), the 17 SDGs are intended to defend environmental integrity by addressing climate change and protecting ocean and land ecosystems, promote cooperation between various social actors, foster a climate of peace, and ensure responsible consumption and production. Participants expressed that the goal of the SDGs is to improve the quality of life and achieve a sustainable world. Hence participants believed that Life Science is more relevant to learners' lives when the SDGs are incorporated in the classrooms as they contribute to the achievement of the goals of SDGs.

5.3.1.3 Importance of ESD in teaching Life Sciences

Participants believed that the integration of ESD allows for creative thinking hence ESD should not be integrated in Life Sciences only but in all subjects. The main reason for this belief is that all learners should be able to take responsibility for their actions and should acquire creative thinking skills. They mentioned that all learners, not only sciences learners, need to understand that for every action, there is a consequence. Participant P1 shared that even learners who are studying commercial subjects should be taught about how to take care of their environment because if they are not aware of their environment, they will destroy it. The participants' views are the same as those of UNESCO (2015) who suggested that ESD should be interdisciplinary and holistic and should be incorporated in the entire science and technology curriculum and other subjects and should not be represented as a separate topic. Participants believed that all learners have the right to learn about ESD and should be able to think positively about their environment. As future generations, they need to be prepared and acquire creative thinking skills. The findings are also in line with the findings from Kavai, Williams and Tsakeni (2022) who also found that lecturers from South Africa and Sweden also believed that ESD is a concept that should be integrated across the school curricula and each subject should play a role in the teaching of ESD. Participant P3 shared a different view and suggested that ESD should be a subject on its own and should be compulsory where all learners will study it because it has so much impact and should continue to study this concept throughout even at university level.

Participants P1 and P3 believed that the concept of ESD can be incorporated in all the topics of Life Sciences but participant P2 believed that it can only be incorporated in

certain topics. The findings are the same as those of the United Nations (2018) that most of the SDGs are incorporated in Biology as a discipline. These topics include food security, improved nutrition, sustainable agriculture, healthy lifestyles, sustainable water management and sanitation, climate change, sustainable consumption and production of materials, sustainable use of oceans, seas and marine resources, and sustainable ecosystem management (Tsakeni, 2018). However, participants also believed that not all Life Sciences topics can incorporate the concept of ESD. The findings are in line with the findings from Kavai et al., (2022) who revealed that some lecturers felt that it was difficult to incorporate ESD into some Biology content as some topics are taught for conceptual understanding.

Participants indicated that there were some topics in which it would be easy to include ESD while some topics like genetics are difficult to incorporate ESD because they are taught conceptually. It was also noted that with topics like biodiversity and ecology, it is much easier to incorporate ESD because most SDGs exist as topics in the stream of ecology. Participants also mentioned that when they teach ESD in the Life Sciences classrooms, they ensured that learners recognize connections between related topics so that they can gain a comprehensive grasp of life's nature and interconnection. They also emphasized that these connections are also formed across grades.

Participant P3 stated that it is very important to give practical examples when teaching so that learners can relate it to their everyday lives. Participants are willing to practice transformative learning in which real-life challenges and examples are used in their classrooms. This was evident from their lesson plans that there is no planning for ESD when they prepare for their classes. However, during lesson observations, teachers practiced the concept of ESD. This finding is the same as that of Kavai et al., (2022) that although teachers believed that ESD is more applicable to Life Sciences as a discipline, it was observed that the integration was neither deliberate nor planned for.

Participants believed that it is important that learners be taught about ESD so that they can be aware of the challenges their communities face and will also acquire the problem-solving skills to deal with those challenges. Participant P2 stated learners should be assisted in achieving a sustainable world by preserving the resources we

have and taking good care of their environment. They need to be engaged in community discussions so that they can also contribute as to how we can overcome the challenges. Participants shared that the integration of ESD in Life Sciences does not only ensure that learners learn about their environmental challenges but also learn about the safety of the environment so that they can make good decisions for their environment. Participants highlighted that it is important for learners to be taught about ESD from primary schools not only in high schools. They believed that good decisions should be taken from an early stage so that they can practice these skills as they grow up. Participant P1 mentioned that this concept should be introduced to learners at a very early age so that they can learn about good decision making while they are still young. This finding is in line with the findings from Qablan (2018); Redmann et al., (2018) where teachers agreed that beginning to teach about the notion of ESD in early childhood education settings, such as primary schools, is critical.

Participants also mentioned that the concept of ESD promotes cooperative skills such as decision-making, critical thinking, and imagining future scenarios. According to Leonard (2012), ESD should equip learners with the necessary practical skills so they can continue their education when they graduate and make ethical decisions about their lives.Participants have emphasized that learners are taught to become engaged citizens who play a role in changing how our societies run through ESD, and youngsters are encouraged to see themselves as people who are actively constructing a better future. They have explained that the goal of ESD is to encourage their learners in developing positive attitudes and skills necessary to make informed decisions that benefit themselves, others, and future generations.

5.3.1.4 Motivation for learning ESD

Participants mentioned the importance of rewarding learners who participate in ESD. They mentioned that incentives encourage learners to participate in ESD, especially when the participants reward learners who take care of their classrooms as well as their environment. Participants mentioned that learners enjoy being recognized for doing the right thing and as a result others gets encouraged and join in doing justice to their environment. Incentives are believed to motivate learners to be more productive and

also create a feeling of achievement. Participant P1 and participant P3 shared that when learners are encouraged to take care of their environment, they get to do it willingly with time and get used to it knowing that they will be rewarded. Rewards are used to improve learners' achievements. Incentives can motivate learners to become more interested in activities and motivate them to continue their involvement in these activities. This study is consistent with Yang's (2019) findings that teachers must improve fundamental skills including critical and systemic thinking, teamwork, and taking ownership of the present and future generations by stimulating learning and promoting core competencies. Participants explained that giving rewards to learners shows that their hard work is appreciated. They believed that it encourages learners to feel better about the work they do, which also promotes feelings of pride and happiness.

5.3.2 Integrating ESD in Life Sciences Classrooms

This section discusses the teaching strategies that participants employed when integrating the concept of ESD in their Life Sciences classrooms as well as the activities given to learners for assessment.

5.3.2.1 Teaching strategies

Participants believed that the best way to integrate ESD is through learner-centered approaches where learners become active in classrooms and are in control of their lessons, where a teacher acts as a facilitator in the lesson. They believed that learners learn best when they learn by themselves or from each other than from a teacher. Participant P1 preferred using an inquiry-based approach when integrating ESD, participant P2 employed a participatory and exploratory learning as an approach to incorporate ESD in her classroom while participant P3 employed collaborative learning in her classrooms which she believed is the best and effective strategy for ESD. Participants mentioned that different teaching strategies are employed in the Life Sciences classrooms when teaching the concept of ESD. But they believed that the best strategy is when learners are taught practically where they can explore on their own. They have mentioned that it is best when learners participate in the lesson so that they can relate to their personal lives and can apply the knowledge in their everyday lives. Participants believed in constructivism learning which is a learner-centered approach. They explained that it is an active approach where learners work independently and in groups where they construct their own interpretations of the information given using their experiences and test the new information against what they already know. Participant P1 emphasized that ESD is a practical concept where learners need to be fully engaged in a lesson so that what is being taught to them makes sense and they acquire the knowledge, they need to understand fully what sustainable development is.

Participant P3 used an inquiry-based approach as a stimulus in her lesson to find learners' preconceptions of the topic. She believed that it should be used as a strategy to initiate interest, interaction and discussions within the classroom. Furthermore, she

explained that she divided her learners into groups or in pairs and gave them activities to work on. When working in groups learners helped each other to work out the activity given, and she saw improvement when they worked together compared to when she is the one explaining to them. All they did during group discussions was to ask for assistance when it was needed. This type of interaction helped learners a lot and had benefits as learners were very enthusiastic and become interested in the lesson. Nikoloski (2017) highlighted that participatory teaching and learning is an appropriate method that is required as it motivates and inspires learners to act for sustainable development by altering their behavior.

Participants mentioned that their learners learn best when they explore and take part in the lesson. Participatory learning helps learners to understand deeply the topic they are learning about as they get to do practical work on their own with the guidance of a teacher, explore by touching the materials and follow the steps in every procedure. Participant P3 also suggested exploratory learning as the best approach as she was taught ESD through exploring. She mentioned that she took her learners to the laboratory to perform experiments on their own and this approach catered for the kinesthetic learners who learn by doing. The findings correlate with the findings from Kavai et al., (2022) who indicated that it is important to teach ESD through strategies which allow learners to actively participate in constructing the knowledge so that their learning can be effective.

Participant P2 also mentioned that it is important for learners to explore when learning so that the lesson makes sense to them. The finding is in line with Biasutti (2015), who attested that these teaching methods stimulate behavioural changes as well as changes in how people think about and react to processes as well as knowledge. Collaborative learning seemed to be one of the effective approach participants practiced in their classrooms. Participants indicated how important it is for learners to collaborate and work with each other while learning. When analyzing participants' lesson plans, it was evident that they value group work. Participants prefer that learners work in groups for them to understand the concept of ESD. Participant P1 expressed that learner-orientated learning enables learners to decide for themselves while they are learning.

Participant P3 also agreed that a lesson conducted by learners is much better than the one conducted by the teacher because ESD is practical. The participant believed that the benefit of this strategy is that all learners get included in discussions which allowed each learner to take part in the learning process at every stage as she was facilitating the lesson. During discussions, the participant was moving around the classroom asking questions and guiding learners. Participants believed that group work also teaches learners about peace and interaction which is an essential part of the social pillar. They believed that learners get to be taught about how to reflect on their personal actions individually before they come into a decision in a joint function.

When analyzing participants' lesson plans, it was indicated in participant P2's lesson plan that one of her lesson objectives is to allow learners to work in groups and share responsibility. Participant P3 indicated that with experience you get to know the ATP and the assessment guideline by heart such that they get used to how the concept/topics relate to each other as well as the concept of ESD. Hence, when analyzing her lesson plan, the concept of ESD was not included yet she practiced it in the classroom. One of the benefits that participants mentioned about this approach is that learners enjoy the learning process as they are encouraged to relate it to their own experiences. Instead of learners memorizing, they learn to think and understand what is required from the questions which is an important skill. Participants also added that the strategy helped learners to develop social skills as well as the ability to communicate effectively. In this approach the participant is an active agent, facilitating and guiding the learners to tackle problems and create solutions together. This view is supported by Venkataraman (2015), who stated that approaches which are participatory can be achieved through inquiry-based methodologies, through discussions and group work, as well as experiential learning where they engage with one another and their surroundings.

5.3.2.2 ESD activities

Participants mentioned some of the activities encourage learners to participate in ESD such as presentations, debates, competitions and problem-based learning. Participants preferred that learners do presentations as an activity when learning. This is usually

when learners are working in pairs or groups where one learner will be selected to do a presentation. Participant P3 shared that in her classrooms she encouraged learners to work together in groups and be able to present their findings to the rest of the class. This method ensured that every learner has an opportunity to raise their views and give their explanation of how best they understood that concept. Participants consider this type of activity as a learner-centered method where learners provide feedback based on what they were working. They believed that learners usually have different perceptions on different topics, so they learn better when they hear from the others. Participant P1 explained that during presentations, learners can interact with each other, and each member of the group has an opportunity to contribute something they have learnt from the investigation which affords learners to gain good communication skills. Participants also mentioned that presentations help learners learn a topic thoroughly as they will be able to explain in detail their findings with discussions of how they got their results. Presentations also provide learners with a presenting skill which is an important skill in the workplace. The finding is the same as that of UNESCO (2016), who suggested that learner-centered methods such as fieldwork, case studies, discussions, role play, reflective accounts, as well as inquiry-based learning, experiential learning, and action competence are very effective in classrooms.

Participants opined that problem-based learning is one of the effective learner-centered approaches that work best in teaching and learning as learners solve real problems and skills they can put in place when they face challenges. Participants mentioned that the aim of posing a question is to enable learners to develop skills such as problem-solving skills. Learners respond to the problem posed by identifying creative and innovative solutions. Participants indicated that it is one activity that allows learners to reflect on their communities and think about how they can assist where possible. Participants also shared that problem-based learning enabled learners to think, understand and share solutions to their community challenges. Participant P2 also agreed that posing a problem enabled learners to be always aware of the situations around them. Participants explained how effective learning becomes when learners' debate or compete in their classrooms. They believed that debates are positive competitions that enabled learners to study hard on a specific topic and share with their classmates. They

find debates as one of the effective learning activities that learners enjoyed the most as they have indicated the benefits of this activity such as the skills learners gain from debates. They expressed that debates helped learners to stay fully engaged with the topic and come out of the debate informed on the issue.

5.3.2.3 ESD assessment

Participants believed that it is necessary to assess learners after learning a lesson in classrooms. They mentioned that the importance of assessing this concept of ESD is to check if they really understood it so that they can apply it in real situations. Participant P1 mentioned that after assessment, she believes that it is very important to reward those learners who practice the concept in their classrooms. Although it's important for learners to be taught and understand this concept, participant P3 suggests that teachers should be the first to practice it in and outside their classrooms so that they can lead by example. Participants stated that it is useless for learners to be taught the concept when it cannot be practiced. Participant P1 stated learners are assessed to ensure that what they were taught in class was indeed understood and assesses the level of their understanding to see if they interpret it in the correct way so that she can clear any misconceptions.

According to the participants, giving learners projects helped them to interact with their environment in so many ways. Participants gave learners projects related to ESD so that they can learn more about the pillars of sustainability. Participants mentioned that projects are very helpful especially to those learners struggling with a certain topic as they get to associate with others and learn from them. Participants also highlighted how easy it is to assess learners in groups compared to when they work individually. Participants mentioned that the expectation from group work is that learners work together on a specific task and help each other. Participant P2 stated that when learners are assessed in groups, they usually obtain good marks because they give themselves enough time to outsource the correct information, they are allowed to search not only from the textbooks they are using but also, from the internet and create the correct solutions. They believed learners work best when they delegate each other

the roles in the groups so that each one of them contributes to the assessment. Participant P1 also mentioned that when learners work in groups, they develop that sense of ownership because they understand that they must work on their own, to find the correct solutions for the assessment. Participants added that group assessments improve their understanding of that topic as they provide feedback to each other before they write a final task.

Participants believed that group assessments allow learners to work collaboratively and receive a common grade as learners are divided into groups according to different levels of learners' understanding. Participants expressed that when they work in groups, they are motivated and develop skills such as teamwork and communication skills. Learners working in groups can plan and manage their time and be able to work with understanding through discussions and explanations. The aim is to encourage learners to contribute to group interactions, share knowledge and promote learning at a group level and teach them leadership skills. Participants mentioned the importance of giving learners concept tests at the end of the lesson. They believed that it is an effective way of checking if teaching occurred. Participant P3 stated that she gave learners informal and formal tests. As much as they have mentioned how they value group work or group assessments, concept tests assess learners individually. Participants believed that concept tests are summative assessments because they require more dedication, time and preparation compared to other forms of assessments but are important for assessing learners individually. Participants believed that there are skills that learners need to acquire such as problem-solving skills and teamwork which will help them even in the workplace. These skills are also mentioned in the CAPS document that in order to demonstrate responsibility for the environment and the health of others, learners must possess knowledge and abilities such as problem-solving abilities, teamwork, critical thinking, communication skills, and the capacity to gather, use, and evaluate information. These abilities are all part of the NCS essential outcomes (DESA, 2018).

5.3.3 The influence of Teachers' Perceptions on Practicing ESD in Life Sciences

This section provides a discussion of the sustainability pillars included in participants' lessons in the Life Sciences classrooms as well as the challenges they faced when integrating the concept of ESD.

5.3.3.1 Inclusion of Sustainability pillars

It is believed that teachers' perceptions influence their teaching in their classrooms. Out of all the three sustainability pillars, the most well understood and practiced sustainability pillar is the environmental pillar. Participants expressed the importance of the environmental pillar and have realized that it is the most incorporated pillar in the Life Sciences content rather than the other two sustainability pillars. Participants believed that the environmental pillar is the most important pillar and reasoned that it is because it is included in most topics especially the environmental studies in the last strand of Life Sciences. The finding is in line with that of Purvis et al. (2018), who commented that the environmental pillar is the biggest pillar and more practiced than the other pillars. The environmental pillar seemed to be the most practiced than the social and economic pillars.

Participant P1 emphasized that there is no sustainability without the environmental pillar as there is a relationship between the three pillars which is in correlation to Wanamaker (2018) who also attested that the biggest pillar of the three is the environmental pillar which connects the other pillars. Hence the conception of sustainable development lies essentially on the three pillars, and it is only when all three pillars are in balance is true sustainability achieved. According to Taylor (2016) when considering the environmental factors, economic and social factors must also be considered in sustainability hence true sustainability requires the balance of environmental, economic, and social factors. Participants confessed that there are many topics in Life Sciences that incorporated sustainability issues as a way of implementing ESD. However, participants were not confident about the incorporation of the three sustainability pillars simultaneously in their classrooms. Participant P2 acknowledged that she needs development in all three sustainability pillars. She believed that all three sustainability pillars are equally

important and should be incorporated simultaneously in the lesson. However, she felt the environmental pillar is incorporated in most topics of Life Sciences such as human impact in the environment, ecosystems and population growth.

When participants were asked about sustainable development, they always defined it from a point of the environmental pillar; their responses were based more on the environmental pillar and the social pillar to some extent. Participants mentioned that out of all the pillars, the environmental pillar is integrated more in Life Sciences than any other pillar. This implies that the environmental pillar is more understood by participants and is more supported by the topics under the ecological dimension of the Life Sciences curriculum. Regarding the social pillar of sustainable development, participants expressed that it relates to the importance of learner participation in their communities as well as decision making. When they were asked about the social pillar, they indicated that they do integrate it in their classroom although not as directly as the environmental pillar. The social pillar was discussed when they talked about resource security to promote, maintain, and restore access to basic resources such as food and land. Participant P3 stated that through the social pillar, learners acquire the skill of participation and teamwork.

Participants also mentioned that it is very important to empower learners to participate in order to improve their health as well as that of their environment; and to achieve healthy and sustainable societies. Participant P1 said that learners must understand their human rights and practice them with their responsibilities. The social pillar is promoted in their classrooms by ensuring that learners take part in decision making exercises on ways to conserve natural resources and when learners work in groups to share responsibilities. Participant P2 mentioned that when learners work in groups they learn how to socialize as they learn from one other and contribute their knowledge to each other. She emphasized that she wants her learners to learn about diversity and volunteerism even in their communities. Participants indicated through their teaching approaches that they promote the social pillar in their classrooms through group work so that learners get used to working together, sharing ideas and engaging in discussions. Participants ensured that all their learners in their classrooms were treated

equally. Participants have mentioned that there are very few topics where the social pillar of sustainable development is integrated in Life Sciences although it is mentioned in the CAPS document that is should be incorporated.

Participants mentioned that out of the three pillars of sustainable development, the economic pillar is the pillar that is less practiced. It was evident in this study that the integration of the economic pillar is a challenge, but it can only be achieved when discussing the cost of living in grade 10 environmental studies and the economic growth in grade 11 human populations. The findings from Tsakeni (2018) also revealed that the opportunity for integrating the economic pillar is not explicit. However, participants also believe that it can be implied from other pillars such as in the topic of environmental studies. Participant P2 also mentioned that she cannot integrate the three pillars of sustainable development simultaneously especially regarding the economic pillar. The environmental challenges presented by the chemistry curriculum, according to Tsakeni (2018), present potential for combining the social, civic engagement, pedagogical and less of the economic pillars into teaching and learning. This implies that the challenge of incorporating the economic pillar is not faced only in Life Sciences but also in other subjects. Participants have noticed that the economic pillar of sustainability is not visible compared to the other two pillars in the subject of Life Sciences. This means that only the two dimensions of ESD, environmental and social, were clearly visible.

5.3.3.2 Factors influencing the teaching of ESD

Participants find it difficult to fully integrate the concept of ESD in their Life Sciences classrooms because of lack of knowledge of this concept. Participant P2 stated that she does not fully integrate it in her lessons because she is unsure about this concept of ESD. Participants have also indicated that not only do they lack knowledge but also the strategies or appropriate methods to integrate it in their classrooms. These findings correlate to those of Maidou et al. (2019) where it was revealed that there is a shortage of skilled and knowledgeable teachers for ESD principles in science instruction. Their findings also revealed that many science teachers are not trained as science teachers, which leads to insufficient knowledge, a lack of key parts of science, and a lack of exposure to effective learner-centered teaching. Howlet et al. (2016) are of the view that

teachers' attitudes have an impact on their lack of understanding and awareness of ESD. This is primarily due to a lack of comprehension of the ESD concept's uniqueness, as well as teachers' lack of conceptualization of ESD in the classroom practice. Participants admitted that they wish to fully implement it in their classrooms, but they do not have sufficient knowledge about this concept because they were not trained enough about this concept as a result; they feel the need for development. The findings are also supported by Riekmann et al. (2018), who found that teacher preparation is necessary both in a university setting and on the job in the form of continual professional development in order to accomplish and ensure adequate implementation of ESD at all levels.

Participant P3 expressed her lack of knowledge and suggested that she needs to be developed with this concept of ESD. Participants therefore suggest that there should be workshops where district officials will be involved as well as the subject advisors of different subjects. Cordina and Mifsud (2016) in their study also found that many teachers' lack of knowledge of sustainability issues is related to a lack of proper training during their studies. Participants also shared that not only do they lack knowledge of this concept; they also lack motivation to practice it. Participants therefore believe that workshops are important and are required to overcome the challenges of implementing ESD in South African schools which may include Life Sciences content

Participants indicated that one of the challenges they have is lack of resources which hinders them from practicing the concept of ESD. Participants believe that the concept of ESD is more practical and requires teaching approaches that will allow learners to explore and practice it in their classrooms. They have mentioned that as much as they understand the importance of ESD, they do not have enough resources or materials when integrating it. Participants shared that it is important that when ESD is being taught, learners should explore and do things practically. But due to lack of materials and resources, their lessons are more passive which makes it hard for learners to relate the concept to their personal lives Participants believe that it is very difficult to teach learners without resources because they cannot relate to what you are teaching about

except through their textbooks. Lack of teaching materials does not only make the teaching difficult for teachers but makes learners not enjoy the concept at all.

Participants have also indicated that time is another challenge that hinders them from integrating ESD. They have mentioned that the integration of ESD requires a lot of time especially if they want to incorporate all three sustainability pillars simultaneously during their lessons. They mentioned that even if they try to use different approaches to teaching ESD such as outdoor lessons, preparing for such lessons takes time and to organize learners in groups for outdoor learning requires time. Participant P1 shared that time limits what she can do and what she cannot do in her classroom as she has only eight hours of teaching. Most of the time she is required to do extra time (classes after school hours) which is also not enough because some learners participate in other activities such as sports. Although they felt they are incorporating ESD when they teach it is not enough because time limits them.

Participants have complained that the Annual Teaching Plan (ATP) they are provided with by the Department of Basic Education has limited them in what to teach in their classrooms. They felt that the ATP channels them too much on how each concept should be taught, for how long, and which method to use and as a result it becomes a challenge integrating ESD. Participant P1 expressed that the ATP states clearly what they need to do every week and sometimes in a week there is more content than other weeks. She said that the concept of ESD is not mentioned more in the ATP, hence she felt like the ATP does not allow them an opportunity to integrate ESD in their classrooms as each topic on the ATP has its time allocated for it.

5.4 SUMMARY OF THE FINDINGS

5.4.1 Research sub-question 1: How do the teachers perceive education for sustainable development teaching in Life Sciences?

Participants had a positive attitude towards ESD and understood the importance of ESD. Participants had different perceptions on ESD. They believed that it should be

incorporated in Life Sciences as it promotes interactive learning and prepares learners to become responsible citizens. They also believed that it promotes a culture of accountability and allows for creative thinking. They mentioned that through the integration of ESD learners acquire skills such as problem solving and decision-making skills. Participants believed that for learners to participate in ESD they should be a motivation for learning ESD such as incentives for learners participating in ESD.

5.4.2 Research sub-question 2: How do the teachers facilitate education for sustainable development in Life Sciences classroom?

Participants have shown interest in integrating the concept of ESD and have been practicing it in the classrooms. Participants have shown that they employed different strategies when integrating ESD in their classrooms. Teaching strategies employed were mostly learner centered approaches such as inquiry-based approach, participatory and exploratory learning, and collaborative learning. Participants have shown that they give learners different ESD activities in their classrooms such as presentations, problem-based learning, and debates. They also had different assessment methods, they preferred assessments such as project-based assessment, assessing learners in groups and giving them concept tests.

5.4.3 Research sub-question 3: How do the teachers' perceptions of education for sustainable development influence classroom practices?

Participants' positive attitudes and good perceptions towards ESD lead them to a successful integration of ESD in their classrooms. Participants have included the sustainability pillars of ESD in their classrooms. Participants included the environmental pillar when they addressed some of the challenges such as air pollution and soil pollution. The inclusion of the social pillar was more based on the importance of peace and interaction in classrooms and in communities. The inclusion of the economic pillar involved the growth as the business skills learners should acquire. The environmental pillar and the social pillar were integrated more than the economic pillar. Participants also indicated the challenges they face that hinder the successful integration of ESD in

their classrooms. Their challenges include lack of teacher development/ support programmes, lack of resources, time constraints as well as how packed the annual teaching plan is.

5.5 DISCUSSION OF FINDINGS IN RELATION TO THEORETICAL FRAMEWORK

The theoretical framework of the study is based on Magnuson's et al.'s 1999 science model which explains the teachers PCK. The science model enabled the researcher to understand teachers' PCK and how they integrate the concept of ESD.

5.5.1 Orientation towards ESD in Life Science teaching

Data collected revealed that teachers were oriented towards ESD from university. They were taught in different ways such as outdoor learning and field trips as ESD is believed to be a practical concept. Participants believed that they also use different methods to orientate their learners towards ESD. Participant P1 and P3 used an inquiry-based approach to orientate their learners in their classrooms to get their preconceptions of the topic. They believe that it is important for learners to relate to the concept by practicing it and that is through them discovering things for themselves. The most practiced orientations to ESD were discovery, activity-driven, project-based as well as guided inquiry. They asked questions which are real life related so that learners can get a clear meaning of what they are being taught.

5.5.2 Knowledge and beliefs about the understanding of ESD in Life Science

As participants understood clearly what ESD is, they stated that learners should be taught in a way that they will understand and practice sustainability at school and at home. They mentioned the knowledge and skills that learners will acquire through the learning of the concept of ESD such as decision-making and problem-solving skills. Participants believed that ESD should be incorporated in all subjects from primary school so that they grow up having this knowledge for them to be able to

practice it daily. Participants understood that ESD prepares learners to become responsible citizens and promotes a culture of accountability. It ensures that learners understand that there are consequences for their actions. Hence, they believed that it should be a compulsory subject where every learner will learn about it instead of it being incorporated only in science subjects.

5.5.3 Knowledge and beliefs about ESD in the Life Science curriculum

Participants mentioned that there are many Life Sciences topics that can incorporate the concept of ESD but due to lack of knowledge, they seem to be more familiar with the environmental pillar than the social and economic pillars. They indicated topics that they believed they can incorporate the concepts of ESD such as human impact in the environment, ecosystems and population ecology. Other topics in Life Sciences are quite complex and are not easy to include in ESD. They believed that the concept of ESD exists already as topics in the Life Sciences curriculum especially in grades 10 and 11. ESD topics appear as the environmental pillar than the other pillars hence the environmental pillar is more practiced than the other two pillars of sustainable development.

5.5.4 Knowledge and beliefs about instructional strategies of ESD in Life Sciences

Participants mentioned that there are many approaches that they use to incorporate the concept of ESD such as a learner-centered approach where learners learn on their own and a teacher act as a facilitator to guide learners. Participants stated that methods such as exploratory as well as participatory learning are crucial and are mostly practiced allowing learners create their ideas and solve problems on their own through the guidance of the teacher. Participants also showed an interest in collaborative learning as they believed that learners learn better when they learn from each other. These approaches allowed learners to interact with each other and engage in discussions. Participants mentioned that it is important to have different resources for ESD lessons to allow learners to explore such as charts, the use of videos, enough apparatus for investigations and practical/experiments.

5.5.5 Assessment of learning ESD in Life Science

Participants indicated the importance of assessment when teaching learners. They believed that learners should be assessed after being taught specifically about ESD so that they can apply and practice it in their daily activities. They mentioned that they assess their learners differently. Participants preferred that learners work in groups not individually so that they can interact and learn from one another. Assessment given to learners included informal and formal activities, group discussions where all members of the groups will present their findings as well as debates. Participants also stated that a learner or groups or classes that practiced ESD should be rewarded so that they are encouraged to practice it every day.

5.6 LIMITATIONS OF THE STUDY

The data was collected in the third term of the year when teachers are preparing for the final examinations. All three participants in the study were grade 12 teachers as a result; they all had very tight schedules. This is because the syllabus as indicated on the ATP for grade 12 should be completed by this term to prepare for the trial examination. Two of the participants had a different timetable (blocked) compared to the normal timetable they have during the year as the school tends to focus more on grade 12 during that time of the year. So, it was a challenge for them to create time to participate in the study since their timetable changed. Due to this, the interviews were initially planned to be face-to-face but had to be changed to telephonic interviews since most of their classes ended at 17:00, so the researcher could not find enough time to interact with them. However, classroom observations went as planned as they tried to make time for other grades to be taught as well but if data were collected in term one or two, the researcher could have collected more data of them practicing the concept of ESD with their learners in their classroom without the pressure of preparing grade 12s for their trial examinations.

In future, the study to be conducted for ESD should have data collected in the first or second term of the year when the teachers are not too busy with grade 12 so that they

can get enough time to interact with the teachers. Another limitation is that all the three participants taught grade 12 but indicated that they practiced ESD more in lower grades and most topics of ESD exists in the curriculum of grades 10 and 11 than in grade 12. Therefore, in future, teachers teaching in lower grades should be considered more than grade 12 teachers. Furthermore, the study was conducted in government schools in the same context, following the same curriculum and under the same subject advisor and same circuit. Therefore, it is recommended that a future study should be conducted in a private school so that different perceptions of ESD could be obtained and compared to those of the government school teachers.

5.7 IMPLICATIONS AND RECOMMENDATIONS FOR PRACTICE, POLICY, AND TRAINING

5.7.1 Implications

Participants have mentioned many challenges that hinder them from integrating the concept of ESD in their classrooms such as lack of ESD knowledge, lack of resources and funds, timetables being too packed and ATP not including ESD when developed. For teachers to be able to integrate the concept of ESD, knowledge related to sustainability and ESD issues are necessary and crucial. Participants have mentioned that programmes such as workshops are needed for them to be developed fully in this concept. They suggested that the Department of Education intervene and provide development programmes that will equip them with the required knowledge that will also enable them to practice this concept in their classrooms. District officials as well as subject advisors are required to develop programmes where teachers are going to be taught about this concept and how it should be integrated in their Life Sciences classrooms. Participants suggested that the Department of Basic Education should provide funds for trips where learners will be taken to different places where they will learn practically about their environment so that they will be able to also incorporate other pillars. Participants suggested that ESD concepts should be incorporated in the Life Sciences ATP because the other reason they find it difficult to integrate ESD in their lesson is because they are too restrained by the ATP.

5.7.2 Recommendations

Participants suggested that they are developed on the concept of ESD through programmes such as workshops. These workshops should be made specifically for ESD concepts. The Department of Basic Education should be responsible for such workshops. Support from district officials and a subject advisor is needed by teachers for them to successfully integrate ESD in their teaching. They have also mentioned that if all materials/ resources and funds are provided they will be able to integrate them in their lessons. For curriculum developers, they suggested that this concept be incorporated in the curriculum, specifically in the ATP as they are guided by it.

5.8 CONCLUSIONS OF THE STUDY

ESD is an important concept that can benefit the world when practiced by everyone. Teachers are believed to play an important role in addressing the sustainability issues we face. The data collected indicated that teachers were able to integrate the concept of ESD in Life Sciences although there were challenges they faced in their classrooms. The presented data shows that teachers had positive attitudes towards ESD and are willing to practice it daily in their classrooms. Participants indicated that there are different strategies that can be used to incorporate the concept of ESD in their classrooms as well as activities and assessments. Out of the three pillars of sustainability, the most practiced pillar is the environmental pillar because they seem to understand it better than the two other pillars. Participants also believed that the environmental pillar is more incorporated in the Life Sciences curriculum than the others. Participants mentioned challenges such as lack of ESD knowledge. The recommendations made here suggest that teachers require development from the Department of Education. Support from the district officials and as well as their subject advisor through content workshops to successfully integrate this concept are needed.

REFERENCES

Aceska, N. and Nikoloski, D. (2017). The role of teachers' competencies in education for sustainable development. In: International Balkan and Near Eastern Social Science Conference Series (IBANESS), 28-29 October, Ohrid.

Aksland, C., and Rundgren, S.C. (2020). 5th -10th grade in service teachers' pedagogical content knowledge (PCK) for sustainable development in outdoor environment. *Journal of Adventure Education and Outdoor Learning*, 20(3), 274-283.

Allen, C., & Clouth, S. (2012). *Green economy, green growth, and low-carbon development – history, definitions and a guide to recent publications*. UNDESA: A guidebook to the Green Economy. Retreived from https://sustainabledevelopment.un.org/content/documents/GE%20Guidebook.pdf

Alvi, M.H. (2016). *A Manual for Selecting Sampling Techniques in Research*, University of Karachi, Iqra University.

Anney, V.N. (2014). Ensuring the quality of findings of qualitative research: Looking at trustworthiness criteria. *Journal of Emerging Trends in Educational Research and Policy Studies.* 5(2), 272-281.

Barth, M., Michelson, G., Rieckmann, M and Thomas, I. (Eds). (2016). Routledge handbook of higher education for sustainable development, *Routledge International Handbooks, First Issued in Paperback*, Routledge; Earthscam from Routledge, London, New York, NY.

Bertschy, F., Kunzli, C. and Lehmann, M. (2013). Teachers' competencies for the implementation of educational offers in the field of education for sustainable development, *Sustainability*, 5(12), 5067-5080.

Bezeljak, P., Torkar, G., and Scheuch, M. (2019). Understanding of sustainability and education for sustainable development among pre-service biology teachers. *International Conference on Research in Teaching and Education*: Austria.

Biasutti, M. (2015). An intensive programme on education for sustainable development: the participants' experience. *Environmental Education Research*, 21(5), 734-752. https://doi.org/10.1080/13504622.2014.921805.

Biasutti, M., & Frate, S. (2017). A validity and reliability study of the Attitudes toward Sustainable Development scale. *Environmental Education Research,* 23(2), 214-230. https://doi.org/10.1080/13504622.2016.1146660

Borg,C. N., Gericke,H, Houglund,O & Begman, E. (2014). "Subject and Experiences Bound Differences in Teachers". Conceptual Understanding of Sustainable Development. *Environmental Education Research*. 20(4),526-551.

Botha, M.L., and Reddy, C. P. S. (2011). In-service teachers' perspectives of preservice teachers' knowledge domain science. *South African Journal of Education*, 31, 257-274.

Brandt, J.O., Burgener, L., Barth, M., and Redman A. (2019). Becoming a competent teacher in education for sustainable development. *International Journal of Sustainability in Higher Education,* 20(4):630-653.

Brandtley, S. L. (2009). Implementation of the external nutrition practice recommendations. *Nutrition in Clinical Practice*, 24(3), 335-343.

Breuer, A., Janetschek, H., & Malerba, D. (2019). *Translating sustainable development goal (SDG)Interdependencies into policy advice: Sustainability*. Bonn, Germany: MDPI German Development Institute (DIE).

Bromley, D.B. (1991). Academic contributions to psychological counselling: a philosophy of science for the study of individual cases. *Counselling Psychology Quarterly*, 3(3),299-307.

Burgener, L., and Barth, M. (2018). Sustainability competencies in teacher education. Making teacher education count in everyday school practice. *J. Clean. Prod*, 174, 821-826.

Burmeister, M., Rauch, F., and Eilks, I. (2012). Education for sustainable development (ESD) and secondary chemistry education. *Chemistry Education Research and Practice*, 13, 59-68.

Burmeister, M., and Eilks, I. (2013). Using Preparatory Action Research (PAR) to develop a course module on Education for Sustainable Development (ESD) in pre-service chemistry teacher education. *Centre for Educational Policy Studies Journal*, 3, 59-78.

Campagnolo, L., Carraro, C., Eboli, F., Farnia, L., Parrado, R., & Pierfederici, R. (2018). The ex-ante evaluation of achieving sustainable development goals. *Social Indicators Research*, 136, 73 –116. doi:10.1007/s11205-017-1572-x

Cao, J. G.; Emission. (2017). Trading contract and its regulation. *Journal of Chongqing University (Social Science Edition)*, 23, 84-90.

Capra, F. (2007). Sustainable Living, Ecological Literacy, and the Breath of Life. *Canadian Journal of Environmental Education*, 12(1), 1875-1882.

Carlson, J. A. (2010). Avoiding Traps in Member Checking. *The Qualitative Report*, 15(5), 1102-1113.

Chipindo, P. (2019). Environmental Education and Sustainable Development. *órbita*, 6,51-62.

Chunteng, L. (2004). Survey of primary and secondary school teachers' teaching competence for environmental education in Xicheng District of Beijing. *Chinese Education & Society*, 37(4), 39-44.

Cohen, L. M., Manion, L. I., and Morrison, K. (2007). *Research methods in education*, 6.

Corbin,J., & Strauss,A. (2008). *Basics of Qualitative Research: Techniques and Procedures for Developing Grounded Theory* (3rd ed.). Thousand Oaks, CA: Sage.

Cordina, M., & Mifsud, M. C. (2016). A Quantitative Study of Maltese Primary School Teachers and Their Perceptions Towards Education for Sustainable Development. *US-China Education Review B*, 6(6), 329-349.

Corney, G., & Reid, A. (2007). Student Teachers' Learning about Subject Matter and Pedagogy in Education for Sustainable Development. *Environmental Education Research*, 13(1), 33-54. https://doi.org/10.1080/13504620601122632

Creswell, J.W. (2003). *Qualitative inquiry and research design: choosing among five traditions*. Thousand Oaks, CA; Sage Publications.

Creswell, J.W. (2007). *Qualitative Inquiry and Research Design*. Thousand Oaks, CA: Sage Publications.

Creswell, J.W. (2008). *Educational research: planning, conducting, and evaluating quantitative and qualitative research.* 3rd edition. New Jersey: Pearson: Merrill Prentice Hall.

Creswell, J.W. (2009). *Research design*. Thousand Oaks, CA: Sage.

Creswell, J.W .(2012). *Qualitative inquiry and research design: choosing among the five traditions*. Thousand Oaks, CA: Sage Publications.

Creswell, J.W. (2013). *Research Design: Qualitative, quantitative, and mixed methods approaches*: Sage Publications.

Creswell, J.W. 2014. *Research Design: Qualitative, Quantitative, and the Mixed method*: Sappro DeVries.

Cropley, A.J. (2015). Introduction to qualitative research methods: A practice-oriented introduction. *Open Access*. https://doi.org/10.13140/RG.2.1.3098.6888/1

Crowe, S., Cresswell, K., Robertson, A., Huby, G., Avery, A. & Sheikh, A. (2011). The case study approach. *BMC Medical Research Methodology*. 11, 100. http://www.biomedical.com/1471-2288/11/100

Daly, H. E. (1992). U.N. conferences on environment and development: retrospect on Stockholm and prospects for Rio. Ecological Economics*: The Journal of the*

International Society for Ecological Economics, 5, 9–14. doi:10.1016/0921-8009(92)90018-N

DBE (Department of Basic Education). (2011). *National curriculum statement. Curriculum and Assessment Policy Statement. Life Sciences Grade 10-12*. Pretoria: Gauteng Department of Education.

DESA. (2015). Sustainable development goals: 17 goals to transform our world.

Du, Q., & Kang, J. T. (2016). Tentative ideas on the reform of exercising state ownership of natural resources: Preliminary thoughts on establishing a state-owned natural resources supervision and administration commission. *Jiangxi Social Science*, 6, 160.

Dzerefos,C. (2020). Reviewing education for sustainable development practices in South African schools. *Environmental Education Research*, 26(11),1621-1635.

Eilks, I. (2015). Science Education and Education for Sustainable Development-justifications, Models, Practices and Perspectives. *Eurasia Journal of Mathematics, Science and Technology Education*, 11(1),149-158.

Etikan, I., and Bala, K. (2017). Sampling and sampling methods. *Biom Biostat Int J*. 5(6):215-217.

Evans, S., Fernando, L., and Yang, M. (2017). *Sustainable Value Creation-From Concept Towards Implementation*. In: Stark, R., Seliger, G., Bonvoisin, J. (eds) sustainable manufacturing. Sustainable production, Life Cycle Engineering and Management. Springer, Cham.

Evers, B.A. (2018). Why adopt the sustainable development goals? The case of multinationals in the Colombian coffee and extractive sector. (Unpublished Master's Thesis) Erasmus University, Rotterdam.

Farazmand, A. (2016). *Global encyclopedia of public administration, public policy, and governance*. Amsterdam: Springer International Publishing.

Farrimond, H.R. (2017). Ethics of research. In W. Dominic, E. Smith, L.E. Suter & N. Selwyn (Eds.), *Handbook of educational research*. Sage Publications.Festile,

R.M. (2017). *The influence of practical work in the teaching and learning of acids,*

bases, and neutrals in natural science. Master's thesis. University of the Western Cape.

Frankel, J.R., and Wallen, N. E. (2009). *How to design and evaluate research in education.* 7th ed. Boston: McGraw Hill Higher Education.

Fraser, J., Fahlman, D.W., Arscott, J. & Guillot, J. (2018). Study of student retention and attrition in online undergraduate programs. *International Review of Research in Open and Distance Learning*. 19(1). https://doi.org/0.19173/irrod.

Gabriel, A. (2008). "*The Meaning of Theory*." Sociological Theory 26. (173-199). Swanson, Richard A. Theory Building in Applied Disciplines, CA: Barrett-Koehler Publishers.

Gess-Newsome, J. 2015. Teacher professional knowledge Bases including PCK; results of the thinking from the PCK summit. In A, Berry, P. Friedrichsen & J.

Guo, F. (2017). The spirit and characteristic of the general provisions of civil law. *Law and Economics*, 3,5 –16,54.

LeRoux, A., and Teise, K. (2016). Education for Sustainable Development in South Africa: A Model Case Scenario. *Africa Education Review*, 13(3-4), 65-79

Loughran (2016). (Eds), *Re-examining Pedagogical Content Knowledge* (pp. 28-42). Oxford: Routledge.

Gentles, S., Charles, C., Ploeg, J. McKibbon, K.A. (2015). Sampling in qualitative research: Insights from an overview of the methods literature. *The Qualitative Report*, 20(11).

Giorgi, A. (2009). *The descriptive phenomenological method in psychology*. Pittsburgh, PA: Duquesne University Press.

Guba, E. G., and Lincoln, Y. S. (2005). Paradigmatic Controversies, Contradictions, and Emerging Confluences.

Hadi, M.A. & Closs, S.J. (2016). Ensuring vigour and trustworthiness in qualitative research in clinical pharmacy. *International Journal of Clinical Pharmacy*. 38(3), 641-646.

Hartley, D. (2010). Paradigm: How far does research in distributes leadership ‘stretch’? *Educational Management Administration and Leadership*, 38(3),271-285.

Hatch, J.A. (2002). *Doing qualitative research in education settings*. New York: State University of New York Press.

Heale, R. & Twycross, A. (2017). What is a case study? *Evidence Based Nursing*. 21(1), 7–8.

Howlett, C., Ferreira, J.A., and J. Blomfield. (2016). Teaching sustainable development in higher education: building critical, reflective thinkers through an interdisciplinary approach. *International Journal of Sustainability in Higher Education*, 17(3), 305-321.

Hill, M.P. (2017). A qualitative, exploratory case study of self- reported influences affecting the decision of homeless sexual minority students to leave home. Doctoral thesis. Stephen F. Austin State University.

Honorene, J. (2017). Understanding the role of triangulation in research. *Scholarly Research Journal for Interdisciplinary Studies.* 4(31), 91–95.

Hylton, K. N. (2019). When should we prefer tort law to environmental regulation? *Washburn Law Journal*, 41, 515–534.

Ikupa, M., Wilfried, A., Berry, A., and Saab, N. (2019). Student-teacher’s commitment to teaching and intentions to enter the teaching profession in Tanzania. *S. Afr. J. Educ*, 39, 1-15.

Jabareen, Y. (2008). A new conceptual framework for sustainable development. *Environ. Dev. Sustain*, 10,179-192.

Jamieson, S. (2016). Analysing qualitative data. *Education for Primary Care*. 27(5), 398– 402.Jamshed, S. (2014). Qualitative research method – interviewing and observation (Editorial). *Journal of Basic and Clinical Pharmacy*. 5(4), 87–88.

Jing-Jing, H.U. (2014). A critical review of Pedagogical content knowledge' components: nature, principle and trend. *International Journal of Education and Research*, 2(4),411-424.

Johnson, B., and Christensen, L. (2008). *Educational research: Qualitative, qualitative, and mixed approaches*: Sage Publications.

Justus, M. (2017). The role of pedagogical beliefs in emerging technology integration: An exploratory case study of faculty perspectives. *The Qualitative Report*. 22(2), 499– 526.https://doi.org/10.46743/2160-3715/2017.2478

Kaindume, A.N. (2018). *Factors limiting science teachers from engaging learners in practical work: A case study*. Master's thesis. University of South Africa.

Kalpokaite, N. & Radivojevic, I. (2019). Demystifying qualitative data analysis for novice researchers. *The Qualitative Report*. 24(13), 44-57. https://nsuworks.nova.edu/tqr/vol24/15513/5

Karaarslan, G., and Teksoz, G. (2016). Integrating Sustainable Development Concept into Science Education Program is not enough; We Need Competent Science Teachers for Education for Sustainable Development-Turkish Experience. *International Journal of Environmental and Science Education*, 11(15), 8403-8424.

Kavai, P., Williams, A.T., & Tsakeni, M. (2022). Exploring a South African and a Swedish teacher education programme of Biology teachers for ESD. A comparative study, in Rocksen, M., Vhurumuku, E., Svensson,M., Mushayikwa, E., & Msimanga,A. (ed). *Science and technology Teacher education in the Anthropocene*. London, 129-148.

Kawulich, B. (2004). *Qualitative data analysis techniques*. Conference proceedings RC33, Amsterdam.

Khaldi, K. (2017). Quantitative, qualitative and mixed research: Which research paradigm to use? *Journal for Educational and Social Research*. 7(2).

Kim, B. (2006). Social constructivism. In M. Orey (Ed.), *Emerging perspectives on learning, teaching, and technology*. Association for Educational Communications and Technology.

Kioupi, V., and Voulvoulis, N. (2019). *Education for Sustainable Development: A System Framework for Connecting the SDGs to Educational Outcomes*. *Sustainabilit*y, Imperial Collage London, London.

Kivunja, C., & Kuyini, A. (2017). Understanding and applying research paradigms in educational contexts. *International Journal of Higher Education*, 6(9), 52-58.

Kohn, L. & Christiaens, W. (2012). The use of qualitative research methods in KCE studies. KCE Report 187C. Belgian Health Care Knowledge Centre.

Kolk, A. (2016). The social responsibility of international business: From ethics and the environment to CSR and sustainable development. *Journal of World Business*, 51(1), 23–34. doi:10.1016/j.jwb.2015.08.010

Korstjens, I. & Moser, A. (2018). Series: Practical guidance to qualitative research: Part 4: Trustworthiness and publishing. *European Journal of General Practice*, 24(1), 1120124. https://doi.org/10.1080/13814788.2017.1375092

Kothari, C. (2004). *Research methodology. Methods and techniques*. New Delhi: New Age International Publishers.

Kumar, S., Raizada, A., & Biswas, H. (2014). Prioritising development planning in the Indian semi-arid Deccan using sustainable livelihood security index approach. *International Journal of Sustainable Development & World Ecology,* 21, 4. Taylor and Francis Group. doi:10.1080/13504509.2014.886309.

Le Grange, L. (2010). The Environment in the Mathematics, Natural Sciences, and Technology Learning Areas for General Education and Training in South Africa. *Canadian Journal of Science*, 10(1), 13-26.

Lemon, L.L. & Hayes, J. (2020). Enhancing trustworthiness of qualitative findings using Leximancer of qualitative data analysis triangulation. *The Qualitative Report*. 25(3) Art 3, 604– 614. https://nsuworks.nova.edu.tqr/vol25/iss3/3

Lester, S. (1999). *An introduction to phenomenological research*. Taunton UK: Stan Lester Developments.

Lobo, M. J., Pietriga, E., and Appert, C. (2015). *An evolution of interactive map comparison techniques. In proceedings of the 33rd Annual ACM Conference on human factors in computing systems*. New York, USA: ACM Press.

Lombard, D. (2015). Natural Science teacher attitudes and Pedagogical Content Knowledge for teaching botany. (Unpublished Masters Dissertation) University of Pretoria, Pretoria.

Loughran, J. Berry. A, and Mulhall, P. (2006). *Understanding and developing science teachers' pedagogical content knowledge*. The Netherlands: Sense Publishers.

Lv, Z. M. (2018). Research group. The implementation outline of the "Green Principle" in civil code. *China Law Sci*, 1,7-8

Magnusson, S., Krajcik, J., and Borko, H. (1999). Nature, sources and development of PCK for science teaching in J. Gess-Newsome & N.G. Lederman (Eds.). *Examining PCK*: 95-132. Dordrecht: Kluwer Academic.

Maguire, M. & Delahunt, B. (2017). Doing a thematic analysis: A practical step-by-step guide for learning and teaching scholars. *All Ireland Journal of Teaching and Learning in Higher Education*. 3, 3351–33514.

Maidou, A., Plakisti, K., and Polatoglou, H. M. (2019). Knowledge, Perceptions, and Attitudes on Education for Sustainable Development of Pre-service Early Childhood Teachers in Greece. *World Journal of Education*, 9(5), 1-15.

Maree, K. (2010). *First steps in research*. 4th Edition. Pretoria: Van Schaik Publishers.

McKeown, R., and Hopkins, C. (2010). Progress has been made in Education for Sustainable Development. *Applied Environmental Education and Communication*, 1(1), 21-23.

Mensah, J. (2019). Sustainable development; Meaning, history, principles, pillars, and implications for human action: Literature review. *Cogent Social Sciences*, 5, 1-34.

Mensah, J., & Enu-Kwesi, F. (2018). Implication of environmental sanitation management in the catchment area of Benya Lagoon, Ghana. *Journal of Integrative Environmental Sciences.* doi:10.1080/ 1943815x.2018.1554591

Merriam, S. (2009). *Qualitative research a guide to design and implementation.* San Francisco, CA: Wiley & Sons, Inc.

Mohajan, H.K. (2018). Qualitative research methodology in social sciences and related subjects. *Journal of Economic Development, Environment and People*. 7(01), 23–48. https://mpra.ub.uni-muenchen.de/85654

Mohamed, M., Ragab, M. & Arisha, A. (2016). *Qualitative analysis methods review*. Technical report. Dublin Institute of Technology. https://doi.org/10.21427/D75Z25

Montaldo, C. R. B. (2013). Sustainable Development Approaches for Rural Development and Poverty Alleviation & Community Capacity Building for Rural Development and Poverty Alleviation.

Moon, K., Brewer, T., Januchowski-Hartley, S., Adams, V. & Blackman, D. (2016). A guideline to improve qualitative social science in publishing in ecology and conservation journals. *Ecology and Society,* 21(3), 17. http://dx.doi.org/10.5751/ES-08663-210317.

Moser, A & Korstjens, I. (2018). Series: Practical guidance to qualitative research. Part 3: Sampling, data collection and analysis. *European Journal of General Practice*. 24(1), 9-18. https://doi.org/10.1080/13814788.2017.1375091

Mudaly, R & Ismail, R. (2016). Professional Development in Environmental and Sustainability Education Voices, Practices and Reflections of Science Teachers. *Southern African Journal of Environmental Education*, 32(1).

Mugo, F. W. (2011). Sampling in research.

Norden, B. (2018). “Transdisciplinary Teaching for Sustainable Development in a Whole School Project.” *Environmental Education Research*, 24 (5), 663–677

Nowell, L., Norris, J., White, D. & Moules, N. (2017). *Thematic analysis: striving to meet the trustworthiness criteria*. Sydney: Sage.

Olsson, D.; Gericke, N.; Chang Rundgren, S.N. (2016). The effect of implementation of education for sustainable development in Swedish compulsory schools—Assessing pupils' sustainability consciousness. *Environ. Educ. Res*. 22, 176–202.

Oyinloye, O. M. & Imenda, S. N. (2019). The impact of Assessment for Learning on Learner Performance in Life Science. *EURASIA Journal of Mathematics, Science and Technology Education*, 15(11), 2-8.

Parveen, H. & Showkat, N. (2017). *Research ethics*. Paper: Communication Research, Module ID P2M10. Aligarh Muslim University, Aligarh.

Peng, W. (2013). Examining Pedagogical Content Knowledge (PCK) for Business English Teaching: Concept and Model. *Polyglossia*, 25, 83-94.

Pierobon, C. (2019). Promoting sustainable development through civil society: A case study of the EU's NSA/LA thematic programme in Kyrgyzstan. *Development Policy Review; Wiley*, 37. doi:10.1111/dpr.12411

Porter, M. E., & van der Linde, C. (1995). Toward a new conception of the environment competitiveness relationship. *Journal of Economic Perspectives*, 9, 97–118. doi:10.1257/jep.9.4.97

Purvis, B., Mao, Y., & Robinson, D. (2018). Three pillars of sustainability: in search of conceptual origins. *Sustainability Science* https://doi.org/10.1007/s

Qablan, A. (2018). Building capacities of educators and trainers. In Leicht, A., Heiss, J. and Byum, W.J. (Eds). *Issues and Trends in Education for Sustainable Development Education on the Move,* Paris.

Redman, E., Wiek, A & Redman, A. (2018). "Continuing Professional Development in Sustainability Education for K-12 Teachers: Principles, Programmes, Applications, Outlook". *Journal of Education for Sustainable Development*. 12(1),59-80.

Rieckmann, M. (2018). Learning to transform the world: key competencies in education for sustainable development. In Leicht, A., Heiss, J. and Byum, W.J. (Eds). *Issues and Trends in Education for Sustainable Development Education on the Move*. Paris.

Rollnick, M., Bennett, J., Rhemtula, N.D., Dharsey and Ndlovu, T. (2008). The place of subject matter knowledge and pedagogical content knowledge: a case study of South African teachers teaching the amount of substance and chemical equilibrium. *International Journal of Science Education,* 20(10),1365-1387.

Ronoh, J. (2017). *Indigenous knowledge in the school curriculum: Teacher educator perceptions of place and position*. Master's thesis, Nelson Mandela University, South Africa.

Sagadin, J., and Bertoncelj, L. (1991). *Razprave iz pedagoske metodologije*: Znanstveni Institute Filozofske Fakultete.

Saner, R., Yiu, L., & Nguyen, M. (2019). Monitoring the SDGs: digital and social technologies to ensure citizen participation, inclusiveness and transparency. Development Policy Review (Wiley). doi:10.1111/ dpr.12433

Schild, R. (2016). Environmental citizenship: What can political theory contribute to environmental education practice? *Journal of Environmental Education*, 47(1), 19-34.

Scopelliti, M., Molinario, E., Bonaiuto, F., Bonnes, M., Cicero, L., De Dominicis, S., & Bonaiuto, M. (2018). What makes you a "hero" for nature? Sociopsychologicalprofiling of leaders committed to nature and biodiversity protection across seven; EU countries. *Journal of Environmental Planning and Management*, 61, 970–993. doi:10.1080/ 09640568.2017.1421526

Seidman, I. (2013). *Interviewing as qualitative research: a guide for researchers in education and social sciences*. Thousand oaks, CA: Sage.

Shepherd, E., Milner-Gulland, E. J., Knight, A. T., Ling, M. A., Darrah, S., Soesbergen, A., & Burgess, N. D. (2016). Status and trends in global ecosystem Molinario et

al. 29 services and natural capital: Assessing progress toward Aichi Biodiversity Target 14. *Conservation Letters*, 9, 429–437. doi:10.1111/conl.12320

Shulman, L.S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher*, 3(15),4-14.

Shulman, L.S. (1987). Knowledge and teaching-foundation of the new reform. *Harvard Education Review*, 57(1):1-22.

Somekh, B. (2011). Observation. In B. Somekh & C. Lewin (Eds.), Theory and methods in social research. (2nd ed.) 131-138. London: Sage Publications.

Songqwaru, N,Z. (2012). Supporting Environment and Sustainability Knowledge in the Grade 10 Life Sciences Curriculum and Assessment Policy Context: A case study of the Fundisa for Change Teacher Education and Development Programme Pilot Project. Master's Thesis, Rhodes university, South Africa.

Ssosse, Q., Wagner, J., and Hopper,C. (2021). Assessing the impact of ESD: Methods, Challenges, Results. *Sustainability*, 13(5), 2854.

Sund, L. (2016). Facing global sustainability issues: Teachers' experiences of their own practices in environmental and sustainability education. *Environ. Educ. Res*. 22, 788–805.

Sund, P. (2015). "Experienced ESD-Schoolteachers' Teaching – an Issue of Complexity." *Environmental Education Research*, 21(1), 24–44.

Sund, P & Gericke, N. (2020).Teaching contributions from secondary school subject areas to education for sustainable development – a comparative study of science, social science and language teachers*, Environmental Education Research*, 26(6), 772-794.

Taylor, P.C. & Medina, M.N.D. (2013). Educational research paradigms: From positivism to multiparadigmatic. *Journal of Meaning-Centred Education*. 1, 1-16. https://doi.org/0.13140/2.1.3542.0805

Taylor, S.J. (2016). *A review of sustainable development principles: centre for environmental studies*. South Africa: University of Pretoria.

Thanh, N.C. & Thanh, T.T. (2015). The interconnection between interpretivist paradigm and qualitative methods in education. *American Journal of Educational Science*, 1(2), 24-27.

Theron, P.M. (2015). Coding and data analysis during qualitative empirical research in Practical Theology. In die Skriflig. 49(3), Article 1880. http://dx.doi.org/10.4102/ids.v49i3.1880

Thomas, G. (2009). *How to do your research project: a guide for students in education and social sciences*. London: Sage Publications.

Timm, M.J., & Barth, M. (2020): Making education for sustainable development happen in elementary schools: the role of teachers*, Environmental Education Research*, DOI: 10.1080/13504622.2020.1813256

Tsakeni, M. (2018) Opportunities for Teaching Sustainable Development through the Chemistry Component of CAPS Physical Sciences, *African Journal of Research in Mathematics, Science and Technology Education*, 22(1), 125-136.

Tugel, J. (2018). Using formative assessment to uncover how students think about science: McGrawHill Education.

UN. (2006). *Millennium Development Goals*. New York: United Nations.

UNCED. (1992). Agenda 21. Retrieved from: http://www.un.org/esa/dsd/agenda21/

UNESCO. (2005). United Nations Decade of Education for Sustainable Development (2005-2014). Retrieved from http://unesdoc.unesco.org/images/0014/001486/148654e.pfd.

UNESCO. (2016). Education 2030*: Incheon Declaration and Framework for Action Towards Inclusive and Equitable Quality Education and Lifelong Learning for All*: Paris, France.

United Nations. (2018). *The sustainable development goals report 2018*. New York, NY: United Nations Publications.

UNSD (2018c). SDG indicators metadata repository. Retrieved fromhttps://unstats.un.org/sdgs/metadata/

Wanamaker, C. (2018). The Environmental, Economic, and Social Components of sustainability: The Three spheres of sustainability.

World conference on environment and development-WCED. (1987). *Our common future*. New York: Oxford University Press.

Williams-McBean, C.T.W. (2019). The value of qualitative pilot study in multiphase mixed methods in research. *The Qualitative Report*. 24(5), Article 9, 1055-1064. https://nsuworks.nova.edu/tqr/vol24/iss5/9

Wilson, S. M. and Shulman, L.S. (1987). 150 different ways of knowing: representations of knowledge in teaching. In: Calderhead, J. (Ed.). *Exploring teachers' thinking*. London: Cassell Educational.

Yang, L.X. (2019). From general principles of civil law to general provisions of civil law: A historical leap in a contemporary Chinese civil law. *Social Sciences in China*, 2, 58-91.

Yin, R. (2003). Case research study: design and methods. *Case research study: design and methods*.

Zhai, T. T., & Chang, Y. C. (2019). Standing of environmental public-interest litigants in China: Evolution, obstacles and solutions. *Journal of Environmental Law*, 30, 369–397.

APPENDICES

APPENDIX A: INTERVIEW PROTOCOL

Title: Teacher's perceptions and practices of Education for Sustainable Development in Life Sciences classrooms

There are many sustainability challenges that humanity face such as poverty, freshwater crisis, population growth, solid and hazardous waste and sewage problems. Education is the key response to address these issues. Education for Sustainable Development (ESD) is the process of developing learners' sustainability knowledge, attitudes, and behaviours in favour of the environment and its economic and social implications (Besong & Holland 2015; Filho & Pace 2016). The goal is to motivate learners to become sustainably engaged citizens through their commitment to environmental stewardship, and reflection about the interaction of social justice, ethics, wellbeing, and ecological and economic factors. Therefore, ESD is the formal teaching and learning devoted to sustainability.

Teacher should be agents of change and prepare learners, teach them how to be responsible citizens and be aware of their actions or behaviour. The focus of ESD is to prepare our younger generation to become responsible citizens of the future. Learners should learn how to take responsibility for both themselves and this society for today and in the future based on the concept of sustainable development. Sustainable development is based on the three pillars: environmental, economic and society and it is only when the three pillars are incorporated simultaneously is true sustainability achieved.

The purpose of the interview is to explore teachers' perceptions of ESD and how they integrate it in their Life sciences classrooms and what challenges they face when integrating it.

SECTION A

A. BIOGRAPHIC DETAILS

1. Age group:

35-39	40-49	50-59	60-69	70+
1	2	3	4	5

2. Gender:

Male	Female
1	2

3. Education:

3.1	Matriculation	
3.2	Diploma (specify)	

3.3	Undergraduate (specify)	
3.4	Postgraduate (specify)	
3.5	Other (specify)	

4. Teaching position:

Post level 1	
Post level 2	
Post level 3	
Post level 4	

5. Number of years teaching:

0-5	6-10	11-15	16-20	25+
1	2	3	4	5

SECION B

A. TEACHER PERCEPTIONS OF ESD

1. Were you ever taught about ESD when you were at school, college or university or professional development activities?
2. What were you taught?
3. How were you taught?
4. What is your understanding of ESD teaching in your Life Sciences classrooms?
5. What is your perception (belief/view) about ESD?

6. Do you think it is important to incorporate ESD in teaching Life Sciences? Why?
7. According to your understanding, what do you think is the aim of ESD?
8. What knowledge of ESD do you think learners need to learn?
9. Why do you think learners need to be assessed on ESD concepts?

B. TEACHER PRACTICES WHEN TEACHING ESD

1. In your opinion, why should learners be taught ESD concepts?
2. What is your experience of teaching ESD in Life Sciences?
3. What knowledge or skills do learners need in order for them to be able to participate in ESD concepts?
4. Which background knowledge or topics do you think learners need that are related to ESD?
5. Which topics in the Life Sciences curriculum do you think incorporate ESD concepts?
6. Which methods/teaching strategies do you use when teaching this concept of ESD? Why?

C. OPPORTUNITIES FOR TEACHING ESD

1. Are you able to incorporate the three sustainability pillars (social, economic and environmental pillars) simultaneously when teaching the concepts of ESD?
2. Do you develop your own materials for teaching ESD concept? If so, how?
3. How do you motivate your learners to participate towards sustainable development?
4. How do you assess learners learning and understanding of the concept of ESD?
5. Can you give me examples of activities you give your learners?
6. What challenge do you face when teaching ESD concepts?

7. How do you ensure that learners understand the concept of ESD and understand its importance?
8. How do you ensure that you connect ESD concepts to their personal life and make them enjoy the concept?
9. Would you like to get more information about ESD or you feel that you are well prepared and developed for this concept?
10. In what area (the three pillars) do you think you are doing enough when teaching ESD?
11. In what area (the three pillars) would you like to have more support and help?
12. Do you have any suggestions on how teachers can be helped with integrating ESD successfully in their teaching?

APPENDIX B: OBSERVATION GUIDE

Topic of the lesson: _____

Classroom number: _____ Pseudonym: _____

Name of observer: _____

Role of an observer: _____

Time of observation: _____

Length of observation: _____

Descriptive field notes	Indicators (pillars/pck)	Reflective field notes (observation notes)
Classroom checklist • Posters		

• Models PCK SCIENCE MODEL 1. Orientation towards ESD in Life Science teaching, Introduction activity How does the teacher surface the knowledge of learners of a concept? (preconception) How is the topic introduced? 2. Knowledge about learners' understanding of ESD in Life Science, What type of questions does the teacher ask while teaching? How does the teacher ensure that leaners understand the concept? 3. Knowledge about ESD in the Life Science curriculum, How does the teacher conceptualise ESD? How does the teacher teach the concept of ESD (teaching method) Types of examples the teacher give learners while teaching relating to real life situations Main activity 4. Instructional strategies for ESD in Life Science, Which strategy is the teacher using to teach? Teacher centred or learner centred to cater for all kinds of learners		

What type of resources does the teacher use to teach (appropriate teaching materials) How does the teachers' perception of ESD affect their classroom practice? 5. Assessment of learner learning of ESD in Life Science. Types of activities the teacher gives learners Do learners work in groups, pairs or individually? Closing activity Concluding comments or remarks		

Document analysis guide (Lesson plan)

PCK elements	Notes
1. Orientation towards ESD in Life Science teaching, -Are the objectives/goals of the lesson clearly stated and incorporates ESD -Any ideas/concepts concerning ESD -Pre-activity for the lesson addresses ESD 2. Knowledge about learners' understanding of ESD in Life Science, -Type of questions the teachers is going to ask are clearly indicated -knowledge about learners thinking that influences the ideas/concepts of ESD 3. Knowledge about ESD in the Life Science curriculum,	

-The learning activities the teachers plans to do in class incorporates the ESD concepts 4. Instructional strategies for ESD in Life Science, -The strategies the teacher is using accommodate all learners to facilitate the concept of ESD well -The type of materials used in class -limitations/difficulties connected to the idea of ESD -Other factors influencing the teaching of ESD 5. Assessment of student learning of ESD in Life Science. -Does the teacher assess the concept of ESD when teaching and assessing the learners -Way of ascertaining learners understanding or confusion about ESD -The skills leaners need to be sustainably skilled are assessed	

APPENDIX C: LETTER TO THE TEACHERS

18 Riverside

Phuthaditjhaba

9866

25 July 2022

Dear_____

RE: REQUEST FOR PERMISSION TO CONDUCT RESEARCH IN SCHOOLS

My name is Lerato Mofokeng. I am a master's student at the University of the Free State, Qwaqwa campus. I am conducting a study based on **teachers' perceptions and practices of Education for Sustainable Development in Life Sciences classrooms**. The purpose of the

study is to better understand teachers' perceptions of ESD and how they practice it in Life Sciences classrooms.

I will conduct interviews with structured questions to obtain in-depth perceptions on ESD and understand your personal experiences. I will also observe one of your lessons to explore how you practice the concept of ESD in your Life Sciences classroom. There will be complete confidentiality including participants' names and schools. Pseudonyms will be used to maintain confidentiality. You will be given enough time to respond to the questions. In addition, if, at any time, you wish to withdraw from the study, you may. If you have questions you may contact my University supervisor, Dr Maria Tsakeni at 078 640 3218 or 058 718 5001, email address tsakenim@ufs.ac.za.

Your participation in the study is voluntarily and will help me provide recommendations to the policymakers and stakeholders in the field of education. Your participation will also help me complete my degree requirements for my master's programme and the information gathered here will be used in my project.

If you are willing to participate in the study, please send an email at 2019346671@ufs4life.ac.za or call me at 082 636 5441 to confirm your willingness to participate.

Sincerely,

Lerato Mofokeng

APPENDIX D: LETTER TO THE PRINCIPALS

18 Riverside

Phuthaditjhaba

9866

25 July 2022

Dear Principal

RE: REQUEST FOR PERMISSION TO CONDUCT RESEARCH IN SCHOOLS

My name is Lerato Mofokeng. I am a master's student at the University of the Free State Qwaqwa campus. I am conducting a study to understand **teachers' perceptions and practices of Education for Sustainable Development in Life Sciences classrooms**. The purpose of the study is to better understand teachers' perceptions of ESD and how they practice it in Life Sciences classrooms

I would like to ask your permission to collect data from one of the teachers from your school. I will conduct semi-structured interviews with the teacher and observe one of their lessons in their Life Sciences Classrooms. The study requires a Life Sciences teacher who has more than three years of teaching experience, teaching the concept of ESD. The teacher will share their experiences and their perceptions on the concept of ESD. The researcher will schedule convenient times with the selected teacher to conduct interviews and observations. Kindly take note that I shall conduct the interviews during their lunch breaks and/or even after school, to minimize disturbance of the functionality of the school.

My contact details are 082 636 5441, email address 2019346671@ufs4life.ac.za. If you have any questions you can contact my University supervisor: Dr Maria Tsakeni at 078 640 3218 or 058 718 5001, email address tsakenim@ufs.ac.za.

Yours faithfully,

Lerato Mofokeng

APPENDIX E: PERMISSION LETTER FROM DEPARTMENT OF EDUCATION

Enquiries: M.Z. Thango
Ref: Research Permission: L.A. Mofokeng
Tel. 051 404 8808
Email: MZ.Thango@fseducation.gov.za

education
Department of
FREE STATE PROVINCE

18 RIVERSIDE
PHUTHADITJHABA
9866

Dear Ms. L.A. Mofokeng

PERMISSION TO CONDUCT RESEARCH IN THE FREE STATE DEPARTMENT OF EDUCATION: THABO MOFUTSANYANA DISTRICT

This letter serves to inform you that you have been granted permission to conduct research in the Free State Department of Education within the Thabo Mofutsanyana Education District. The details in relation to your research project with the University of the Free State are as follows

Topic: Exploring teacher's perceptions and practices of Education for Sustainable Development in Life Sciences classrooms

1. **List of schools involved:** Sekgulong Secondary school, Manthatisi Secondary school and Setlalekela Secondary school.
2. **Target Population:** Three teachers teaching life sciences in Grade 10 to 12 at the selected schools.
3. **Period of research:** From the date of signature of this letter until 30 September 2022. Please note that the department does not allow any research to be conducted during the fourth term (quarter) of the academic year. Should you fall behind your schedule by three months to complete your research project in the approved period, you will need to apply for an extension. The researcher is expected to request permission from the school principals to conduct research at schools
4. The approval is subject to the following conditions:
   4.1 The collection of data should not interfere with the normal tuition time or teaching process.
   4.2 A bound copy of the research document should be submitted to the Free State Department of Education, Room 10A, 1st Floor, Thuto House, St. Andrew Street, Bloemfontein or can be emailed to the above-mentioned email address.
   4.3 You will be expected, on completion of your research study to make a presentation to the relevant stakeholders in the Department.
   4.4 The ethics documents must be adhered to in the discourse of your study in our department.
5. Please note that costs relating to all the conditions mentioned above are your own responsibility.

Yours Sincerely

DATE 25/04/2022

Mr. MZANDILE W. JACOBS
DIRECTOR: QUALITY ASSURANCE, M&E AND STRATEGIC PLANNING

APPENDIX F: ETHICAL CLEARANCE LETTER

UNIVERSITY OF THE FREE STATE
UNIVERSITEIT VAN DIE VRYSTAAT
YUNIVESITHI YA FREISTATA

UFS
UV

GENERAL/HUMAN RESEARCH ETHICS COMMITTEE (GHREC)

14-Jun-2022

Dear Ms Lerato Mofokeng

Application Approved

Research Project Title:
Exploring teacher's perceptions and practices of Education for Sustainable Development in Life Sciences classrooms

Ethical Clearance number:
UFS-HSD2022/0373/22

We are pleased to inform you that your application for ethical clearance has been approved. Your ethical clearance is valid for twelve (12) months from the date of issue. We request that any changes that may take place during the course of your study/research project be submitted to the ethics office to ensure ethical transparency. furthermore, you are requested to submit the final report of your study/research project to the ethics office. Should you require more time to complete this research, please apply for an extension. Thank you for submitting your proposal for ethical clearance; we wish you the best of luck and success with your research.

Yours sincerely

Dr Adri Du Plessis
Chairperson: General/Human Research Ethics Committee

205 Nelson Mandela Drive
Park West
Bloemfontein 9301
South Africa

P.O. Box 339
Bloemfontein 9300
Tel: +27 (0)51 401 9337
duplessisA@ufs.ac.za
www.ufs.ac.za

APPENDIX G: CONFIRMATION OF EDITING

Angela Bryan & Associates

6 Martin Crescent
Westville

Date: 26 June 2023

To whom it may concern

This is to certify that Masters' Thesis: Exploring Teachers' Perceptions and Practices of Education for Sustainable Development in Life Sciences Classrooms written by Lerato Alphonsina Mofokeng has been edited by me for language.

Please contact me should you require any further information.

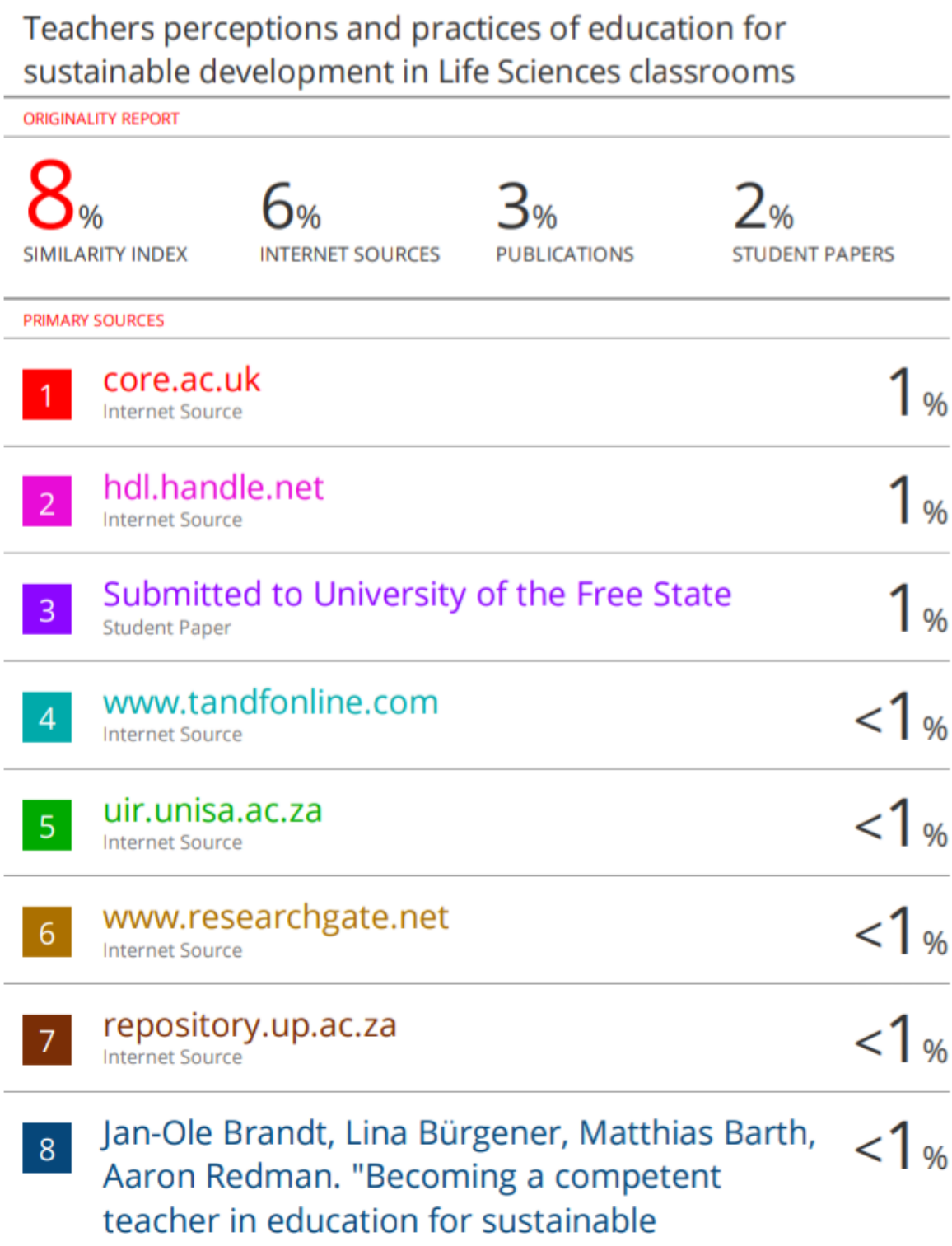
Kind Regards

Angela Bryan

angelakirbybryan@gmail.com

0832983312

APPENDIX H: ORIGINALITY REPORT



Teachers perceptions and practices of education for sustainable development in Life Sciences classrooms

ORIGINALITY REPORT

8%	6%	3%	2%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	core.ac.uk Internet Source	1%
2	hdl.handle.net Internet Source	1%
3	Submitted to University of the Free State Student Paper	1%
4	www.tandfonline.com Internet Source	<1%
5	uir.unisa.ac.za Internet Source	<1%
6	www.researchgate.net Internet Source	<1%
7	repository.up.ac.za Internet Source	<1%
8	Jan-Ole Brandt, Lina Bürgener, Matthias Barth, Aaron Redman. "Becoming a competent teacher in education for sustainable	<1%

development", International Journal of Sustainability in Higher Education, 2019
Publication

9	Submitted to University of Johannsburg Student Paper	<1 %
10	www.ajol.info Internet Source	<1 %
11	etd.uwc.ac.za Internet Source	<1 %
12	scholarworks.wmich.edu Internet Source	<1 %
13	scholar.ufs.ac.za Internet Source	<1 %
14	Submitted to BATANGAS STATE UNIVERSITY Student Paper	<1 %
15	ukzn-dspace.ukzn.ac.za Internet Source	<1 %
16	Submitted to University of Witwatersrand Student Paper	<1 %
17	vital.seals.ac.za:8080 Internet Source	<1 %
18	Jan H. van Driel. "Science Teachers' Knowledge Development", Brill, 2022 Publication	<1 %

profesus.eu

19	Internet Source	<1%
20	Submitted to Universiti Malaysia Terengganu UMT Student Paper	<1%
21	wiredspace.wits.ac.za Internet Source	<1%
22	Submitted to American University in the Emirates Student Paper	<1%
23	Submitted to Luiss Guido Carli University Student Paper	<1%
24	ujcontent.uj.ac.za Internet Source	<1%
25	researchspace.ukzn.ac.za Internet Source	<1%
26	Submitted to American College of Education Student Paper	<1%
27	Sabrine Dhahri, Sana Slimani, Anis Omri. "Behavioral entrepreneurship for achieving the sustainable development goals", Technological Forecasting and Social Change, 2021 Publication	<1%
28	dspace.nwu.ac.za Internet Source	<1%

29	mafiadoc.com Internet Source	<1 %
30	useas.sead.com.tr Internet Source	<1 %
31	Anthoula Maidou, Katerina Plakitsi, Hariton M. Polatoglou. "Expansive Learning of Preservice Teachers Teaching Sustainable Development during Their Practicum", World Journal of Education, 2020 Publication	<1 %
32	Submitted to University of Macau Student Paper	<1 %
33	Maria Tsakeni. "Opportunities for Teaching Sustainable Development through the Chemistry Component of CAPS Physical Sciences", African Journal of Research in Mathematics, Science and Technology Education, 2018 Publication	<1 %
34	Submitted to Tshwane University of Technology Student Paper	<1 %
35	repository.kulib.kyoto-u.ac.jp Internet Source	<1 %
36	matt-koehler.com Internet Source	<1 %

37	uzspace.unizulu.ac.za	<1 %

37	uzspace.unizulu.ac.za Internet Source	<1%
38	Ronit Rozenszajn, Anat Yarden. "Expansion of Biology Teachers' Pedagogical Content Knowledge (PCK) During a Long-Term Professional Development Program", Research in Science Education, 2013 Publication	<1%
39	Submitted to University of Northumbria at Newcastle Student Paper	<1%
40	aterfa.alfa145.com Internet Source	<1%
41	getd.libs.uga.edu Internet Source	<1%
42	Understanding Science Teachers' Professional Knowledge Growth, 2015. Publication	<1%
43	open.uct.ac.za Internet Source	<1%
44	vital.seals.ac.za Internet Source	<1%
45	Submitted to University of KwaZulu-Natal Student Paper	<1%
46	ebin.pub Internet Source	

		<1%
47	ugspace.ug.edu.gh Internet Source	<1%
48	"Learning for sustainability in times of accelerating change", Wageningen Academic Publishers, 2012 Publication	<1%
49	Submitted to Anglia Ruskin University Student Paper	<1%
50	Michael R. Mack, Marcy H. Towns. "Faculty beliefs about the purposes for teaching undergraduate physical chemistry courses", Chemistry Education Research and Practice, 2016 Publication	<1%
51	Submitted to University of Venda Student Paper	<1%
52	Wu, Peng. "Examining Pedagogical Content Knowledge (PCK) for Business English Teaching: Concept and Model", Ritsumeikan Asia Pacific University, 2013. Publication	<1%
53	d1c337161ud3pr.cloudfront.net Internet Source	<1%
54	opencommons.uconn.edu	

Internet Source

	Internet Source	<1%
55	Submitted to Bellbird Park State Secondary College Student Paper	<1%
56	Submitted to University College London Student Paper	<1%
57	allafrica.com Internet Source	<1%
58	theses.gla.ac.uk Internet Source	<1%
59	Submitted to National School of Business Management NSBM, Sri Lanka Student Paper	<1%
60	Submitted to University of South Africa Student Paper	<1%
61	jultika.oulu.fi Internet Source	<1%
62	Submitted to University of Hull Student Paper	<1%
63	events.saip.org.za Internet Source	<1%
64	www.dc2rvarail.com Internet Source	<1%
65	www.mona.uwi.edu	<1%

65	www.mona.uwi.edu Internet Source	<1%
66	www.sahrc.org.za Internet Source	<1%
67	pdxscholar.library.pdx.edu Internet Source	<1%
68	rucore.libraries.rutgers.edu Internet Source	<1%
69	Takashi Toriizuka. "Application of performance shaping factor (PSF) for work improvement in industrial plant maintenance tasks", International Journal of Industrial Ergonomics, 2001 Publication	<1%
70	www.clearias.com Internet Source	<1%
71	A Sondlo, U Ramnarain. "The South African pre-service teacher's physics pedagogical orientations.", Journal of Physics: Conference Series, 2020 Publication	<1%
72	Hatice Belge Can. "Learning Science Teaching by Taking Advantages of Lesson Study: An Effective Form of Professional Development", Journal of Educational Issues, 2019 Publication	<1%
73	helda.helsinki.fi Internet Source	<1%

73	helda.helsinki.fi Internet Source	<1%
74	scholarworks.waldenu.edu Internet Source	<1%
75	wrap.warwick.ac.uk Internet Source	<1%
76	www.africanminds.co.za Internet Source	<1%
77	www.coursehero.com Internet Source	<1%
78	www.math.columbia.edu Internet Source	<1%
79	5dok.net Internet Source	<1%
80	Ndaba Xolisile, Dube Bekithemba. "Critical Emancipatory Research Approach to Enhance Performance Among Progressed Learners in Life Sciences", Mediterranean Journal of Social Sciences, 2021 Publication	<1%
81	Submitted to Nottingham Trent University Student Paper	<1%
82	Sinem Uner, Huseyin Akkus. "Secondary students' perceptions of their teachers' pedagogical content knowledge: a scale	<1%

development study", Teacher Development,

development study", Teacher Development, 2019
Publication

83	Yael Shwartz, Emil Eidin, Debora Marchak, Miri Kesner et al. "A Holistic Approach to Incorporating Sustainability into Chemistry Education in Israel", American Chemical Society (ACS), 2020 Publication	<1 %
84	acuresearchbank.acu.edu.au Internet Source	<1 %
85	banglajol.info Internet Source	<1 %
86	digital.unam.edu.na Internet Source	<1 %
87	dspace.knust.edu.gh Internet Source	<1 %
88	egitimvebilim.ted.org.tr Internet Source	<1 %
89	fr.slideshare.net Internet Source	<1 %
90	openaccess.leidenuniv.nl Internet Source	<1 %
91	repository.bilkent.edu.tr Internet Source	<1 %

92	repository.nwu.ac.za Internet Source	<1 %
93	researchbank.rmit.edu.au Internet Source	<1 %
94	researchcommons.waikato.ac.nz Internet Source	<1 %
95	silo.pub Internet Source	<1 %
96	tpls.academypublication.com Internet Source	<1 %
97	westminsterresearch.westminster.ac.uk Internet Source	<1 %
98	wordpress.caset.buffalo.edu Internet Source	<1 %
99	worldwidescience.org Internet Source	<1 %
100	www.grafiati.com Internet Source	<1 %
101	www.slideshare.net Internet Source	<1 %
102	Deborah L. Hanuscin, Michele H. Lee, Valarie L. Akerson. "Elementary teachers' pedagogical content knowledge for teaching the nature of science", Science Education, 2011 Publication	<1 %

102	Deborah L. Hanuscin, Michele H. Lee, Valarie L. Akerson. "Elementary teachers' pedagogical content knowledge for teaching the nature of science", Science Education, 2011 Publication	<1 %
103	Matthias Krepf, Wilfried Plöger, Daniel Scholl, Andreas Seifert. "Pedagogical content knowledge of experts and novices-what knowledge do they activate when analyzing science lessons?", Journal of Research in Science Teaching, 2018 Publication	<1 %
104	Tatyana Novossiolova. "Governance of Biotechnology in Post-Soviet Russia", Springer Science and Business Media LLC, 2017 Publication	<1 %
105	Sedef Canbazoglu Bilici, S. Selcen Guzey, Havva Yamak. "Assessing pre-service science teachers' technological pedagogical content knowledge (TPACK) through observations and lesson plans", Research in Science & Technological Education, 2016 Publication	<1 %
106	digitalscholarship.unlv.edu Internet Source	<1 %