INTEGRATION OF EDUCATION FOR SUSTAINABLE DEVELOPMENT INTO THE LIFE SCIENCES CURRICULUM: TEACHERS' PEDAGOGICAL CONTENT KNOWLEDGE AND PROFESSIONAL DEVELOPMENT

By

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DECLARATION

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I, *Khathutshelo Ronald Munasi*, affirm that the presented thesis is the result of my own effort, and I have appropriately identified and acknowledged all sources I utilized or quoted through comprehensive references.

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Abstract

This study explores enhancing Life Science teachers' pedagogical content knowledge (PCK) through professional development to facilitate seamless integration of Education for Sustainable Development (EE/ESD) into the curriculum. Despite EE/ESD being part of the South African curriculum for over two decades, teachers often struggle due to limited environmental knowledge. Anecdotal evidence reveals ongoing challenges, including a lack of effective teaching strategies and insufficient continuous professional development support.

This study adopted a synthesis of three key theories: Pedagogical Content Knowledge (PCK), the Theory of Educational Change, and Social Learning Theory. The research aims to identify essential professional development initiatives for nurturing teachers' PCK and integrating EE/ESD into their curriculum. Employing an exploratory case study approach, the study focuses on four secondary schools in the Vhembe East district, Limpopo province, South Africa. Data collection methods include document analysis, semi-structured interviews, and participant observations, forming the basis for constructing the Integrated Professional Development Model. Thematic analysis underscores a gap in explicit guidelines for EE/ESD integration, despite teachers demonstrating proficiency in concepts and strategies.

Recommendations from the study advocate for targeted professional development initiatives tailored to meet teachers' diverse needs. Moreover, the study emphasizes advocating for equitable distribution of resources to support EE/ESD integration. Collaboration between subject advisors and policymakers is deemed essential for developing clear guidelines supporting diverse teaching strategies effectively. Additionally, the study strongly endorses systematically integrating the Integrated Professional Development Model into various educational practices. This versatile model can be applied across teacher training programs, workshops, curriculum enhancements, support structures, advocacy efforts, resource allocation, guideline development, community engagement, and continuous evaluation, fostering a holistic and sustainable approach to EE/ESD integration within the curriculum.

KEY TERMS: *Environmental Education; Education for sustainable development; Environment; professional development; Pedagogical Content Knowledge, Teachers.*

Abstract

Lolu cwaningo luhlola ulwazi oluthuthukisiwe lwezifundo zothisha be-Life Science (PCK) ngokuthuthukiswa kochwepheshe ukuze kube lula ukuhlanganiswa kwe-Education for Sustainable Development (EE/ESD) ohlelweni lwezifundo. Naphezu kokuthi i-EE/ESD ibiyingxenye yohlelo lwezifundo eNingizimu Afrika iminyaka engaphezu kwamashumi amabili, othisha bavamise ukuthwala kanzima ngenxa yolwazi oluncane lwezemvelo. Ubufakazi benganekwane buveza izinselele eziqhubekayo, okuhlanganisa ukuntuleka kwamasu okufundisa aphumelelayo kanye nokwesekwa okwanele kokuthuthukiswa kochwepheshe.

Lolu cwaningo lwamukele ukuhlanganiswa kwamathiyori amathathu abalulekile: Ulwazi Lokuqukethwe Kwezemfundo (PCK), I-Theory of Educational Change, kanye ne-Social Learning Theory. Lolu cwaningo luhlose ukuhlonza izinhlelo ezibalulekile zokuthuthukiswa kochwepheshe zokuthuthukisa i-PCK yothisha kanye nokuhlanganisa i-EE/ESD ohlelweni lwabo lwezifundo. Ngokusebenzisa indlela yokuhlola izibonelo eziningi, ucwaningo lugxile ezikoleni ezine zamabanga aphezulu esifundeni saseVhembe East, esifundazweni saseLimpopo, eNingizimu Afrika. Izindlela zokuqoqwa kwedatha zifaka phakathi ukuhlaziywa kwamadokhumenti, izingxoxo ezingahleliwe, kanye nokubhekwa kwabahlanganyeli, okwenza isisekelo sokwakha Imodeli Yokuthuthukiswa Kochwepheshe Edidiyelwe. Ukuhlaziywa kwetimu kugcizelela igebe kuzinkombandlela ezicacile zokuhlanganiswa kwe-EE/ESD, naphezu kothisha ababonisa ubungcweti emicabangweni nasemasu.

Izincomo ezivela kummeli wocwaningo mayelana nezinhlelo ezihlosiwe zokuthuthukiswa kochwepheshe eziklanyelwe ukuhlangabezana nezidingo ezihlukahlukene zothisha. Ngaphezu kwalokho, ucwaningo lugcizelela ukumela ukusatshalaliswa ngokulinganayo kwezinsiza ukuze kusekelwe ukuhlanganiswa kwe-EE/ESD. Ukusebenzisana phakathi kwabeluleki bezifundo nabakhi benqubomgomo kuthathwa njengokubalulekile ukuze kwakhiwe imihlahlandlela ecacile esekela amasu ahlukahlukene okufundisa ngempumelelo. Ukwengeza, ucwaningo lugunyaza ngokuqinile ukuhlanganisa ngokuhlelekile Imodeli Yokuthuthukiswa Kochwepheshe Edidiyelwe ezinkambisweni ezihlukahlukene zemfundo. Le modeli eguquguqukayo ingasetshenziswa kuzo zonke izinhlelo zokuqeqesha othisha, ama-workshops, ukuthuthukiswa kwekharikhulamu, izinhlaka zokweseka, imizamo yokumela,

ukwabiwa kwezinsiza, ukuthuthukiswa kwemihlahlandlela, ukusebenzelana nomphakathi, nokuhlola okuqhubekayo, okugqugquzela indlela ephelele neqhubekayo yokuhlanganiswa kwe-EE/ESD ngaphakathi kwekharikhulamu.

IMIGOMO EYINGQONDO: Imfundo Yezemvelo; Imfundo yentuthuko esimeme; Imvelo; ukuthuthukiswa kochwepheshe; Ulwazi Lokuqukethwe Kwezokufundisa, Othisha.

Xianakanyiwa

Dyondzo leyi yi lavisisa ku ndlandlamuxa vutivi bya nhundzu ya dyondzo ya vadyondzisi va Sayense ya Vutomi (PCK) hi ku tirhisa nhluvukiso wa xiphurofexinali ku olovisa ku hlanganisiwa loku nga na swiphiqo ka Dyondzo ya Nhluvukiso lowu Yaka emahlweni (EE/ESD) eka kharikhulamu. Hambi leswi EE/ESD yi nga xiphemu xa kharikhulamu ya Afrika-Dzonga ku tlula makume mambirhi ya malembe, vadyondzisi va tala ku tikarhata hikwalaho ka vutivi lebyi nga nyawuriki bya mbango. Vumbhoni bya switori byi paluxa mintlhontlho leyi yaka emahlweni, ku katsa na ku pfumaleka ka tindlela to dyondzisa leti tirhaka na nseketelo lowu nga enelangiki wa nhluvukiso wa xiphurofexinali lowu yaka emahlweni.

Dyondzo leyi yi amukerile nkatsakanyo wa tithiyori tinharhu ta nkoka: Vutivi bya Vuxokoxoko bya Dyondzo (PCK), Tiyori ya ku Cinca ka Dyondzo, na Tiyori ya Dyondzo ya Ntshamisano. Ndzavisiso wu kongomisa ku kuma migingiriko ya nkoka ya nhluvukiso wa xiphurofexinali eka ku kurisa PCK ya vadyondzisi na ku hlanganisa EE/ESD eka kharikhulamu ya vona. Hi ku tirhisa endlelo ra dyondzo ya timhaka ya vukambisisi byo tala, ndzavisiso wu kongomisa eka swikolo swa mune swa sekondari eka xifundzankulu xa Vhembe East, exifundzheninkulu xa Limpopo, Afrika-Dzonga. Maendlelo yo hlengeleta datha ya katsa nxopaxopo wa matsalwa, mimbulavurisano leyi nga hlelekangiki ngopfu, na ku langutisisa ka vatekaxiave, leswi vumbaka xisekelo xo aka Modele wa Nhluvukiso wa Xiphurofexinali lowu Hlanganisiweke. Nxopaxopo wa nhlokomhaka wu kandziyisa xivandla eka swiletelo leswi nga erivaleni swa ku hlanganisiwa ka EE/ESD, hambileswi vadyondzisi va kombisaka vutshila eka miehleketo na maqhinga.

Switsundzuxo ku suka eka ndzavisiso swi seketela migingiriko ya nhluvukiso wa xiphurofexinali leyi kongomisiweke leyi lulamisiweke ku fikelela swilaveko swo hambana swa vadyondzisi. Ku tlula kwalaho, ndzavisiso wu kandziyisa ku seketela ku hangalasiwa hi ku ringana ka switirhisiwa ku seketela ku hlanganisiwa ka EE/ESD. Ntirhisano exikarhi ka vatsundzuxi va tidyondzo na vaendli va tipholisi wu tekiwa wu ri wa nkoka ku tumbuluxa swiletelo leswi nga erivaleni leswi seketelaka tindlela to hambana to dyondzisa hi ndlela leyinene. Ku engetela kwalaho, ndzavisiso wu seketela swinene ku hlanganisa hi ndlela leyi hlelekeke Modele wa Nhluvukiso wa Xiphurofexinali lowu Hlanganisiweke eka maendlelo yo hambana ya dyondzo. Modeli

leyi yo cinca-cinca yi nga tirhisiwa eka minongonoko hinkwayo ya ndzetelo wa vadyondzisi, tiwekhixopo, ku antswisiwa ka kharikhulamu, swivumbeko swa nseketelo, matshalatshala ya vuyimeri, ku averiwa ka switirhisiwa, nhluvukiso wa swiletelo, ku nghenelela ka vaaki, na ku kamberiwa loku yaka emahlweni, ku kurisa endlelo ro angarhela na leri nga heriki eka ku hlanganisiwa ka EE/ESD endzeni ka kharikhulamu.

MATIRHISELO YA NKOKA: Dyondzo ya Ntivo-mbango; Dyondzo ya nhluvukiso lowu nga heriki; Mbango; nhluvukiso wa xiphurofexinali; Vutivi bya Vuxokoxoko bya Dyondzo, Vadyondzisi.

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ATPs	Annual Teaching Plans
BA	Bachelor of Arts
BBA	Bachelor of Business Administration
BED	Bachelor of Education
BEDFET	Bachelor of Education and Further Education Training
CAPS	Curriculum and Assessment Policy Statement
CEO	Chief Executive Officer
cPCK	Collective Pedagogical Content Knowledge
CK	Content Knowledge
DBE	Department of Basic Education
DEFSD	Decade of Education for Sustainable Development
DFFE	Department of Forestry, Fisheries and the Environment
DHET	Department of Higher Education and Training
EE	Environmental Education
EEASA	Environmental Education Association of South African
EECI	Environmental Education Curriculum initiative
EEPI	Environmental Education Policy Initiative
ELRC	Educational Labour Relations Council
EPA	Environmental Protection Agency
ePCK	Enacted Pedagogical Content Knowledge
ESD	Education for Sustainable development
FET	Further Educational Training
GET	General Education and Training
IUCN	International Union for the Conservation of Nature and Natural resources
KZN	KwaZulu Natal

NCF	Nigerian Conservation Foundation
NCS	National Curriculum Statement
NEAC	National Environmental Awareness Council
NECC	National Education Coordination Committee
NEEP-GET	National Environmental Education Project for General Education and Training
NES	National Environmental Strategy
NGO	Non-Governmental Organisation
OBE	Outcome-Based Education
PD	Professional Development
pPCK	Personal Pedagogical Content Knowledge
PCK	Pedagogical Content Knowledge
PK	Pedagogical Knowledge
PLC	Professional Learning Communities
RCM	Refined Consensus Model
RNCS	Revised National Curriculum Statement
SADC	Southern Africa Development Community
SDGs	Sustainable Development Goals
SIDA	Swedish International Development Agency
TCK	Teacher Content Knowledge
TPD	Teacher Professional Development
UN	United Nations
UNEP	United Nation Environmental programme
UNESCO	United Nations Educational, Scientific and Cultural Organisation
UNISA	University of South Africa
UNSDGs	United Nations Sustainable Development Goal

USSR	Union of Soviet Socialist Republics
USA	United States of America
UVP	Umgeni Valley Project
WCED	World Commission on Environment and Development
WSSD	World Summit for Sustainable Development
WWF	Wildlife and the Wildlife Fund

CHAPTER 1: ORIENTATION OF THE STUDY

1.1 Introduction

This chapter serves as an introduction to the research endeavour, focusing on investigating the degree of integration of Education for Sustainable Development (EE/ESD) into the Life Sciences curriculum within selected schools. The primary objective of the study is to delve into the role of professional development in supporting the pedagogical content knowledge of Life Science teachers, with the aim of enhancing the seamless integration of EE/ESD into the curriculum. The specific context under scrutiny is the Vhembe East District in the Limpopo Province of South Africa. Commencing with an exploration of the background, the chapter navigates through various elements such as the context of the study, research problem, research questions, purpose of the study, study aims and objectives, rationale, theoretical framework, research methodology, limitations and delimitations, definition of terms, chapter outline, and concludes with closing remarks. Each section contributes to framing the study's foundation, providing a comprehensive overview of the key aspects that guide and inform the research journey.

1.2 Background

The unbridled exploitation of natural resources, commencing with the agricultural revolution and intensifying during the Industrial Revolution, coupled with the development paradigm inherent in capitalist societies, has culminated in the contemporary "ecological crisis" confronting humanity (Tiago, Rodrigues & Ramos, 2021: 49). Echoing this concern, at the summit held on September 24–25, 2019, in New York, where heads of state and government convened to discuss and assess the progress of the 2030 Agenda for Sustainable Development, the Secretary-General of the United Nations underscored that "the natural environment is deteriorating at an alarming rate" (The Sustainable Development Goals Report, 2019).

In response to the escalating exploitation of natural resources and the degradation of the natural environment, numerous world summits and conferences have convened across different countries. Pioneering this global discourse was the United Nations Conference on Human Environment, held in Stockholm in 1972 (UNESCO, 1972). This landmark conference laid the foundation for subsequent pivotal gatherings, including the Belgrade Charter (UNESCO, 1976), the Tbilisi Declaration (UNESCO, 1978), the Brundtland Report (WCED, 1987), the Rio Earth Summit (United Nations

Conference on Environment and Development, 1992), and the Johannesburg Summit, which took place in South Africa with the aim of discussing sustainable development, commemorated 10 years since the first Earth Summit in Rio de Janeiro (United Nations, 2002). The most recent significant conference addressing environmental concerns was the United Nations Summit on Sustainable Development, held in New York in 2015. This summit marked a crucial milestone with the establishment of the 2030 Agenda for Sustainable Development and its 17 Sustainable Development Goals. These goals represent a commitment to strike a balance between economic growth, environmental preservation, and social well-being (UNESCO, 2015).

Goal 4 of the United Nations Sustainable Development Goals (UNSDGs) emphasizes the significance of Education for Sustainable Development (ESD) within formal school settings, recognizing the imperative for providing professional development to educators, thereby enhancing the delivery of quality education by 2030 (The Sustainable Development Goals Report, 2019). Recognizing that sustainable development hinges on addressing global challenges such as poverty, inequality, and environmental degradation, the integration and implementation of ESD within formal contexts emerge as critical components. Consequently, the aim of this study is to scrutinize the extent to which ESD is integrated into the Life Science curriculum within selected schools. Throughout this study, the terms EE (Environmental Education) and ESD will be used interchangeably.

The initiative to integrate Environmental Education (EE) and Education for Sustainable Development (ESD) into global school curricula was initially advocated by UNESCO and other governmental agencies during the 1972 United Nations Conference on Human Environment in Stockholm. This conference marked a collaborative effort among nations, both affluent and economically challenged, to address environmental crises. Responding to this global call, South African policies, exemplified by the White Paper on Environmental Education (1995), actively endorsed the incorporation of EE/ESD into the school curriculum (Damoah & Adu, 2019). Additionally, Section 24 of the South African Constitution legally mandates the government to ensure that individuals not only refrain from harming the environment but are also cognizant of environmental crises and take responsible actions to address them. Section 24 of The South African Constitution states:

Everyone has the right- (a) to an environment that is not harmful to their health or wellbeing: and (b) to have the environment protected, for the benefit of present and future generations, through reasonable legislative measures that- (i) prevent pollution and ecological degradation; (ii) promote conservation; and (iii) secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development (The Constitution of the Republic of South Africa, 1996:9).

Within the South African education system, the imperative to integrate Environmental Education and Education for Sustainable Development (EE/ESD) is enshrined in Section 24 of the South African Constitution of 1996. The development of the National Curriculum Statement (NCS) aimed at realizing a cohesive curriculum with a systematic progression of concepts, as highlighted by Dada et al., (2009). However, a pivotal revision occurred in 2011, resulting in the introduction of an updated curriculum named the National Curriculum and Assessment Policy Statement (CAPS), which currently stands as the official document governing the educational landscape.

The CAPS document underscores the integration of Environmental Education and Education for Sustainable Development (EE/ESD) by infusing environmental themes across all school subjects throughout the General Education and Training (GET) and Further Education and Training (FET) phases (DBE, 2011). Damoah and Adu (2020) posit that, aligned with the ethos of the CAPS document, it is the responsibility of every teacher to cultivate learners' interest in environmental issues by seamlessly incorporating EE/ESD themes into their respective subjects. In the South African educational context, teachers are expected to analyse the content areas of their teaching subjects, identifying opportunities to integrate environmental themes without compromising the integrity of the core subject (DBE, 2011). Affirming this approach, UNESCO-UNEP in 1994 emphasized that the effective integration of EE/ESD themes across the curriculum significantly contributes to reshaping learners' behaviour towards the environment. Consequently, EE/ESD themes can be discerned in subjects such as Life Sciences, Languages, Agricultural Sciences, Arts, Geography, Economics, Business Studies, Tourism, Consumer Studies, Mathematics, and Mathematical Literacy during the FET phase. In the GET phase, these themes manifest in subjects like Natural Science, Social Sciences, Technology, Economic and

Management Sciences, Home Language, First Additional Language, and Life Skills across South African schools.

The awareness and understanding of teachers regarding the integration of Environmental Education and Education for Sustainable Development (EE/ESD) play a pivotal role in realizing the objectives of curriculum integration. The efficacy of the system may be compromised if teachers lack sufficient information about EE/ESD as an integrated component. Therefore, it becomes imperative to equip teachers with the necessary training and resources, empowering them to seamlessly integrate EE/ESD themes into their teaching subjects. This, in turn, aims to foster environmental awareness and sustainability among learners. This study seeks to address this crucial gap by identifying effective methods and providing guidelines to professionally support teachers in the seamless integration of EE/ESD into their subjects. Additionally, the study aspires to enhance environmental awareness and sustainability among teachers, fostering a ripple effect wherein they can impart this knowledge to their students. Ultimately, the goal is to contribute to a more informed and environmentally conscious educational landscape.

1.3 Context of the study

This study was carried out in the Limpopo province, a selection made for its convenience to the researcher. The choice of the province was facilitated by the researcher's origin from the same region, simplifying access to information-rich participants within the limited timeframe available for the research. Additionally, residing in the same province made it both convenient and financially viable for the researcher to obtain any supplementary information as needed. The study focused on a group of participants consisting of teachers specializing in Life Sciences and subject advisors for this subject.

The study was conducted in Limpopo province, situated in the northern part of South Africa. This province shares borders with neighbouring SADC (Southern Africa Development Community) countries, including Botswana to the west, Mozambique to the east, and Zimbabwe to the north. Geographically, Limpopo Province encompasses an area of approximately 125,754 square kilometres and is home to a population of 5,779,090, making it the fifth-largest province in South Africa (Cai, Magidi, Nhamo, van Koppen, 2017). According to Cai et al., (2017) Limpopo is characterized by a hot and subtropical climate with distinct wet and dry seasons. Renowned for its natural beauty, the province boasts several natural reserves and parks, including the iconic Kruger National Park. These areas are celebrated for their rich biodiversity and wildlife, attracting tourists from around the world (Cai et al., 2017).

Limpopo Province boasts a rich historical and cultural heritage, with traces of human habitation in the region dating back to ancient times. Throughout history, the province has been home to diverse indigenous groups, including the Venda, Tsonga, Pedi, and Northern Sotho, each contributing their unique languages, customs, and traditions (Cai et al., 2017). With ancient lands and pre-historic treasures, Limpopo is renowned for its cultural gems, featuring the legendary Rain Queen, Modjadji, the Stone Age and Iron Age relics of Makapansgat Valley, and the ancient wonders of the World Heritage site, Mapungubwe, dating back to time immemorial. Economically, Limpopo Province stands out for its wealth of natural resources, encompassing minerals like platinum, chrome, and coal, alongside a thriving agricultural sector and vibrant tourism industry (Britannica, 2023). The province plays a significant role in agriculture, with subsistence farming, commercial farming, and agribusiness serving as crucial contributors to its economy. However, Limpopo also grapples with challenges such as poverty, unemployment, and inequality, which pose obstacles to its economic development and the well-being of its inhabitants (Cai et al., 2017).

Environmental considerations bear significant weight in the study context of Limpopo Province, given its abundant biodiversity and natural resources. The province grapples with environmental challenges, including deforestation, soil erosion, pollution, and the impacts of climate change (Cai et al., 2017). Simultaneously, there are ongoing efforts to champion sustainable natural resource management, conservation, and the implementation of climate change adaptation and mitigation strategies (Britannica, 2023). The province comprises five districts: Capricorn, Greater Sekhukhune, Mopani, Vhembe, and Waterberg. This study specifically focused on the rural areas of the Vhembe District, which is further divided into Vhembe East and Vhembe West. The research was conducted within the Vhembe East District under the jurisdiction of Thulamela Municipality, where both Life Sciences teachers and subject advisors are actively engaged. These teachers and subject advisors collectively constitute the study's sample.

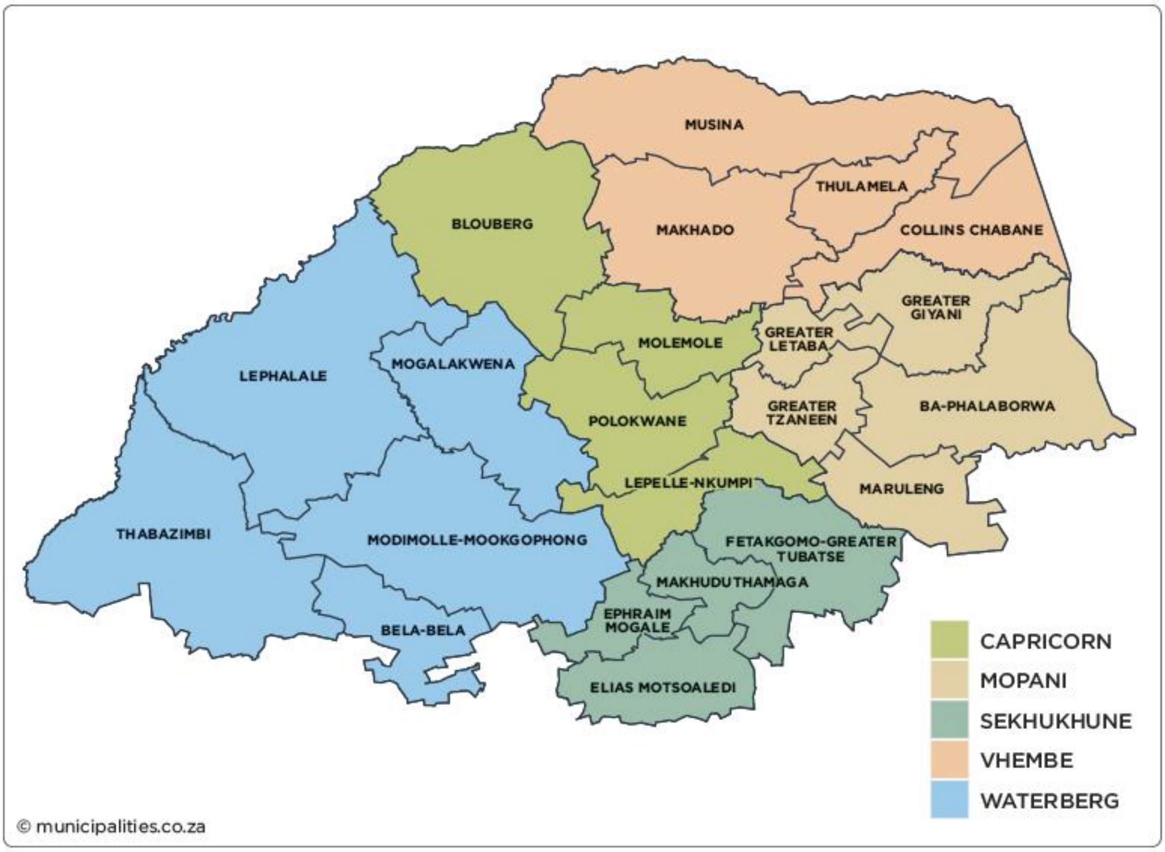

Figure 1.1: Map of Limpopo province showing all five Districts including Vhembe where the study will be conducted

1.4 Statement of the problem

The cultivation of environmentally literate citizens capable of sustainable environmental management hinges on Environmental Education and Education for Sustainable Development (EE/ESD) (Kimaryo, 2011:16). Schools, recognized as pivotal players in fostering such citizens, depend on the efficacy of teachers in heightening environmental awareness and seamlessly integrating EE/ESD into their subjects. In South Africa, educators grapple with challenges such as a lack of appropriate knowledge and skills for integrating EE/ESD, limited teaching and learning resources, time constraints, and large class sizes (Tsotetsi, 2021; Ntuli et al., 2022). Similar challenges are reported in Nigeria, where inappropriate teaching strategies, insufficient content knowledge, and pedagogical content knowledge impede the learning of EE (Aladejebi, 2020). Furthermore, in South Africa, Damoah (2019) identified that teachers face difficulties with the approach to integrate EE/ESD into the school curriculum, as it is not explicitly indicated in the CAPS document. They often prioritize examinable content due to an exam-oriented approach to teaching.

The role of teachers in implementing environmental education and nurturing environmentally literate citizens is pivotal. To fortify this role, the government should prioritize the development of a curriculum with explicit goals and content, enhance teachers' capacity in teaching Environmental Education and Education for Sustainable Development (EE/ESD), and ensure the provision of necessary teaching and learning materials. However, Damoah (2019) highlights a lack of clarity and policy guidelines for integrating EE/ESD as outlined in the CAPS document, leading to confusion among teachers. The prevailing exam-oriented approach to teaching, coupled with teachers' insufficient basic knowledge about the environment, further impedes the seamless integration of EE/ESD into subjects (Munasi & Madikizela, 2020; Damoah, 2019). Therefore, there is a critical need for continuous professional development and support for teachers to enhance their environmental literacy and promote resource sustainability in schools (Ever, 2012). This includes interpreting and understanding the specific areas that need coverage in individual subject curricula and fostering personal professional agency (Masemene & Msezane, 2021).

The primary challenges impeding the successful implementation of Environmental Education and Education for Sustainable Development (EE/ESD) encompass the absence of an integrated learning approach, insufficient knowledge about EE/ESD, insufficient support from school administration and peers, and the influence of cultural myths and beliefs (Mwendwa, 2017). While the Department of Forestry, Fisheries and the Environment (DFFE) and the Department of Basic Education (DBE) play crucial roles in ESD implementation in the country, there is a recognized need for improved planning and structuring of EE/ESD integration into subjects to ensure effective execution (Damoah, 2019). To address these challenges, continuous professional development for EE/ESD teachers is essential, enhancing their interpretation of subject curricula and cultivating professional agency (Ever, 2012). This study seeks to address the existing gap stemming from the lack of clarity and policy guidelines for integrating EE/ESD into the South African school curriculum. The aim is to develop comprehensive guidelines that can support Grade 11 Life Sciences teachers in effectively incorporating EE/ESD topics into their subjects.

1.5 Research questions

The main research question of this study was:

How is the pedagogical content knowledge of Life Science teachers reinforced through professional development to advance the seamless integration of Environmental Education and Education for Sustainable Development (EE/ESD) into the Life Sciences curriculum?

The sub questions of this study are as follows:

- What is the existing extent of coverage of Environmental Education and Education for Sustainable Development (EE/ESD) within the Life Science curriculum?
- Which teaching strategies are presently employed by teachers to integrate EE/ESD into the Life Science curriculum?
- What are the primary challenges encountered by teachers when integrating EE/ESD into the Life Science curriculum?
- Which professional development initiatives are currently accessible to support teachers in integrating EE/ESD into the Life Science curriculum?
- What key elements should be incorporated as guidelines for Life Sciences teachers to proficiently integrate EE/ESD into their lessons?

1.6 Aims, objectives and purpose of the study

The study investigated the integration of Environmental Education and Education for Sustainable Development (EE/ESD) into the Life Science curriculum within selected schools. The outcomes of this research have played a significant role in crafting an integrated professional development model. This model incorporates guidelines on leveraging teacher professional development initiatives to facilitate the seamless integration of EE/ESD into the teaching of Life Sciences.

1.6.1 Aim of the study

The aim of this study was to explore how professional development contributes to the enhancement of Life Science teachers' pedagogical content knowledge for the integration of Environmental Education and Education for Sustainable Development (EE/ESD) into the Life Sciences curriculum.

1.6.2 Objectives of the study

- Examine the current extent of coverage of Environmental Education and Education for Sustainable Development (EE/ESD) within the Life Science curriculum.
- Identify the teaching strategies currently employed by teachers to integrate EE/ESD into the Life Science curriculum.
- Examine the primary challenges faced by teachers when integrating EE/ESD into the Life Science curriculum.
- Evaluate the accessibility and effectiveness of existing professional development initiatives supporting teachers in integrating EE/ESD into the Life Science curriculum.
- Determine key elements to be incorporated as guidelines for Life Science teachers to adeptly integrate EE/ESD into their lessons.

1.7 Rationale of the study

The justification for this study stems from the observation that Environmental Education and Education for Sustainable Development (EE/ESD) is not effectively incorporated into the current South African school curriculum. Despite its inclusion in the curriculum for the General Education and Training (GET) and Further Education and Training (FET) phases, the integration of EE/ESD is not uniform across all subjects (Damoah, 2019). Additionally, the South African public school curriculum policy framework lacks explicit guidelines on how EE/ESD should be integrated into teaching, and there is an absence of policy guidance for teachers, impeding the seamless implementation of EE/ESD as an integrated component (Damoah & Adu, 2019; Hebe, 2021). This study aims to develop guidelines that can assist the Department of Basic Education (DBE), Department of Forestry, Fisheries and the Environment (DFFE), and other key educational stakeholders in enhancing teachers' integration of environmental education into Life Sciences.

Researchers like Damoah and Adu (2020), Hebe (2021), and Tsotetsi (2021) have underscored persistent challenges in the integration of Environmental Education and Education for Sustainable Development (EE/ESD) within schools. These challenges encompass a scarcity of teaching and learning resources, time constraints, and large class sizes, all of which impede teachers from effectively incorporating EE/ESD into their subjects. Moreover, the absence of training for teachers on how to seamlessly integrate EE/ESD into their lessons underscores the need for professional development to enhance teachers' content knowledge and instructional strategies in this domain. The findings from these studies have served as a catalyst for the current research, aiming to address the existing gaps in teachers' knowledge and understanding of integrating EE/ESD into their subjects, particularly in the context of Life Sciences.

The impetus behind this study is rooted in the escalating environmental challenges faced not only by South Africa but also by the global community. Predominant among these challenges are issues such as pollution, poverty, health hazards, overpopulation, urbanization, waste, littering and recycling, the greenhouse effect, global warming, deforestation, and the depletion of natural resources (Loubser et al., 2014:2). Recognizing the importance of fostering awareness among the younger generation about these challenges, Environmental Education and Education for Sustainable Development (EE/ESD) play pivotal roles in addressing these environmental issues. Teachers, as key influencers, bear the responsibility of guiding the younger generation in implementing EE/ESD for a sustainable future. However, the insights from prior studies, as highlighted by Mwendwa (2017), Sikhosana (2022), and Kimaryo (2011), underscore that teachers lack adequate knowledge and understanding of how to effectively integrate EE/ESD into their subjects, including pedagogical knowledge. Therefore, this study contributes to the existing body of knowledge by exploring how professional development can enhance the pedagogical content knowledge of Life Sciences teachers and support their integration of environmental education into their lessons.

1.8 Theoretical framework

As posited by Grant and Osanloo (2014), a theoretical framework serves as a comprehensive "blueprint" for the entire dissertation, offering guidance from philosophical, epistemological, methodological, and ontological perspectives. This study adopted a synthesis of three key theories: Pedagogical Content Knowledge (PCK), the Theory of Educational Change, and Social Learning Theory. The selection of these theories is grounded in their collective contribution to comprehending the rationale for the integration of Environmental Education and Education for Sustainable Development (EE/ESD) into the Life Sciences curriculum. Pedagogical Content

Knowledge (PCK) theory, as proposed by Shulman (1987), provides a framework delineating the skills, knowledge, teaching strategies, and classroom management essential for Life Sciences teachers to proficiently integrate EE/ESD into their subject curriculum. PCK serves as a guide in this study, outlining the specific competencies that teachers must acquire over time to enhance students' understanding. This theory plays a pivotal role in addressing the identified gap concerning the teaching strategies that support Life Science teachers in integrating EE/ESD into their curriculum.

Fullan's educational change theory was selected for this study due to its elucidation of the sequential events that instigate change in the educational system. The theory's advantage lies in providing a structured framework outlining the requisite steps when implementing Environmental Education and Education for Sustainable Development (EE/ESD) into the Life Sciences curriculum. Fullan's theory also delves into the factors influencing the implementation of educational change, thereby aiding in addressing gaps related to overcoming challenges encountered by Life Sciences teachers during the integration of EE/ESD into their subject curriculum. Bandura's social learning theory, recognized for its versatility, is harnessed in this study. As highlighted by Nabavi (2012), one of its strengths lies in its adaptability to elucidate an individual's behaviour or learning. According to social learning theory, alterations in a person's environment can precipitate changes in their behaviour. In this study, the theory functions as a framework to examine whether the behaviour of Life Sciences teachers in integrating EE/ESD into their subject curriculum will change when they are supported in altering their environment. This application of the theory addresses the gap concerning how subject advisors support teachers in integrating EE/ESD into the Life Science curriculum.

The integration of the three selected theories allowed the researcher to effectively address the primary research question of the study: How is the pedagogical content knowledge of Life Science teachers reinforced through professional development to advance the seamless integration of Environmental Education and Education for Sustainable Development (EE/ESD) into the Life Science curriculum? Additionally, this theoretical amalgamation aimed to bridge the identified gap by developing guidelines to assist Grade 11 Life Sciences teachers in integrating EE/ESD content into their curriculum. Detailed discussions on these three theories are presented in

Chapter 3 of this study. Table 1.1 below delineates the three theories along with their respective components.

Table 1.1 Pedagogical content knowledge theory, educational change theory and social learning theory with their components

Theory	Components
1. Pedagogical content knowledge	Content knowledge
	Pedagogical knowledge
	Pedagogical content knowledge
2. Educational change theory	Initiation
	Implementation
	Institutionalization
3. Social learning theory	Attention
	Retention
	Reproduction
	Motivation

1.9 Research methodology

According to Goundar (2012), research methodology delineates the procedures employed in conducting research. The exploration of research methodology serves to enlighten the reader on how the study was conducted and how the research findings were attained.

1.9.1 Research paradigm

This study embraced the interpretive paradigm. According to Cohen, Manion, and Morrison (2018), a research paradigm functions as a lens through which a phenomenon is observed. Guba and Lincoln (1994) explain that a research paradigm is characterized by how scientists respond to fundamental questions concerning ontology, epistemology, and methodology. Ontology delves into the researcher's beliefs about truth, reality, and the existence of that truth and reality (Snape & Spencer, 2003). Epistemology is the philosophical underpinning that elucidates how humans acquire and communicate knowledge (Crotty, 1998). Methodology encompasses a broad spectrum, encompassing a study's research design, methods, approach, and procedure (McMillan & Schumacher, 2010). The interpretivist paradigm, as articulated by Cohen et al. (2018), aims to comprehend the subjective world of human experience (in this study, Life Science teachers) and extract meaning from shared aspects of individuals' experiences.

1.9.2 Research approach

Creswell and Creswell (2018) define the research approach as the structure and plan employed by a researcher to gather evidence. Research approaches can be qualitative, quantitative, or a mixed method involving both. This study opted for a qualitative research approach. In the qualitative approach, as elucidated by Cohen et al. (2018), data are collected on naturally occurring phenomena, and the data are in the form of words, not numbers. According to Sutton and Austin (2015), the qualitative approach necessitates an understanding of human behaviour and the reasoning that governs it. In this study, the qualitative method was employed to scrutinize the behaviour and attitudes of teachers regarding the integration of environmental education into their lessons. The qualitative method enabled the exploration of participants' thoughts, opinions, and beliefs (Sutton & Austin, 2015). Therefore, this approach facilitated a deeper understanding of how Life Science teachers' pedagogical content knowledge is supported through professional development to enhance the integration of Environmental Education and Education for Sustainable Development (EE/ESD) into the Life Science curriculum.

1.9.3 Research design

According to Creswell and Creswell (2018), a research design encompasses data collection, data analysis, and report writing, serving to integrate all the elements of the research into a cohesive study. Creswell (2013) elucidates that a comprehensive research design must incorporate four main components: the strategy, the conceptual framework, questions shaping the study, and the tools and procedures used for collecting and analysing empirical materials. In alignment with these principles, this study adopted a case study design. A case study design, as described by Creswell (2014), is an inquiry framework utilized across various fields of study. It allows the researcher to conduct an in-depth analysis of the causal factors, event processes, or activities involving one or more individuals. As emphasized by Cohen et al. (2018), cases are bound by specific time and activity constraints, requiring the utilization of diverse data collection methods over a designated period. Incorporating multiple data sources in case studies is imperative to avoid a singular perspective, aiming for a more profound understanding of the phenomenon under investigation (Baxture & Jack, 2008). Yin (2014) outlines three potential methodologies for case studies: descriptive, explanatory, and exploratory. This study adhered to an exploratory case study design, focusing on an in-depth analysis of multiple cases to gain a deeper insight and understanding of how Life Sciences teachers are supported in integrating Environmental Education and Education for Sustainable Development (EE/ESD) into their lessons.

1.9.4 Population and Sampling strategies

1.9.4.1 Population

Shukla (2020) defines population as "the set or group of all the units on which the findings of the research are to be applied." Creswell (2013) contends that a population comprises individuals who share certain characteristics. In the context of this study, the population consisted of all Life Sciences teachers from the three selected circuits and all Life Sciences subject advisors from the Vhembe East District.

1.9.4.2 Sampling strategies

According to Polit and Hungler (1999), "sampling" refers to the process of selecting a subset of a population to serve as a representative stand-in for the entire population. The choice of sampling strategies is contingent on the research approach, whether it is quantitative, qualitative, or a mixed method (Creswell, 2013). A fundamental distinction between quantitative and qualitative sampling, as highlighted by Creswell (2013), is that the former adheres to probability methods, while the latter employs non-probability methods. Various sampling strategies are recognized, including random sampling and stratified sampling for quantitative approaches, and purposive sampling, quota sampling, convenience sampling, and snowball sampling for qualitative methodologies (McMillan & Schumacher, 2010). In this study, purposive sampling was employed. Four schools from the Vhembe East District were purposively selected. These schools were drawn from three distinct circuits, and one Grade 11 Life Sciences teacher was purposively selected from each school. Additionally, three Life Sciences subject advisors were purposively selected for the Vhembe East District.

1.9.5 Data collection methods

Data collection is the "process of gathering and measuring information on variables of interest in a systematic fashion that enables one to answer the research question" (Creswell, 2013: 81). McMillan and Schumacher (2010:326) identify five major methods of data collection: observation, interviews, questionnaires, document analysis, and audio-visual materials. In this study, a combination of document analysis, observation, and semi-structured interviews was employed for data collection.

1.9.5.1 Document analysis

Document analysis, as described by Bowen (2009), is a method for reviewing electronic or printed documents. McMillan and Schumacher (2010:361) identify three different kinds of documents: personal documents like diaries and letters; official documents like policy statements and personal files; and object symbols that are used to infer meanings and values. In this study, the analysis focused on official documents, including the CAPS document for Grade 10–12, with a specific emphasis on Grade 11 due to its substantial coverage of EE/ESD content. Textbooks for Grade 11 used at each school were also analysed as official documents.

These documents were scrutinized to address the question: "What is the existing extent of coverage of Environmental Education and Education for Sustainable Development (EE/ESD) within the Life Science curriculum?" The CAPS document was obtained online and printed for accessibility in hard copy. Textbooks and Annual Teaching Plans (ATPs) were requested from the participants to account for variations in the choice of textbooks among different schools.

1.9.5.2 Semi-structured Interviews

Semi-structured interviews, a qualitative data-gathering technique, involve a researcher asking a series of predetermined open-ended questions (Creswell, 2012). In this study, one-on-one semi-structured interviews were conducted to allow participants to comfortably express their views in the presence of only the researcher. An interview guide was used, containing a list of questions arranged from simple to complex. Separate interview guides were designed for teachers and subject advisors. These face-to-face interviews were scheduled after contacting participants telephonically. Permission was sought to record the participants' responses using an audio recorder. Audio recording facilitated thorough discussions on the questions, and probing questions were employed during the interviews to gather comprehensive information about the integration of EE/ESD in their lessons. The recorded interviews were later transcribed during the data analysis process.

1.9.5.3 Observation

Observation, as defined by McKechnie (2008), involves systematic and meaningful looking and listening, relying on one's senses. Creswell (2012) expands on this, describing observation as the process of gathering open-ended, first-hand data by systematically observing people and locations at a research site. In this study, the researcher observed Grade 11 Life Sciences teachers during their classes while teaching topics with EE/ESD content. Observations can take various roles, such as participant-observer (actively involved in activities at the research site), non-participant observer (observing and recording notes without involvement), or changing observational roles (shifting between participant and non-participant roles) (Creswell, 2012). For this study, the researcher assumed the role of a non-participant observer, allowing for the observation and simultaneous recording of notes while Life Sciences teachers taught topics with EE/ESD content.

1.9.6 Data analysis

Thematic analysis, as described by Dawadi, Shrestha, and Giri (2021), is a qualitative research technique used to systematically organize and examine extensive amounts of data. Maguire and Delahunt (2017) define it as the process of recognizing patterns or themes in qualitative data. In this study, the researcher followed the six-step structure introduced by Braun and Clarke (2006) for thematic analysis. Braun and Clarke's (2006) six-step structure involves: a) Getting familiar with the data; b) Creating initial codes; c) Exploring themes; d) Reviewing themes; e) Defining themes; f) Writing up. This framework was chosen for its straightforward and pragmatic approach to conducting thematic analysis.

1.9.8 Ethical issues

Firstly, I initiated the process by seeking ethical clearance from UNISA. Upon obtaining the ethical clearance certificate, I proceeded to request permission from the Limpopo Department of Education to conduct research in the chosen district. Subsequently, I sought permission from the Vhembe East District to carry out the research in the selected schools. Permission was then requested from the circuit managers of the three chosen circuits. Following this, I obtained approval from the school principals and, subsequently, from the Life Sciences teachers in Grade 11. For the subject advisors, permission to conduct research was sought from their circuit manager before approaching the advisors for their participation. Throughout the process, participants were encouraged to ask any questions for clarification, and the researcher maintained transparency by providing comprehensive information about all aspects of the study. Participants were assured that the information they shared would be treated with the utmost confidentiality, and their privacy would be safeguarded. Moreover, participants were explicitly informed that their involvement in the study was entirely voluntary, granting them the freedom to withdraw at any stage.

1.10 Limitations and Delimitations

The aim of this study was to investigate the extent of the integration of EE/ESD into the Life Science curriculum in selected schools. Consequently, one limitation of the study is that it does not provide insights into all school subjects, despite the expectation that EE/ESD should be integrated into the curriculum across all subjects. Given that Life Sciences is exclusively taught in secondary schools, the study focused solely on secondary education. Due to constraints in time, resources, and funding, the researcher opted to examine four secondary schools within the Vhembe East District. The limited sample size precluded the use of a quantitative approach, leading to the adoption of a qualitative methodology where data was expressed in narrative form. The study concentrated specifically on Grade 11 Life Sciences, and the sample was confined to Grade 11 Life Sciences teachers from the four selected schools, selected through purposeful sampling as outlined in the sampling methods section.

1.11 Definition of key concepts

1.11.1 Environmental Education

Environmental education can be conceptualized as a dynamic process that empowers individuals to explore environmental issues actively and engage in problem-solving endeavours, enabling them to take proactive measures for environmental improvement (Environmental Protection Agency, 2017). Participation in environmental education equips individuals with a heightened comprehension of environmental concerns, fostering their capacity to make well-informed decisions. The International Union for Conservation of Nature (IUCN, 1971) defines environmental education as the systematic progression of recognizing values, elucidating concepts, and cultivating skills and attitudes. This multifaceted approach aims to facilitate an understanding and appreciation of the intricate interconnectedness among people, their cultural contexts, and the biophysical environment.

1.11.2 Integration

The term "integration" encompasses the amalgamation of distinct elements into a unified whole, as outlined by Hughes (2004). Additionally, McNeil (1996) underscores the significance of "integration" as a method for organizing content. The process of integration requires transformative measures within educational institutions, potentially involving a reassessment of educational goals and objectives or implementing activities that encourage parental involvement in classroom dynamics and organization (McNeil, 1996). In the scope of this inquiry, integration specifically pertains to the fusion of Environmental Education (EE) with the study of Life Sciences.

1.11.3 Teacher professional development

Teacher Professional Development (TPD), as outlined by Thenga et al. (2020), refers to in-service teacher education that enhances teachers' subject-matter knowledge, subsequently improving their teaching practice. In the context described by Nkhahle (2021), TPD is the ongoing process designed to equip teachers with the skills and knowledge essential for enhancing their practice, allowing them to adapt to a dynamically changing world and, in the case of South Africa, to stay abreast of a continually evolving curriculum. In the context of this study, TPD involves providing Life Sciences teachers with the requisite skills and knowledge necessary for integrating environmental education into their lessons.

1.11.4 Pedagogical content knowledge (PCK)

Pedagogical Content Knowledge (PCK), initially defined by Shulman (1987), encompasses the knowledge essential for effective teaching. Kimaryo (2011) further emphasized that an effective teacher possesses a robust knowledge base and demonstrates proficient representation and communication of that knowledge to learners. In essence, PCK can be articulated as the knowledge a teacher acquires and develops to facilitate effective learning for students. Shulman's (1987) framework identifies five key components constituting PCK: subject matter knowledge, knowledge of the learner, knowledge of the curriculum, knowledge of the context, and knowledge of pedagogy.

1.11.5 Social learning theory

Bandura (1986) originally developed the Social Learning Theory, positing that human learning occurs through the observation and imitation of others who function as role models. In essence, this theory asserts that learning involves the process of observation, extracting information from those observations, and making decisions about whether to replicate a particular behaviour. Emphasized by Bandura and Hall, (2018) the Social Learning Theory centres on the understanding of behaviour change through observational learning.

1.11.6 Educational change

Morgan and Roberts (2002:5) state that educational change demands significant negotiation, communication, inclusiveness, team building, leadership, and motivation. Fullan (2007) expands on this, noting that the implementation of educational change must encompass practice, which can manifest at various levels—teacher/classroom, school, or district. In this study, the term "change" specifically pertains to practices occurring at the teacher/classroom level, as this is the level where the integration of EE/ESD is executed.

1.12 Chapter outline

The study was organized into the following chapters:

Chapter 1: Introduced the study and provided background information. Highlighted the study objectives. Included sections on the problem statement and the rationale/significance of the study.

Chapter 2: Discussed the reviewed literature on the integration of environmental education into the Life Sciences curriculum.

Chapter 3: Explored the theoretical framework and key concepts of the study.

Chapter 4: Provided details on the research approach, population, and sampling. Discussed data collection techniques, data analysis, and interpretation. Addressed research ethics, limitations of the study, and delimitations of the study.

Chapter 5: Presented the findings derived from the analysis of interviews, observations, and document analysis.

Chapter 6: Engaged in the discussion and synthesis of findings, relating them to the developed themes.

Chapter 7: Summarized and concluded the study. Included recommendations for future research or action.

1.13 CHAPTER SUMMARY

This chapter serves as an introduction to the study, providing essential background information. It outlines the rationale, statement of the problem, research questions, aims, and objectives. Additionally, the chapter includes details on the theoretical framework, research methodology, limitations, and delimitations. It also provides definitions for key terms and an outline for the subsequent chapters. The following chapter delves into an extensive literature review on environmental impact topics, covering global, regional, and local perspectives.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

In this chapter, a comprehensive exploration of the literature pertaining to the evolution of environmental education (EE) and education for sustainable development (ESD) is presented, spanning global, African, and South African perspectives. Commencing with a clear definition of the environment, the chapter subsequently delves into the historical development of EE. Furthermore, it investigates sustainable development, education for sustainable development, and the intricate connections between EE and ESD. The chapter extends its focus to encompass literature detailing the incorporation of ESD into school curricula. This includes discussions on integration at the global/international, African, and South African levels. Within this literature review, the challenges confronting educators in the integration of EE/ESD are brought to light, offering insights from both international and regional perspectives—African and South African. The chapter underscores the difficulties faced by teachers in aligning EE/ESD with the global context, as well as navigating challenges specific to the African and South African educational landscapes. Additionally, the review introduces the concept of professional development, elucidating its definition and exploring the evaluation of the professional environment for teachers in South Africa. In addressing the existing gaps in research, the chapter also identifies areas where further investigation is warranted, thereby contributing to the ongoing discourse on environmental education and sustainable development.

2.2 Environmental education and Education for sustainable development

2.2.1 Overview of Environment

Prior to delving into the discourse surrounding Environmental Education (EE) and Education for Sustainable Development (ESD), it is crucial to establish a clear understanding of the term "environment" and its encompassing components. Kimaryo (2011) asserts that attempting to define EE without considering associated concepts such as environment and ESD proves challenging. Therefore, a comprehensive comprehension of concepts like environment and ESD becomes imperative for an accurate definition of EE. The perception and interpretation of these foundational concepts significantly shape how EE is conceptualized. Kimaryo (2011:24) further emphasizes that to gain insight into educators' perspectives on EE/ESD, one must initially grasp their perceptions of the environment. The rationale behind this assertion lies in the profound influence that teachers' views of the environment exert on their comprehension of EE/ESD and their subsequent incorporation of these concepts into their instructional practices.

In her examination of research conducted between 1995 and 2004, Tani (2006) revealed diverse perspectives on how individuals perceive the environment. She identified three distinct ways in which people conceptualize their relationship with the environment. Firstly, there are those who consider the environment as a distinct entity, separate and devoid of any direct connection to them. Secondly, some individuals position themselves at the focal point of their surroundings, seemingly encircled by vacant space, perceiving the environment as an experiential phenomenon. The third perspective, as outlined by Tani (2006), characterizes the environment as an unstructured, socially, or culturally produced phenomenon. According to this viewpoint, individuals perceive the environment as a product of social or cultural constructs.

Examining these perspectives, I advocate for a holistic consideration of the environment. Oyewale (2015) defines the environment as the collective sum of all natural and social systems that sustain humans and other life forms. Additionally, Kimaryo (2011:25) offers a comprehensive definition, describing the environment as "the totality of things that surround man," encompassing biophysical, social, economic, and political aspects. In this thesis, I align with Kimaryo's (2011) holistic viewpoint, endorsing the incorporation of all dimensions of environmental interaction. This includes not only the biophysical aspects but also the social, economic, and political dimensions. Embracing this holistic perspective allows individuals to cultivate a profound understanding of the environment, acknowledging their integral role within it and the consequential impact of their actions. A comprehensive grasp of all four environmental dimensions enables individuals to coexist harmoniously with nature, recognizing the interconnectedness of their activities with the environment. Figure 2.1 illustrates the intricate interplay among these environmental dimensions.

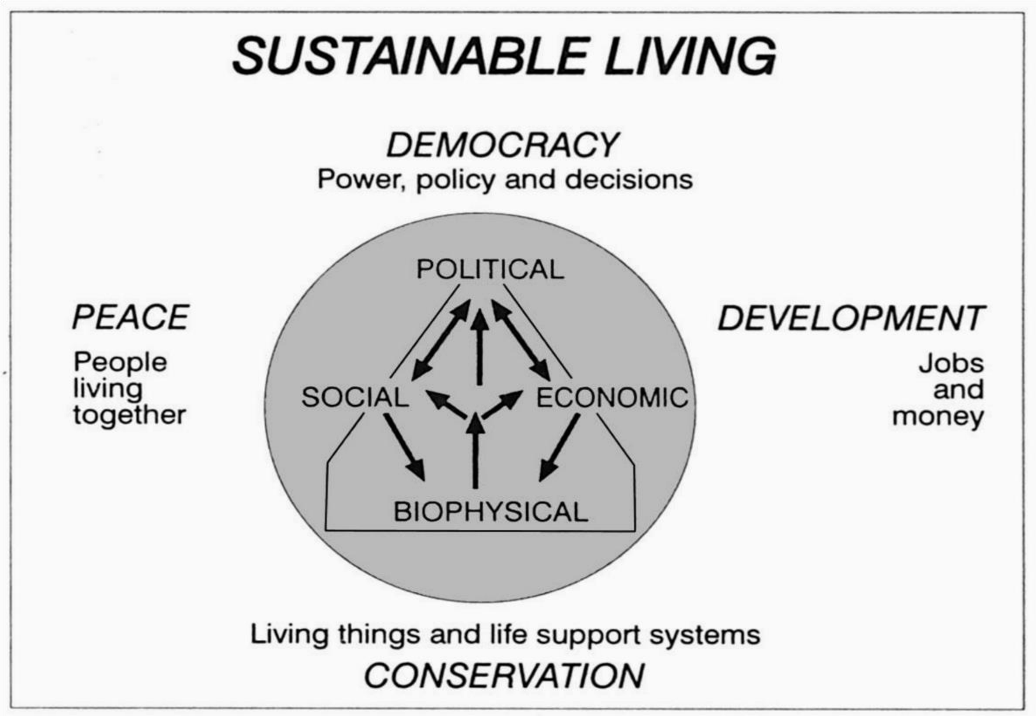

Figure 2.1. Interacting dimensions of environment. Adapted from O'Donoghue, (1993:337)

The depicted Figure 2.1 offers a visual representation of the intricate interactions among different facets of the environment. Positioned at the base of Figure 2.1 is the biophysical dimension, encapsulating all living organisms and life-sustaining systems, including non-living elements. It serves as the foundational layer from which other dimensions, such as the social, political, and economic, derive their existence. This hierarchical relationship underscores the critical role of the biophysical dimension, as the presence of life and life support systems forms the prerequisite for the existence of other dimensions. The biophysical component emerges as the locus of environmental challenges, including issues such as the depletion of natural resources, pollution, and deforestation, among others (Engrid, 2020). Recognizing the pivotal role of the biophysical dimension is essential for comprehending the interconnectedness of environmental aspects and addressing the challenges that arise within this foundational layer.

The social dimension pertains to the collective of individuals coexisting within the environment. This inclusive component encompasses people of diverse races, genders, and cultures, engaging in addressing issues that impact the overall quality of human life. Illustrated in Figure 2.1, the economic dimension encompasses the occupations and activities that empower individuals to sustain their lives by fulfilling financial responsibilities. According to Kimaro (2018), the economic dimension is not only concerned with economic activities but also aims to alleviate the environmental impact associated with the production and disposal of goods and services. It advocates for the advancement and adoption of energy and water efficiency measures. The political dimension, as delineated in Figure 2.1, revolves around environmental policies and legislation designed to safeguard and preserve life. This dimension plays a crucial role in shaping the regulatory framework that guides environmental conservation efforts.

As illustrated by the interconnected arrows in Figure 2.1, the various environmental factors discussed above are interdependent. To illustrate, consider the scenario where laws and regulations are proposed; their effective implementation would require allocated resources. However, I contend that the absence of sufficient employment opportunities and resources to meet basic needs could pose significant challenges for many individuals. Without a foundation of robust economic and social structures, life might become arduous. Conversely, the flourishing of the biophysical dimension relies on the establishment of rules, regulations, and policies aimed at preserving the planet. In essence, the biophysical component, comprising living and non-living entities along with life-supporting systems, forms the bedrock upon which laws, decisions, policies, financial mechanisms, job opportunities, and social interactions are built. Acknowledging this interdependence underscores the complexity of the environmental ecosystem and emphasizes the need for a holistic approach to address its multifaceted challenges.

Drawing upon the reviewed literature, it becomes evident that to grasp the intricacies of the environment, one must delve into all these dimensions and recognize their interconnectedness. I am of the opinion that the most impactful approach to environmental conservation lies in cultivating the right knowledge, skills, and attitudes, coupled with a profound understanding of how to engage with the environment in a manner that ensures its preservation for future generations. The acquisition of such knowledge and abilities can be facilitated effectively through the judicious application of Environmental Education (EE) and Education for Sustainable Development (ESD).

2.2.2 Defining Environmental Education

In 1969, William Stapp, a professor at the University of Michigan's School of Natural Resources and Environment, and his colleagues were pioneers in defining

Environmental Education (EE) as "a process that produces a citizenry knowledgeable about the biophysical environment and its associated problems, and motivated to work toward their solution" (Stapp et al., 1969: 30-31). Since this initial conceptualization by Stapp and his colleagues, the understanding of EE has undergone evolution over the years, witnessing changes in both its definitions and fundamental concepts (De Lange, 2004). The landscape of EE has been shaped by various definitions, yet a common thread among them is the acknowledgment that EE serves as a method or practice guiding individuals on how to conduct themselves in a manner that fosters responsible environmental stewardship (Fang, Hassan, & LePage, 2022).

One notable definition of Environmental Education (EE) emerged in 1971 from the International Union for Conservation of Nature (IUCN). According to the IUCN, EE is the "process of recognizing values and clarifying concepts in order to develop skills and attitudes necessary to understand and appreciate the interconnectedness of man, his culture, and his biological surroundings." EE encompasses decision-making practices and the self-formulation of a code of behaviour related to environmental quality (IUCN, 1971:7). Janse van Renburg and Lotz (1998:9) also conceptualize EE as a "continuous process of equipping people with knowledge, attitudes, skills, and commitments to address socio-ecological issues." It serves as a dynamic process empowering individuals to explore environmental challenges, identify potential solutions, and take proactive measures to enhance the environment.

By embracing the definition put forth by Janse van Renburg and Lotz (1998:9), individuals become better equipped to comprehend environmental challenges and make informed decisions based on accurate information. The scope of Environmental Education (EE) extends across various educational settings, encompassing primary, secondary, vocational, and technical schools, as well as universities and research institutions. Moreover, EE transcends traditional classrooms, involving the dissemination of environmental knowledge through print, books, websites, and other media channels. Beyond formal education, EE also finds expression in diverse institutions such as aquaria, zoos, parks, and nature centres, which play a crucial role in educating residents about the environment as part of social environmental education (Fang et al., 2022). This broad reach underscores the multifaceted and inclusive nature of EE in fostering environmental awareness and responsibility.

Article 3 of the Republic of China's Environmental Education Act articulates that "Environmental education refers to the adaptation of educational means to culminate citizens' understanding of their ethical relationship to the environment. It aims to enhance citizens' environmental protection awareness, skills, attitudes, and values, steering them towards emphasizing the environment and adopting actions to achieve a civility education process that harbours sustainable development" (Fang et al., 2022:10). Evans (2020) additionally underscores that the intent of Environmental Education (EE) extends to integrating elements from subjects such as biology (Life Sciences), chemistry, earth science, ecology, and mathematics into an interdisciplinary approach, fostering education for sustainability.

The definition of Environmental Education (EE) put forth by Janse van Renburg and Lotz (1998) will serve as the guiding framework for this study, adopted as its foundational premise. According to this definition, the primary objective of environmental education is to equip individuals with the knowledge, skills, and attitudes necessary for the protection of the environment. I align with this objective from Janse van Renburg and Lotz (1998) as it underscores the crucial importance of individuals comprehending their connection to the natural world in order to live in harmony with it and preserve it for the benefit of future generations. This study asserts that individuals must exercise utmost caution when engaging with the environment across various dimensions, including economic, political, and social realms. Such mindfulness ensures that individual decisions pertaining to the environment will either contribute to solving existing problems or, at the very least, will not exacerbate them. This approach is crucial for fostering a sustainable and harmonious coexistence with the natural world.

2.2.2.1 The goals and objectives of Environmental Education

As per UNESCO (1980), the fundamental aim of Environmental Education is to nurture an informed citizenry that possesses environmental sensitivity and is driven to actively participate in the stewardship of the environment and the sustainable utilization of its resources. Consequently, the focal points of Environmental Education revolve around the following three objectives:

- Forster clear awareness of, and concern about economic, social, political, and ecological interdependence in urban and rural areas.

- Provide every person with opportunities to acquire knowledge, values, attitudes, commitment, and skills needed to protect and improve the environment.
- Create new patterns of behaviour of individuals, groups, and society as a whole towards the environment

Examining these objectives is imperative as they form a robust foundation for the integration of Environmental Education (EE) and Education for Sustainable Development (ESD) within the official curriculum. However, the realization of these objectives is intricately tied to the aims outlined by UNESCO (1977), which are quintessential for attaining the aforementioned educational goals. These aims include:

- **Awareness-** to help social groups and individuals acquire an awareness of and sensitivity to the total environment and its allied problems.
- **Knowledge**- to help social groups and individuals gain a variety of experiences in, and acquire basic understanding of the environment and its, associated problems.
- **Attitude**- to help social groups and individuals acquire a set of values and feelings for the environment and the motivation for actively participating in environmental improvement and protection
- **Skills-** to help social groups and individuals acquire skills for identifying and solving environmental problems
- **Participating**- to provide social groups and individuals an opportunity to be actively involved at all levels in working towards resolution of environmental problems. (UNESCO, 1977:71)

Individuals' knowledge, abilities, attitudes, and engagement in environmental care and protection are fostered by the aforementioned aims, which are crucial for the successful integration of EE/ESD.

2.2.3 History of Environmental Education and Education for Sustainable Development

2.2.3.1 International perspective

The roots of Environmental Education (EE) on the international stage can be traced back to ancient China, where sustainability-promoting programs and reforestation initiatives have been in existence for over 3000 years (Loubser et al., 2014). In Greece, during the 4th century BC, Theophrastus, a disciple of the renowned philosopher Aristotle, advocated for a form of integrated environmental management that includes public education. Following his assertion, Theophrastus earned recognition from many environmentalists as the first person to articulate the principles of ecology (Loubser et al., 2014:43).

In the 19th century, Environmental Education (EE) was influenced by the ideas of Jean-Jacques Rousseau, who laid the groundwork for the "Nature study" EE program (UNESCO: 19). However, a key figure in the practical implementation of EE during this century was Patrick Geddes, a Scottish professor of botany with a background in sociology. According to Loubser et al. (2014:44), Geddes is considered the architect of the contemporary understanding of EE. His expertise and insights extended across various environments, emphasizing both rural and urban, including township environments.

In the aftermath of the Second World War (1939-1945) in the 20th century, there was a notable surge in the conceptualization and planning of substantially enhanced environmental management strategies. In 1948, in response to these developments, the International Union for the Conservation of Nature and Natural Resources (IUCN) emerged as the inaugural international organization dedicated to environmental concerns. The primary focus of this organization was the conservation of the world's depleting natural resources and wildlife. Additionally, the World Wildlife Fund (WWF) was established in 1961 with the aim of generating funds for wildlife conservation efforts.

In the context of global environmental education, the most impactful collaboration for the International Union for the Conservation of Nature and Natural Resources (IUCN) was with UNESCO (the United Nations Educational, Scientific, and Cultural Organization), established in 1946 as part of the broader United Nations initiative. Initially focusing on education within the development framework, UNESCO, through its partnership with the IUCN, became actively involved in the establishment of Environmental Education (EE). A pivotal moment in the evolution of EE transpired during the 1972 United Nations meeting in Stockholm on the human environment, where affluent and developing nations convened for the first time to address environmental challenges. It was at this gathering that the United Nations Environment Programme (UNEP) was tasked with coining the term "energy efficiency."

In 1975, UNEP and UNESCO jointly organized the inaugural international workshop on Environmental Education (EE) in Belgrade, Yugoslavia. Subsequently, building on the outcomes of this workshop, the first intergovernmental conference on EE took place in Tbilisi, USSR, in 1977. Held in the Republic of Georgia, this conference played a pivotal role in shaping the direction of EE. During the Tbilisi conference, crucial deliberations led to the formulation of aims, objectives, and principles that continue to guide EE to this day. Among the significant outcomes were the establishment of the "Tbilisi Principles of EE," a set of 12 principles articulating the fundamental tenets that underscore the essence and objectives of EE. These principles unequivocally state that EE should:

- ❖ Consider the environment in its totality - natural and built, technological and social;
- ❖ Be a continuous lifelong process, beginning at the preschool level and continuing through all formal and non-formal stages;
- ❖ Be interdisciplinary in its approach, drawing on the specific content of each discipline in making possible a holistic and balanced perspective;
- ❖ Examine major environmental issues from local, national, regional and international points of view so that students receive insights into environmental conditions in other geographical areas
- ❖ Focus on the current and potential environmental situation while taking into account the historical perspective;
- ❖ Promote the value of, and the necessity for, local, national and international cooperation in the prevention and solution of environmental problems;
- ❖ Explicitly consider environmental aspects in plans for development growth;
- ❖ Enable learners to have a role in planning their learning experiences and provide opportunity for making decisions and accepting their consequences;
- ❖ Relate environmental sensitivity, knowledge, problem-solving skills and values clarification to every age, but with special emphasis on environmental sensitivity to the learner’s own community in the early years;

- Help learners discover the symptoms and real causes of environmental problems;
- Emphasise the complexity of environmental problems and, thus, the need to develop critical thinking and problem-solving skills; and
- Utilise diverse learning environments and a broad array of educational approaches to teaching/learning about and from the environment, with due stress on practical activities and first-hand experience. (Loubser et al., 2014:46)

The Tbilisi meeting sparked a cascade of initiatives in numerous nations, as they sought practical approaches to leverage Environmental Education (EE) for addressing issues related to environmental change. In addition to the aforementioned conferences, several others were convened across different regions globally, serving as platforms for significant declarations and strategies that aimed at advancing the scope and impact of EE (Bosah, 2013; Irwin & Lotz-Sistikas, 2009). A comprehensive overview of these conferences is available in Table 2.1 below.

Table 2.1: Environmental education/Education for sustainable development historical events

Date	Event	Where	By whom	Outcomes
1975	First International workshop on Environmental workshop.	Belgrade, Yugoslavia	UNEP UNESCO	The Belgrade Charter, which establishes the framework for EE, was ratified by the delegates.
1977	Intergovernmental	Tbilisi, Georgia (USSR)	UNESCO	Goals, Objectives and Guidelines
Date	**Event**	**Where**	**By whom**	**Outcomes**
	Conference on Environmental Education	Tbilisi, Georgia (USSR)	UNEP	EE principles were established. The Tbilisi declaration outlined five objectives and twelve principles of EE that

				continue to be widely cited and implemented today.
1987	Publication of the Brundtland Report, also known as Our Common Future		WCED	The report introduced the concept of sustainable development, which considers environmental protection and economic growth to be interdependent concepts.
1992	The Earth Summit. The United Nations Conference on Environmental Education (UNCED)	Rio de Janeiro, Brazil.	UN and country working groups	"Agenda 21" was a key document from this conference. Agenda 21 outlined a plan for protecting the environment. This document focused on public education, awareness, and training, confirming the importance of environmental education in the context of sustainable development.
1992	The gathering of NGOs at the Earth Summit	Rio de Janeiro, Brazil.	The international Forum of NGOs and Social Movements.	The EE Treaty was adopted. As part of the treaty, a set of principles for equitable and sustainable societies was formulated.

2000	Millennium summit	New York, United states	Head of departments	The eight Millennium Development Goals (MDGs) were set out
2002	World Summit for Sustainable Development (WSSD), also known as Rio+ 10.	Johannesburg, South Africa	UN	The need for socio-ecological, political and economic transformation was emphasised.
2005	World Summit	New York, United States	Heads of state and government	The leaders of the world agreed to intervene on multiple fronts to address major global issues. Governments made firm commitments to achieving the Millennium Declaration's development goals.
2008	High-level meeting on the Millennium Development Goals	New York, United States	International leaders	The High-Level Meeting allowed international leaders to review progress, identify gaps, and commit to concrete actions, resources, and mechanisms to address them. The High-Level Meeting sped up MDG implementation and monitoring by requesting specific plans from world leaders.

2010	Millennium Development Goals Summit	New York, United States	Heads of state and government	Adoption of the "Keeping the Promise: United to Achieve the Millennium Development Goals" Global Plan of Action.
2012	United Nations Conference on Sustainable Development (also known as Rio+20)	Rio de Janeiro, Brazil	UN	Member States decided at the Conference to initiate a process to develop a set of Sustainable Development Goals (SDGs), building on the Millennium Development Goals (MDGs) and aligning with the post-2015 development agenda.
2015	United Nations Summit on Sustainable Development	New York, United state	UN	Agenda 2030 and its seventeen sustainable development goals and 169 targets were approved.
2022	Stockholm+50: a healthy planet for the prosperity of all – our responsibility, our opportunity	Stockholm, Sweden	113 countries	Adopted environmental principles include the Stockholm Declaration and the Action Plan for the Human Environment. As a result of the conference, the UN Environment Programme (UNEP) was formed.

Source: Author

2.2.3.2 History of EE/ESD in Africa

In Africa, the roots of Environmental Education (EE) can be traced back to ancient Egyptian Pharaohs, who implemented educational initiatives utilizing extension agents. These agents were tasked with educating farmers along the Nile River to mitigate soil erosion, thereby preserving the agricultural land along the Nile (Rosenberg, 2009). This historical evidence indicates that Egyptian farmers have been employing methods akin to EE for over three thousand years.

History of EE/ESD in Nigeria

Nigeria has a history of adhering to environmental laws dating back to its time as a British colony in the early 1900s (Erhabor & Don, 2016). These regulations included the Criminal Code of 1958, which prohibited the burial of corpses in residential areas to prevent water contamination. The Public Act of 1958 aimed at controlling the spread of diseases, while the Forest Ordinance of 1937 regulated access to forests and the utilization of natural resources (Aladejebi, 2020:23). All these measures were designed to ensure proper utilization of the environment.

The integration of Environmental Education (EE) into the formal curriculum in Nigeria commenced in the 1950s when the West Africa Examination Council introduced a curriculum for teaching subjects like biology in schools. This curriculum included environmental topics such as soil protection. Around 1960, EE was taught in Nigerian schools under the guise of cleanliness and nature studies. However, the curriculum at that time primarily focused on events in British culture rather than addressing environmental issues specific to Nigeria.

It was not until the 1970s that science education programs tailored for Africa were implemented in Nigerian schools. Consequently, the teaching of EE in Nigeria started reflecting the country's own environmental context rather than mirroring British societal events. In 1988, the Nigerian Conservation Foundation (NCF) mandated the incorporation of EE into the official education system. In 1990, a national review conference, followed by a UNESCO-sponsored national workshop, focused on integrating EE aspects into the national school curriculum and teacher training. As a result, EE is now an integral component of the Nigerian school curriculum.

History of EE/ESD in Tanzania

Environmental Education (EE) in Tanzania has roots dating back to the 1960s, but it gained significant momentum in the 1990s, largely catalysed by international initiatives for environmental sustainability led by the United Nations (Kimaro, 2018:34). During the 1980s and 1990s, Tanzania faced pressing environmental and health challenges, including drought, flooding, poor sanitation, lack of clean water, and environmental contamination (United Republic of Tanzania, 2004). In response, the government took proactive measures by enacting environmental regulations, such as the establishment of the National Environmental Management Council (NEMA), tasked with promoting both formal and informal EE.

Formal integration of EE into the Tanzanian school curriculum occurred in the 1990s. Developed environmental courses were introduced and seamlessly incorporated into the official school curriculum at all levels, emphasizing integration rather than separation as a standalone subject (Mwendwa, 2017). The primary objective of this integration was to align with national plans for growth and poverty reduction, aiming to enhance access to clean and affordable water while fostering a sustainable environment (United Republic of Tanzania, 2004). Additionally, the incorporation of EE into the curriculum is expected to help students cultivate environmental knowledge, skills, and positive attitudes from an early age.

History of EE/ESD in Zambia

The history of Environmental Education (EE) in Zambia traces back to the mid-1990s, sparked by growing international concerns for environmental protection. This movement gained momentum following the formulation of Zambia's National Environmental Strategy (NES) in 1985, signalling the government's commitment to ecological sustainability (MOE, 1996). A significant milestone occurred in 1993 when the entire school curriculum underwent a comprehensive review, leading to the integration of EE themes into subjects such as Geography, Science, and Social Studies. The Ministry of Education, in collaboration with the Worldwide Fund for Nature (WWF-UK), subsequently launched in-service training programs for primary school teachers, aimed at equipping them with the interdisciplinary skills necessary for effective EE instruction (MOE, 1996).

Despite these initiatives, the journey towards effective EE implementation encountered notable challenges within Zambia's educational landscape. Research conducted by Namafe and Muchanga (2017) highlighted deficiencies in both the teaching and understanding of EE among educators and students alike. While EE was formally introduced into the primary school curriculum and environmental clubs were established to promote engagement, progress remained constrained. Moreover, formal EE in colleges of education encountered hurdles, with the subject integrated across disciplines rather than being systematically taught (Namafe, 2006).

History of EE/ESD in Kenya

Environmental education (EE) in Kenya witnessed its first significant influence following recommendations from the 1977 and 1987 conferences in Tbilisi and Moscow, respectively (Gilbert, 2019). Alternatively, Glackin (2017) suggests that EE in Kenya was influenced by Chapter 36 of Agenda 21 on Education and Sustainable Development. Presently, EE is integrated into various subjects in Kenya but is considered secondary to these primary subjects.

The escalating impact of human activities on the ecosystem raised concerns among diverse Kenyan stakeholders, prompting a realization that focused attention should be given to developing EE programs in schools. In the early 1980s, the Ministry of Nature Resources invested 34 million Kenyan shillings in establishing environmental protection initiatives (Kimiti & Kipkoech, 2013).

By the early 1990s, dissatisfaction with the ineffectiveness of environmental conservation efforts led the Kenyan government to emphasize EE in both formal and informal learning activities. These initiatives aimed to educate Kenyans against the exploitation of natural resources. Consequently, environmental education issues are now incorporated into the curriculum of several subjects in Kenyan schools.

History of EE/ESD in Namibia

The history of Environmental Education (EE) and Education for Sustainable Development (ESD) in Namibia reflects a concerted effort to address environmental challenges and promote sustainable living. Following Namibia's independence and its participation in international conferences emphasizing environmental concerns, the country recognized the importance of integrating EE into its education system (Onyolo, 2015). Initially, under South African administration, EE elements were present in subjects like General Science, Biology, and Geography. However, formal EE implementation faced obstacles, including ill-prepared teachers and a curriculum reflective of South African and European contexts (Ramutsidela, 2001). Despite these challenges, Namibia's transition to the Cambridge system in 1995 and later to the National Curriculum in 2006 signalled a pivotal moment for EE integration. Efforts were made to prepare for EE introduction, evidenced by policy development and curriculum documents reflecting EE inclusion (DRFN, 2008).

Namibia's participation in international treaties, such as Agenda 21, underscored its commitment to environmental stewardship and sustainable development (Frohlich, 2006). Furthermore, the integration of ESD into the school curriculum, informed by Article 95 of Namibia's Constitution, emphasized the interconnectedness between environmental health, living standards, and economic development (Tarr & Figueira, 1999). However, challenges persisted, including resistance to learner-centered approaches in teaching, limited understanding of EE/ESD concepts among educators and school management, and inadequate policy reinforcement (Kasanda et al., 2005; Hogan, 2008). Collaboration among ministries, NGOs, and donor agencies was deemed essential to address these challenges and ensure effective EE/ESD implementation (Ministry of Environment and Tourism, 2009).

2.2.3.3 The history of EE/ESD in South Africa

In the 1960s, conservation organizations and government agencies sparked an interest in Environmental Education (EE) in South Africa, focusing on the conservation movement rather than curriculum integration (Irwin, 1990). The general concept of EE entered South Africa in the mid-1970s, influenced by the Belgrade Chapter of 1975 and the Tbilisi Principles of 1977 (Loubser et al., 2014:53). Before these influences, environmental activities primarily centred on soil erosion and conservation education.

In the 1980s, outdoor education and EE converged, and the turning point for EE in South Africa occurred with the establishment of the Environmental Education Association of South Africa (EEASA) in 1982. EEASA played a crucial role in EE development, complemented by contributions from NGOs and provincial conservation agencies, such as the Wildlife Society of South Africa (WESSA), the Umgeni Valley Project (UVP), and the National Environmental Awareness Council (Loubser et al., 2014).

The first attempt to incorporate EE into the formal curriculum took place in 1989 with the White Paper on Environmental Education, but it was not adopted by the South

African parliament. The Environmental Education Policy Initiative (EEPI) emerged in 1992, focusing on policy choices for formal education. EE gained prominence in the government white paper on education and training in March 1995, marking a significant outcome.

The Environmental Education Policy Initiative transformed into the Environmental Education Curriculum Initiative (EECI), emphasizing curriculum and policy development. EECI's efforts, with environmental teachers contributing as stakeholders, played a role in the creation of the Revised National Curriculum Statement in 2005 (R-NCS 2005). On World Environment Day in 2000, the Secretary of Education established the National Environmental Education Project for General Education and Training (NEEP-GET) to successfully integrate EE into the school curriculum. This effort contributed to the inclusion of EE in the new national curriculum, Curriculum and Assessment Policy Statement (CAPS), where EE methods are now an integral part of each subject with a unique environmental emphasis (Loubser et al., 2014).

2.2.4 Sustainable development

A precursor to the Brundtland Report, "Our Common Future," and the 1992 UN Conference on Environment and Development (UNCED), sustainable development finds its roots in the 1972 UN Conference on the Human Environment. The idea of sustainable development emerged as a concept that could strike a balance between ecological considerations, social justice, and economic prosperity. The Brundtland Report, a significant milestone, advocated for a sustainable growth plan. Sustainable development gained formal recognition during the 2002 World Summit on Sustainable Development in Johannesburg, South Africa, leading to the United Nations declaring 2005-2014 as the "Decade of Education for Sustainable Development" (DESD) (Loubser et al., 2014).

The Brundtland Report provides the earliest and most acknowledged definition of sustainable development, emphasizing meeting the needs of the present without compromising the ability of future generations to meet their own needs (UNESCO, 2016). In September 2015, a global agreement was reached to adopt a new agenda for sustainable development, titled "Transforming Our World: The 2030 Agenda for Sustainable Development." This comprehensive strategy aims to eradicate extreme poverty and address environmental damage by 2030 (UN 2015). Organized around the themes of people, the environment, and economic well-being, the 2030 Agenda comprises 17 Sustainable Development Goals (SDGs) that balance economic, social, and environmental components. This voluntary agreement requires countries to declare their national priorities and objectives in alignment with the SDGs (Allen, Metternicht, Wiedmann, & Pedercini, 2019). The fourth SDG focuses on creating inclusive and equal opportunities for all through quality education, emphasizing education as a powerful means to achieve sustainable development (Mwendwa, 2017).

2.2.5 Education for Sustainable Development

In Agenda 21, the United Nations (UN) identified education as a pivotal factor in future sustainable development, giving rise to the concept of Education for Sustainable Development (ESD). According to Hoffmann and Siege (n.d.), ESD encompasses all educational concepts, procedures, and processes that encourage individual and/or collective contributions to sustainable development. In essence, ESD aims to develop individual competencies, enabling individuals to contribute to and practice sustainable development.

Similarly, UNESCO (2017:7) posits that the purpose of ESD is to "empower learners so that they can make informed decisions and take responsibility for environmental integrity, economic viability, and a just society for present and future generations." ESD facilitates the development of necessary knowledge, skills, and attitudes for a well-shaped sustainable future.

UNESCO (2014a) defines ESD as an "Education process of achieving human development in an inclusive, equitable, and secure manner." The Council for Environmental Education for the national curriculum for England and Wales also defines ESD as "Education that enables people to develop knowledge, values, and skills to participate in decision-making about the way they do things individually and collectively, both at local and global levels, that will improve the quality of life now without damaging the planet for the future" (Council for Environmental Education (CEE), 1998:3).

The UNESCO definition of ESD focuses on "designing a sustainable future," while the Council of Education in Wales and England's definition emphasizes doing so "without harming the future world." Both definitions align with the goal of sustainable development, aiming to use today's resources without depleting those of tomorrow. Consequently, ESD educates individuals about sustainable development and how to integrate its principles into daily life to enhance the future.

As described by UNESCO in 2021, the objective of ESD is to build the capacity and commitment required to develop a sustainable society that preserves the quality of life in the present and the future. The objective of ESD envisions a sustainable future, emphasizing the integration of human well-being and cultural traditions with a respect for the planet's natural resources. ESD also highlights social factors, ecological systems, economic systems, political systems, etc., and their intricate interconnections.

Kimaryo (2011) emphasizes that sustainable development encompasses economic, environmental, and social concerns. ESD is an educational approach that underscores the interdependence of economic, environmental, and social considerations without jeopardizing the essential resources of future generations. To implement ESD, understanding the relationship between the environment, economy, and society is crucial. The sustainability model depicted in Figure 2.2 clearly illustrates this intricate relationship.

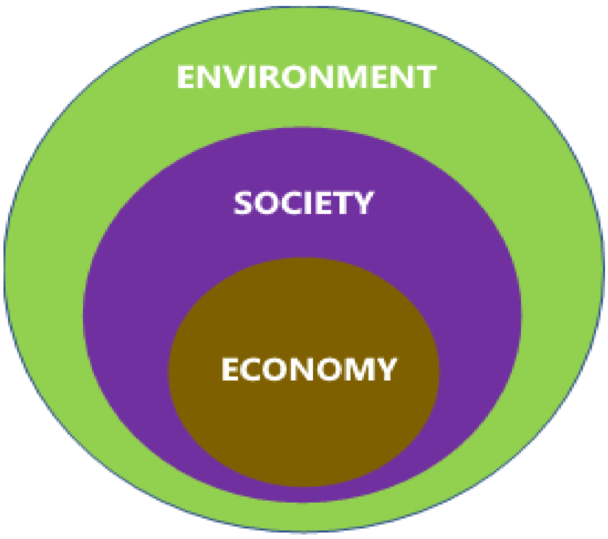

Figure 2.2: *Model for sustainability* (Mwendwa, 2017: 2)

The depicted three pillars of sustainable development must collaborate to forge a sustainable future. The first pillar, the environment, assumes a critical role in society by providing essential natural resources such as fresh water, air, and food (Mwendwa, 2017). Society, representing the second pillar, engages in cultural practices, beliefs, and standards within the environment, an essential backdrop for societal existence. The third and final pillar is the economic dimension of society. Members of society engage in economic activities such as living costs, income, jobs, and currency exchange, and all three pillars must function synergistically.

Without a conducive environment, societies cannot thrive, practice their culture, or engage in economic activities, ultimately affecting factors like food production and raising costs. Therefore, the interdependence of the environment, society, and the economy is evident. The question that arises is how Education for Sustainable Development (ESD) and Environmental Education (EE) relate to each other, and this inquiry will be explored in the subsequent discussion.

2.2.6 The Relationship between Environmental Education and Education for Sustainable Development

Numerous inquiries have been made about the relationship between Environmental Education (EE) and Education for Sustainable Development (ESD), generating disputes and presenting conceptual and practical challenges for educators and policymakers (Pavlova, 2013:657). Some scholars, such as Tilbury and Cooke (2005), assert that ESD has evolved from EE, while others like McKeown and Hopkins (2009) suggest that both terms can be used interchangeably. Kimaryo (2011) even suggests that EE is now known as ESD. In this study, the researcher chooses to adhere to the notion that EE and ESD are interchangeable, and these terms will be used interchangeably throughout.

EE and ESD originated more than three decades apart within the global educational agenda, corresponding to significant shifts in educational discourse about the purpose and nature of education in neoliberal times and its potential role in addressing socio-ecological challenges arising from modern notions of progress and associated progress traps. The transition from EE to ESD seemed complete during the 1980s and 1990s, particularly exemplified by the 1977 international conference in Salonika on environment and society, education, and public awareness for sustainability organized by UNESCO, which summarized the early ideas behind ESD in Chapter 36, "Promoting Education, Public Awareness, and Training" (UNESCO, 1992).

ESD and EE share a vision of building a better world and achieving a balance between the economy, ecology, and society. Both are effective tools for sustainable development, with ESD emphasizing a broader spectrum of sustainability—environment, society, and economy—compared to EE, which primarily focuses on the environmental dimension. ESD has four thrusts, encompassing access to and retention in quality basic education, reorienting existing education programs, increasing public awareness and understanding, and providing training. EE primarily operates in thrusts two and three. While EE and ESD work toward the common goal of developing environmentally literate individuals who can care for their environment, the integration of EE/ESD throughout the curriculum is crucial for achieving this objective effectively.

2.3 Curriculum change effects on ESD coverage in South Africa

2.3.1 Curriculum change in South Africa

Before 1994, South Africa's education system was designed to prepare learners for various roles based on their racial, social, economic, and political backgrounds. A pivotal moment in the post-apartheid education system was the introduction of Curriculum 2005, commonly known as the "outcomes-based education" (OBE) curriculum (Gumede & Biyase, 2016). In 1997, the Ministry of Education implemented the OBE system, emphasizing learner-centred education focused on the outcomes learners should achieve. Ramoroka (2007) notes that the OBE model treats each learner as an individual, without superiority based on colour, nationality, or cultural background, tailoring learning environments to individual needs.

Due to challenges encountered during the implementation of OBE, the National Curriculum Statement (NCS) 2002 was introduced. NCS required students in grades 10-12 to study a minimum of seven subjects, compared to the three subjects required under OBE. In 2000, a ministerial committee was tasked with assessing the development and efficiency of the curriculum, focusing on its structure, design, teacher orientation, training, and development, learning support materials, provincial aid to teachers, and implementation deadlines (Department of Education, 2002). A second review in 2009 led to the merging of the Revised National Curriculum Statement (2002) and the National Curriculum Statement Grades 10-12 into the present National Curriculum Statement Grades R-12 (NCS).

The Curriculum Assessment Policy Statement (CAPS) was introduced in 2012 as an adjustment to NCS rather than a completely new curriculum, according to Pinnock (2011). Both CAPS and NCS share values of social justice, human rights, environmental consciousness, and respect for people of diverse cultural, religious, and ethnic backgrounds (Gumede & Biyase, 2016:3). These curricula align with the aims of the South African constitution, emphasizing the principles of equality and inclusivity.

2.3.2 EE/ESD in school curriculum

The United Nations Conference on Environment and Development (UNCED) in 1992 emphasized the integration of Environmental Education (EE) and Education for Sustainable Development (ESD) into school curricula due to the growing environmental degradation caused by human activities (Corpuz, San Andres, & Lagasca, 2022). Before 1999, environmental protection primarily relied on conservation bodies and non-governmental organizations (NGOs), while the official education system was neglected (Loubser, 2005; Mawela, 2020). The 2005 curriculum marked a turning point by mandating the inclusion of environmental education in all subject areas, providing a foundation for the incorporation of EE across future curricula.

In June 2000, the South African government recognized the significance of EE and promptly ensured its prominence in both general education and training bands (Loubser et al., 2014). EE was integrated into all learning areas of the 2005 curriculum, later amended into the Revised National Curriculum Statement (RNCS) for various grades. Policymakers eliminated the phase organizer, requiring all instructors to consider an environmental theme, and instilled values of human rights, inclusion, environmental stewardship, and social justice across all disciplines.

The National Curriculum Statement underwent revision in 2011, leading to the introduction of the Curriculum and Assessment Policy Statement (CAPS) in January 2012 (DBE, 2014). CAPS is designed to address environmental issues and emphasizes the integration of EE/ESD across the curriculum to foster responsible citizens equipped with the necessary knowledge, skills, and attitudes to address environmental challenges. The key principles and aims of CAPS align with Section 24 of the South African Constitution, emphasizing the government's duty to protect the environment and ensure citizens are not harmed by it (Damoah & Adu, 2019).

EE/ESD has been incorporated into all subjects from Grades R–12 in the South African education system, following international recommendations and national policies, such as the South African Environmental Policy and White Paper on

Environmental Development. This incorporation has been a consistent theme in each curriculum revision, showcasing the commitment to environmental education. The study aims to explore how Life Science teachers' pedagogical content knowledge is supported through professional development to enhance the integration of EE/ESD into the Life Science curriculum.

2.3.3 EE/ESD in the Life Sciences curriculum

The Life Sciences CAPS document defines Life Sciences as "the scientific study of living things from the molecular level to their interactions with one another and their environment" (DBE 2011:8). The primary objective of studying Life Sciences is to assist learners in developing an understanding of the negative impact of human activities on the environment and the organisms within it. Integrating Environmental Education (EE) and Education for Sustainable Development (ESD) into Life Sciences lessons is crucial to achieving this goal. Additionally, Life Sciences aims to cultivate an awareness of responsible citizenship concerning environmental and lifestyle choices (DBE 2011:8).

The subject of Life Sciences consists of four strands: Life at the molecular, cellular, and tissue level; Life processes in plants and animals; Diversity, change, and continuity; and Environmental studies. These strands are consistent across Grades 10-12, and the strand that explicitly includes EE/ESD is Environmental Studies. According to Msezane's analysis (2020), Life Sciences stands out as one of the subjects with a dedicated section focusing solely on environmental studies.

Table 2.2 below provides an overview of the strands and a summary of the content to be covered in each grade. Notably, Environmental Studies in Grade 11 addresses Human Impacts (Current Crises), strategically designed to alleviate the academic burden in Grade 12. In Grade 12, this section of Environmental Studies is primarily assessment-based, building on the foundation laid in Grade 11. This approach ensures a comprehensive understanding of environmental issues while balancing the curriculum load for students.

Table 2.2: Life Sciences: Concept and Content Progression

Strands	Life at molecular, cellular, and tissue level	Life processes in plants and animals	diversity, change and continuity	Environmental studies

Grade 10	• Chemistry of life - Inorganic compounds - Organic compounds • Cell - unit of life • Cell division (mitosis) • Plant and animal tissues	• Support and transport systems in plants • Support systems in animals • Transport system in mammals	• Biodiversity and classification • History of life on Earth	• Biosphere to ecosystems
Grade 11		• Energy transformations to support life: photosynthesis • Animal nutrition • Energy transformations: respiration • Gas exchange • Excretion	• Biodiversity - classification of microorganisms • Biodiversity - plants • Reproduction - plants • Biodiversity - animals	• Population ecology • Human impact on environment: current crises
Grade 12	• DNA code of Life • RNA and protein synthesis • Meiosis	• Reproduction in vertebrates • Human reproduction • Nervous system • Senses • Endocrine system	• Darwinism and • Natural Selection • Human evolution	• Human impact on environment: current crises Grade 11

		• Homeostasis		

(Adapted from: South Africa. DBE, 2011:10)

2.4 Different ways of EE/ESD integration in the curriculum.

Incorporating Environmental Education (EE) and Education for Sustainable Development (ESD) into the curriculum can take various forms. According to Kimaryo (2011), there is no one-size-fits-all approach, and different curricula may adopt different strategies. Three common approaches, as suggested by Faragallah (2016), include integrating EE/ESD as an independent subject, as a cross-curricular subject, or as a theme organized around significant issues and problems.

2.4.1 Environmental education as an independent subject

Implementing environmental education (EE) as an independent subject in the school curriculum is one approach to integrating EE/ESD. This method involves treating EE as a standalone discipline, providing students with dedicated time to learn about environmental-related knowledge, skills, and attitudes. However, there are challenges associated with this approach:

Time Allocation: Limited time within the school calendar is a significant obstacle to implementing EE as a standalone subject. Often, EE is scheduled for afternoons or weekends, which may not be optimal for teachers or students.

Curriculum Load: Increased pressure from parents and the community for a rigorous curriculum can hinder the incorporation of EE. Adding a standalone subject may contribute to an already overloaded curriculum, causing stress among students.

Locality of Students and Teachers: Variations in environmental awareness among students based on their locality can pose challenges. Students from urban and rural areas may differ in their levels of environmental consciousness. Additionally, teachers' perspectives on environmental issues may vary depending on their living location.

Addressing these challenges is crucial to successfully implementing EE as an independent subject, ensuring that it aligns with broader educational goals and meets the needs of both students and educators.

2.4.2 Environmental Education as a cross-curricular subject

The integration approach stands out as the most commonly employed method for infusing environmental education (EE) into the school curriculum, according to Dare (2014). Within this approach, EE doesn't exist as a standalone subject but is seamlessly integrated into the content areas of other subjects like Geography and Life Sciences. Dhull and Verma (2017) describe EE as the "thread" that weaves through the entire curriculum once integrated. Baxter and Jack (2008) highlight one advantage of this integrative teaching approach, emphasizing its capacity to enable teachers to plan the development of crucial skills and understanding. This not only enhances students' subject-specific knowledge but also supports the cultivation of diverse prior knowledge and experiences. Drake (2004) asserts that this strategy makes learning more meaningful by linking it to real-world situations and experiences.

However, scholars like Rusinko (2010) underscore the challenges associated with this approach, including the substantial demands on time, resources, and teacher expertise. Mwendwa (2017) further notes the difficulty teachers face in aligning EE content with the content of their respective subjects due to the absence of a clear implementation formula. Despite these challenges, the researcher in this study aligns with the integration of EE as a cross-curricular initiative, recognizing its potential for allowing teachers to seamlessly incorporate EE topics and themes into their lessons.

Various countries, including Nigeria, China, New Zealand, and Tanzania, have embraced the integrated approach (Kimaryo, 2011). South Africa similarly employs this approach, integrating environmental themes across all school curriculum levels from grades R-12. Nevertheless, scholars have identified challenges faced by teachers in implementing this approach. These challenges are explored in the subsequent section.

2.4.3 Environmental Education as a theme organised around significant issue and problems

This approach involves teachers and students exploring essential topics and concerns without being confined by subject area boundaries. Fraser (2000) notes that the focus in this method is on issues of concern rather than specific themes, and the teacher's role is to provide learning resources. Subsequently, students form groups, apply problem-solving strategies, and reach a consensus on the examined topic.

By actively engaging students in identifying, analysing, and resolving problems, Kimaryo (2011) suggests that they will develop critical thinking skills applicable to various fields, including engineering. This approach exposes students to the intricacies of human interactions with their surroundings and introduces knowledge from diverse disciplines. Mohammed (2016) highlights that this method enhances the curriculum's relevance to real-world environmental settings, enabling students to acquire skills for recognizing, classifying, and interpreting data related to environmental education (EE) issues.

The three preceding models indicate that EE/ESD as an independent subject may pose challenges, with some students potentially opting out unless it becomes mandatory. Integrating EE/ESD into the school curriculum might take longer due to the risk of curricular overload unless it replaces another subject. If EE/ESD is incorporated as a theme organized around significant issues and problems, students can learn to identify, classify, and evaluate data related to EE/ESD concerns. However, successful integration may be hindered if teachers and students lack awareness of environmental issues. In my perspective, incorporating EE/ESD as a cross-curricular subject stands out as the most effective approach. This model turns EE/ESD into the curriculum's "thread," seamlessly integrating it into all subjects and ensuring widespread reach among students.

2.5 The integration of Environmental Education in the South African school curriculum

In South Africa, the Curriculum and Assessment Policy Statement (CAPS) serves as the official standardized, content-based curriculum spanning all grades (R-12) and is grounded in the fundamental values and principles of the Constitution of the Republic of South Africa (Mawela, 2020). The model employed to integrate Environmental Education (EE) and Education for Sustainable Development (ESD) into CAPS involves their inclusion as cross-curricular subjects. This approach comprehensively addresses EE/ESD themes across various school subjects, emphasizing the need for teachers to seamlessly integrate EE/ESD into their curricula and encourage students to actively engage in environmental education.

The directive to incorporate EE into formal education in South Africa dates back several decades and was stipulated in the White Paper on education and training (1995). According to Mosidi (1997), the White Paper integrated guidelines established at international conferences in Belgrade (1975) and Tbilisi (1977). Post-1995, South Africa's educational curriculum underwent multiple changes, leading to the adoption of Outcome-Based Education (OBE) (Loubser et al., 2014: 145). This curriculum revision played a pivotal role in accommodating and promoting EE in pedagogy (Hebe, 2019). In 1998, the South African curriculum underwent further revisions, giving rise to Curriculum 2005. This iteration continued the integration of EE into various school subjects with the aim of fostering awareness of the country's environmental issues and producing environmentally literate citizens (Loubser et al., 2014).

The Revised National Curriculum Statement (R-NCS) was introduced in 2002 as a replacement for Curriculum 2005. R-NCS underscored that all learning areas (subjects) must reflect the principles and practices of social justice, emphasizing respect for the environment and human rights as defined by the constitution (DBE 2002:10). This demonstrated the ongoing commitment to the implementation of environmental education in all subjects. In 2011, the Curriculum Assessment Policy Statement (CAPS) replaced R-NCS, with its initial implementation in 2012. CAPS aims to enhance citizens' quality of life through the sustainability of the environment and its ecosystem. Achieving this goal is contingent upon the integration of EE/ESD across the curriculum. One of the overarching aims of CAPS is to foster a sense of responsibility and environmental stewardship in learners, emphasizing the holistic integration of EE/ESD principles. One of the general aims of CAPS is:

The National Curriculum Statement Grades R-12 aims to produce learners who are able to: … use science and technology effectively and critically showing responsibility towards the environment and the health of others… (DBE, 2011:5)

The aforementioned objective underscores that CAPS continues to promote the incorporation of Environmental Education (EE) into teaching and learning. The production of learners capable of "demonstrating responsibility towards the environment" can only be realized through the integration of EE into teaching and learning across all subjects, as mandated by the government. Despite its noble intent, this concept has encountered various challenges in its implementation. Scholars such as Hebe (2019) and Damoah and Adu (2019) have highlighted issues such as the lack of clear guidelines from the CAPS document for teaching EE content. Tsotetsi (2021) further pointed out that teachers attribute the lack of EE integration to the CAPS document, which, despite being content-rich, allocates limited time for lessons beyond the classroom.

Based on the reviewed research, one might deduce that the South African model for integrating EE/ESD into the school curriculum has not fully achieved its intended goals and objectives. This is evident in the existence of teachers who have not yet incorporated EE into their curriculum. However, in my view, the South African integration model for EE/ESD is not inherently flawed. Instead, responsibility lies with teachers and policy implementers to effectively utilize the model for integrating EE/ESD into their respective disciplines. The Department of Basic Education (DBE) should organize training sessions and workshops to support teachers struggling with EE integration under the cross-curriculum model. This proactive approach will contribute to ensuring that the model attains its goals and objectives, ensuring that all learners acquire essential environmental knowledge, skills, and attitudes.

2.6. Challenges encountered by teachers in the integration of environmental education/education for sustainable development

2.6.1 International challenges

Challenges in Philippines

The integration of Environmental Education (EE) and Education for Sustainable Development (ESD) into school subjects faces various challenges globally. In a study focused on promoting EE/ESD practices among teachers in the Philippines, Marpa (2020) found that despite teachers' efforts to integrate EE/ESD into their lessons, they encountered challenges in the process. These challenges, as identified by Marpa (2020), include a lack of essential knowledge, skills, and technology required for effectively integrating EE/ESD into their teaching.

Corpuz, San Andres, and Lagasca (2022) also highlighted several challenges faced by teachers in integrating EE/ESD. According to them, teachers often encounter difficulties due to unclear guidelines from management on how to seamlessly integrate EE/ESD into their subjects. Other challenges identified in the Philippines concerning the integration of EE/ESD into subjects encompass a lack of teacher training (Marpa, 2020), insufficient support from stakeholders and management for EE integration, and inadequate strategies provided to teachers for the successful integration of EE/ESD into the curriculum (Corpuz et al., 2022).

Challenges in India

India, similar to many other nations, has enacted legislation regarding Environmental Education (EE) and Education for Sustainable Development (ESD) across various sectors and educational curricula. This legislative response is prompted by concerns such as overpopulation, deforestation, and land degradation. Despite the cultural and policy significance of EE/ESD in India, as highlighted by Shin and Akula (2021), the quality of its implementation, educational practices, and effectiveness remains uncertain. The Indian government assigned the National Council for Educational Research and Training the responsibility of formulating a comprehensive EE/ESD-related curriculum in 2003, resulting in over 300 million learners receiving EE education by 2015 (UNESCO, 2016).

For teachers in India, a significant challenge lies in the absence of systemic support for their transformation into sustainable change agents (Shin & Akula, 2021). Research conducted by Laiphrakpam, Aroonsrimorakot, and Shanker (2019) delved into the background of EE/ESD and its long-term sustainability significance in India, Thailand, and Japan. The study revealed that, compared to Japan, India and Thailand faced challenges in EE/ESD integration due to a lack of resources and effective implementation strategies. The inflexible course structures, traditional teaching methods, limited resources, and overwhelming subject load within the current formal education system in India make it difficult to seamlessly integrate EE/ESD into the curriculum (Laiphrakpam et al., 2019). In the absence of clear directives on how to implement EE/ESD in the classroom, teachers are compelled to rely on their own initiative and motivation to bring about this integration.

Challenges in Thailand

Thailand is another country that has embraced the integration of Environmental Education (EE) and Education for Sustainable Development (ESD) into its school curriculum. However, in Thailand, EE/ESD is not commonly presented as standalone subjects; instead, they are integrated into various science programs across the country (Laiphrakpam et al., 2019). The Ministry of Education in Thailand plays a crucial role in formulating guidelines for schools to follow when incorporating environmental education into their regular curriculum. Nevertheless, despite these efforts, there exists a significant gap between theoretical understanding and practical implementation in Thailand. This disparity can be attributed, at least in part, to several challenges currently faced by the education system, including a lack of engaging extracurricular activities or educational field trips and a shortage of teachers. The predominant mode of educational content delivery in Thailand remains traditional classroom lectures, which students often perceive as uninteresting (Laiphrakpam et al., 2019).

Challenges in Australia

Australia has actively embraced Education for Sustainable Development (ESD) in primary education, incorporating it into both indoor and outdoor programs. Initiatives such as projects, recycling, tree planting, and outdoor excursions exemplify this approach. Almeida, Barnes, and Moore (2018) note that the implementation of ESD in primary schools has significantly improved, thanks to a policy adopted in 2010 by the Australian national curriculum authority prioritizing ESD across all domains.

In their exploration of Environmental Education (EE) and ESD in Australian primary schools, Treagust et al., (2016) identified assigning students a final project on a local environmental concern, like waste pollution, as one of the most effective strategies. Successful efforts to reduce solid waste pollution have resulted in a cleaner environment in proximity to elementary schools. Field trips emerged as one way to leverage outdoor experiences in EE/ESD, according to Gough's study (2016). While Australian primary school teachers utilizing EE/ESD recognize the benefits of employing diverse strategies, they also acknowledge challenges associated with their implementation.

Treagust et al. (2016) conducted research in Australia, revealing that assisting primary school students in developing the information, skills, and attitudes needed for environmental responsibility is challenging within a traditional classroom setting. Elementary school teachers find it difficult to pinpoint strategies that allow for greater student agency in solving environmental problems (Treagust et al., 2016). Additionally, the adoption of EE/ESD in elementary schools is influenced by students' perspectives on environmental issues.

2.6.2 Integration challenges in Africa

Integration challenges in Nigeria

UNESCO, along with other governmental bodies, has issued a nationwide call for the integration of environmental education (EE) into school curricula. However, Africa, including Nigeria, encounters challenges in implementing EE. Aladejebi (2020) observed that Nigeria specifically faces constraints in financial resources, hindering the smooth integration of EE. The inadequacy of financial resources is identified as a major obstacle impeding the seamless incorporation of EE in Nigeria. Aladejebi (2020) argues that the lack of financial resources hampers the learning of crucial aspects of EE, such as on-site visits where students can gain first-hand experience with environmental knowledge.

Integration challenges in Tanzania

According to Kimaryo (2011), a significant challenge encountered by teachers when integrating EE into their subjects is the perception of an "unclear syllabus." Kimaryo refers to a syllabus lacking detailed descriptions of environmental content that should be incorporated into subject materials. Consequently, teachers are left without clear indications of what to include for EE/ESD. Mwendwa (2017) highlighted key challenges in implementing environmental education in Tanzania, encompassing an integrated learning approach, insufficient knowledge of environmental education, limited support from peers and school administration, and cultural myths and beliefs.

Kimaro (2018) further observed that the incorporation of EE into the Tanzanian school curriculum faces various challenges. One of these challenges, as noted by Kimaro (2018), is the time required for EE integration. Teachers expressed concerns that incorporating EE/ESD into their subjects would demand excessive time, given the workload they were already managing before the introduction of EE. Teachers in the study believed that integrating EE would be a waste of time, as they were already struggling to complete their syllabi. Consequently, time allocation for teaching a particular subject becomes problematic when integrating EE, especially in subjects lacking specific measures for EE assessment.

Integration challenges in Zambia

Zambia, like other nations, grapples with environmental challenges such as deforestation, pollution, and climate change (Nakwiza, 2019). Recognizing the importance of Education for Sustainable Development (ESD), Zambia has prioritized its inclusion even at the university level. The national environmental policy in Zambia mandates that all educational institutions at various levels integrate ESD into their teaching and learning processes. Consequently, ESD has been acknowledged as a crucial aspect integrated across the entire school system.

However, the integration of EE/ESD into the Zambian curriculum has faced numerous challenges, including a lack of environmental awareness among stakeholders, particularly teachers, and issues related to coordination (Nakwiza, 2019). Monde (2011) noted that some Zambian educators and officials in the Ministry of Education struggle to recognize and define EE/ESD. High school administrators, when questioned about ESD integration, provided conflicting responses about whether or not ESD was being taught in schools.

Shumba and Kampamba (2013) emphasized that teachers lacked guidance on teaching and learning strategies to integrate environmental issues. This resulted in varying beliefs and misconceptions about ESD integration among teachers, as they often approached it from a primarily biophysical perspective. Additionally, Mwama (2016) reported that some Zambian teachers perceived ESD as emerging only in certain disciplines, while others remained uninformed about EE/ESD integration, contributing to its absence in some schools (Nakwiza, 2019).

Integration challenges in Kenya

Implementing Education for Sustainable Development (ESD) in Kenya faces multifaceted challenges that hinder its effectiveness. Inadequate teacher training, poor infrastructure, and significant budgetary implications pose substantial obstacles to the successful implementation of Kenya's Competency-Based Curriculum, which prioritizes ESD (Wandabi, 2019b). Moreover, systemic issues such as poor governance, corporate irresponsibility, and lack of accountability exacerbate the challenges, leading to unsustainable utilization of natural resources and environmental degradation (Nyakuta, 2020). Milne (2019) highlights the importance of fostering a supportive ethos within schools for ESD, underscoring the need for curriculum alignment and senior management commitment. However, achieving ESD requires both physical and mindset changes, including reevaluating waste management, water and energy conservation, and promoting environmental awareness through workshops and cross-curricular activities (Milne, 2019).

Furthermore, Kenya grapples with various institutional and strategic challenges that impede the effective implementation of ESD. These include the lack of comprehensive ESD strategies and policies, insufficient ESD educator competencies, and limited capacity-building and training skills in ESD (Nyakuta, 2020). Additionally, the absence of robust research and innovation in ESD, along with inadequate partnerships among stakeholders, further complicates the implementation process. To address these challenges, concerted efforts are needed to formulate action plans, enhance professional capacities, promote research, foster collaboration among stakeholders, and establish robust monitoring and evaluation mechanisms ((Republic of Kenya, 2017). Ultimately, ensuring successful ESD implementation in Kenya hinges on comprehensive strategies that address both conceptual and practical barriers while fostering collaboration across sectors (Nyakuta, 2020).

Integration challenges in Namibia

In the Caprivi area of Namibia, Loubser and Simalumba (2016) examined the implementation of EE/ESD in geography for Grades 10–12. The study revealed that teachers demonstrated sufficient knowledge and understanding of environmental concepts and issues. However, challenges arose in integrating EE/ESD into the Geography curriculum due to their limited awareness of skills and attitudes related to the environment. The research found that teachers tended to rely on a singular teaching strategy instead of employing a variety of teaching methods or alternative assessment approaches. To effectively introduce EE/ESD into their teaching, Loubser and Simalumba (2016) identified obstacles, such as the need for additional resources, further training, and departmental support, suggesting improvement in these areas.

Ashipala (2021) similarly noted that geography teachers in Namibia faced challenges in delivering EE/ESD content in the classroom. Teachers highlighted the inadequacy of time for instruction as a significant hindrance to EE/ESD development in their departments. Anyolo, Kärkkäinen, and Keinonen (2018) identified additional challenges faced by teachers in Namibia, including limited time, lack of learner motivation, insufficient teaching and learning tools, and a dearth of ESD content in the curriculum.

Haindoingo (2013) reported that Namibian teachers encountered difficulties implementing EE/ESD due to a lack of understanding about the concepts and underlying principles. The study revealed that neither teachers nor subject advisors fully grasped how EE/ESD should be integrated into the curriculum, primarily due to the absence of pre-established curriculum documents. Moreover, there was a shortage of professional support for EE/ESD implementation, resulting in a perceived lack of implementation in Namibian schools, as suggested by subject advisors who believed teachers might not be voicing their concerns (Haindoingo, 2013)..

2.6.3 Integration challenges in South Africa

The incorporation of EE/ESD into various subjects faces diverse challenges, as observed by Mokhele (2011). Tsotetsi (2021) discovered that teachers encounter difficulties in integrating EE into their subjects, primarily due to the extensive curriculum coverage in the CAPS document, leaving limited time for lessons beyond the classroom. Similarly, Sikhosana's (2019) study indicated that teachers struggle to integrate EE/ESD into their lessons due to time constraints.

Bopape, Mudau, and Msezane (2021:167) identified the absence of integration guidelines in the CAPS document as a hindrance to the process. Hebe (2019) also noted the lack of guidelines to assist teachers in making informed decisions on how to integrate EE into their subjects. Damoah (2019) emphasized teachers' familiarity with a prescribed curriculum and the absence of an environmental policy in schools to guide environmental practices.

Lack of support emerges as a significant challenge in integrating EE/ESD into lessons, as highlighted by Damoah and Adu (2019). The absence of support extends beyond schools to include the District office, school administration, and fellow teachers, creating a challenging environment for teachers aiming to integrate EE/ESD effectively. Siddqui and Khan (2015) argued that insufficient support or motivation from the institution's administration can negatively impact EE/ESD teaching, emphasizing the need for support from subject advisors.

Another challenge is the lack of understanding among teachers regarding EE/ESD. Sikhosana's (2019) study revealed that teachers often fail to integrate EE in the senior phase curriculum due to a lack of understanding of what EE is and how to integrate it. Tunce, Booner, Tuzun, and Oztekin (2014) similarly stressed that teachers' inadequate knowledge of EE/ESD hampers their teaching efforts. The study conducted by Mathenjwa (2014:50) found that many teachers in Ubombo Circuit, South Africa, do not integrate EE in their lessons due to insufficient knowledge.

Moreover, teachers may face confusion about instructional methodologies for integrating EE/ESD, as indicated by Sikhosana (2022). Equipping teachers with a greater understanding of instructional methodologies for EE/ESD integration is crucial to overcoming this challenge. Finally, inadequate environmental literacy among teachers, as highlighted by Masemene and Msezane (2021), hampers the formation of self-efficacy beliefs, making it challenging for teachers to effectively incorporate EE into their lessons. Addressing these challenges requires collaborative efforts and professional development initiatives, as the study anticipates contributing to the development of guidelines for facilitating the integration of EE/ESD.

2.7 Pedagogical Content Knowledge (PCK) of Life Science Teachers

Pedagogical content knowledge (PCK), as defined by Shulman (1987), involves the fusion of a teacher's subject matter or content knowledge with pedagogical knowledge. According to Kimaryo (2011), an effective teacher should possess a robust knowledge base, encompassing skills, knowledge, and an understanding of collective responsibility. Palonsky (1993) further emphasizes the importance of a teacher's ability to communicate their knowledge and skills to learners. In the context of this study, Life Sciences teachers are expected to possess skills, knowledge, and an understanding of environmental knowledge, along with the capability to effectively convey this information to their students.

Three knowledge bases influence PCK, as outlined by Abell (2007): subject matter knowledge, pedagogical knowledge, and contextual knowledge. Subject matter knowledge entails the capacity to organize and synthesize concepts, facts, principles, and theories within a specific discipline (Abell, 2007). For Life Sciences teachers to proficiently teach environmental studies, they must have a solid grasp of the topics encompassed in environmental studies. Effective teaching demands extensive knowledge of the subjects being taught, with environmental studies being a key focus in this study as one of the strands within Life Sciences.

Pedagogical knowledge for teachers encompasses familiarity with educational theories, classroom management, and the management of learners and their learning processes. Shulman (1987) elucidates that teachers' pedagogical knowledge involves integrating educational content with teaching methods, organizing lessons, and leveraging the interests and skills of learners to facilitate effective learning. This pedagogical knowledge is pivotal, enabling Life Sciences teachers to amalgamate environmental studies content with appropriate teaching methods, thereby integrating EE/ESD content into their lessons. This approach ensures that learners are exposed to critical environmental issues faced by the world. The assessment of PCK among teachers in this study will involve data collection through semi-structured interviews and classroom observations. Teachers will be queried on their grasp of environmental studies content and their teaching methodologies. Concurrently, an observation tool will be utilized to evaluate how teachers deliver environmental studies topics in class, focusing on the strategies employed to impart environmental studies knowledge.

2.8 Teachers' Professional development

The success of any education policy, regardless of its sophistication, hinges on the pivotal role played by teachers. Merely implementing policy changes is insufficient for enhancing the education system; the mere alteration of policies does not equate to an improvement in education (Songqwaru & Tshiningayamwe, 2021). Effective policy changes necessitate concurrent efforts in teacher development. High-quality professional development programs play a crucial role in equipping teachers with the necessary skills for professional teaching and learning. While initial teacher education lays the foundation, it falls short in meeting the evolving needs of teachers throughout their careers. Continuous professional development is imperative to ensure that teachers remain pertinent in today's rapidly changing social and educational landscapes (Luneta, 2012). This section delves into the realm of teacher professional development on both international and South African fronts. To begin, the section provides a comprehensive definition of professional development.

2.8.1 What is professional development

According to Antley (2020), "professional development" (PD) is defined as "continuous education and career training once a person has entered the profession in order to assist them in developing new abilities, staying current on the most recent trends, and advancing their career." In essence, professional development (PD) represents ongoing education post-entry into a profession, aiming to enhance both knowledge and skills. Darling-Hammond, Hayler, and Gardner (2017) offer another perspective, defining professional development as a structure of professional learning leading to changes in teacher knowledge and practice, coupled with improvements in student learning outcomes. This underscores that the primary focus of professional development (PD) should extend beyond enhancing professional learning to encompass the enhancement of student learning.

Guskey (2002) characterizes professional development as processes and activities designed to enhance the professional knowledge, abilities, and attitudes of teachers, enabling them to, in turn, elevate student learning. Teacher education is an ongoing journey that extends beyond the confines of the classroom. Given the swift evolution of society and education, traditional teacher education programs alone cannot provide a lasting foundation for sustained professional competence. Therefore, continuous professional development (PD) becomes imperative to ensure teachers remain at the forefront of their respective fields (Luneta, 2012).

Initial teacher training inevitably falls short of preparing educators for the breadth of challenges they encounter in their profession. As one's career progresses, there is a perpetual need to refine professional practices continually (DBE & SACE, 2008). Consequently, professional development for teachers is indispensable for any educational system that prioritizes student achievement.

2.8.2 Teacher professional development

Teachers must be equipped with confidence to effectively teach about the environment and sustainable development using appropriate pedagogies. Thenga, Goldschaga, Ferguson, and Mandikonza (2020) explain 'Teacher Professional Development' (TPD) as "in-service teacher education that can enhance teachers' subject-matter knowledge and, consequently, their teaching practice." Nkhahle (2021) also notes TPD as the process of equipping teachers with skills and knowledge to enhance their practice to adapt to an ever-changing world and, in the case of South Africa, to keep up with a constantly evolving curriculum. According to Avalos (2011:10) TPD "is about teachers learning, learning how to learn, and applying their knowledge for their students' growth."

Teacher Professional Development is intended to improve teachers' practice by addressing the difficulty they face in implementing curriculum in the classroom. Reviewed literature from scholars such as Mokhele (2011), Siddqui & Khan (2015), and Damoah & Adu (2019) shows that teachers face challenges when attempting to integrate EE/ESD into their classrooms. Avalos (2011) emphasized that TDP has the potential to transform the knowledge and skills of teachers, thereby to improve the performance of students. Teachers, as knowledge-mediators, must have a broad understanding of what is occurring in the world around them, therefore, teacher development is always necessary. TPD seeks to enhance not only the competence of teachers but also the academic performance of students (Steyn & Van Niekerk, 2005:128).

Teachers Professional Development (TPD) is an ongoing process that should continue throughout a teacher's career (DBE and SACE, 2008). Harwell (2002) also indicated that TPD is a process and not an event, so any form of TPD results in a long-term, gradual progression of change. Guskey (2002) argues that there is no universally applicable model of ongoing professional development for teachers. What is needed is a well-balanced regimen of tasks that can be tailored to each unique educator. In terms of career advancement, a "one size fits all" mentality is futile. Continuing TPD is a crucial component of any educational system that seeks to enhance the quality of teaching and learning in all aspects of the curriculum (Songqwaru, and Tshiningayamwe, 2021). Nkhahle, (2021) emphasized that TPD for environment and sustainability education must be responsive to context, be emerging, participatory, critical, and praxiological, so that teachers can reflect on and respond to their own practices.

Different modalities can be utilized to advance professional development. Among the various TPD modalities are seminars, conferences, workshops, coaching, mentoring, formal courses, and collaborative models. The traditional models for TPD, according to Darling-Hammond et al., (2017), are seminars, workshops, and conferences. These models, usually, only last a few hours, preventing some teachers from fully acquiring the addressed skills and knowledge for their development. Wood (2007) described the collaborative professional model as a departure from the traditional methods as the approach views teachers as both implementers and creators of knowledge. Lesson study, utilized in Japan, certain regions in South Africa and in some professional learning communities (PLC) are examples of collaborative professional models. Fundisa for Change is one of the PLCs implemented to empower teachers in the areas of the environment and sustainable education, (Thenga et al., 2020). The researchers, however, maintain that teachers are hesitant to use the methods taught in these courses, and some have challenges on how to implement the taught strategies. This study therefore seeks to investigate how Life Science teachers’ pedagogical content knowledge is supported, through professional development, to ensure the integration of EE/ESD into their lessons.

Workshops, seminars, conferences, and even courses have been cited as examples of models of professional development that have been subjected to criticism, as stated by Villegas-Reimers (2003). The fact that these models are one-time events that do not cater to the needs of teachers and do not provide follow-up is one of the criticisms that has been levelled against them. Villegas-Reimers (2003) agrees that there have been times when these models have been successful when coupled with additional opportunities for professional development. She said that these situations have been rare.

Providing professional development events that meet each participant's needs is difficult. According to Guskey (2002), professional development programs boost student achievement. Teachers attend professional development seminars expecting to learn new techniques to improve student performance. Most professional development programs fail to meet this goal because they don't consider what motivates teachers to participate or how teachers change. According to Darling-Hammond, et al (2017), teacher professional development programs should address those expectations and consider how people learn.

Teachers can be motivated to do their best work if they have access to resources that will help them do so, as well as opportunities to have those efforts pushed. If experts want to keep using the same methods or find ways to make them better, they must assess the state of the art (Winch, Oancea & Orchard, 2015). Teachers need to develop a habit of reflective thinking and action that can fuel transformation in their classrooms. Therefore, teachers could benefit from programs designed to enhance their professional knowledge and skills, including self-assessment (Darling-Hammond, 2006).

2.8.3 Teacher professional development in South Africa

According to Mestry, Hendricks, and Bisschoff (2009), apartheid education negatively impacted professional development in South Africa prior to 1994. This was due to a lack of emphasis on quality teacher education at that time, despite the understanding that the quality of a country's workforce is contingent on qualified teachers. Following South Africa's transition to democracy in 1994, teacher development became a focal point in the education system. However, advancements were hindered by ongoing curriculum revisions and a deficiency of adequate models to guide instructors in adapting to the new curriculum (Songqwaru, 2020). The cascade approach to teacher training was employed to aid teachers in implementing the new curriculum, but this model was deemed insufficient (Jansen, 2004).

The 2009 review of the South African National Curriculum Statement underscored the importance of teacher preparation and the provision of high-quality, content-rich textbooks. However, teachers received perfunctory, generic, and low-quality training for the implementation of the National Curriculum Statement, which did not effectively support curriculum implementation. The South African training system adopted a "one-size-fits-all" and ineffective approach. Many departmental personnel responsible for educating instructors lacked a comprehensive understanding of the curriculum, providing teachers with superficial information. Additionally, departmental authorities were uncertain about their roles in implementing the curriculum (Dada et al., 2009). As a result, the following recommendations were proposed:

- In-service teacher training should target areas of need. Training must be topical.
- To help teachers, principals, heads of departments, and district and provincial support staff need extensive training on duties, curriculum, and evaluation.
- Subject advisers should be qualified to provide in-class support and training to teachers.
- Higher education institutions should integrate their teacher education programs with national curriculum plans to better align present (mostly generic) curricula with the specific training needed for successful curriculum implementation. (Dada et al., 2009: 57)

According to the Department of Basic Education South African Action Plan (2014), the focus of teacher development should be on enhancing content comprehension, with continued emphasis on training related to curriculum and assessment requirements. The professional development for teachers should aim to instil a sense of professional identity, professional pride, and skills (South Africa, DBE, 2011). To maintain their position, South African teachers are encouraged to engage in ongoing professional development (DoE, 2006). This recommendation was put forth in the 2009 curriculum evaluation study addressed to education department officials. While key stakeholders play a crucial role in improving education, the responsibility for school reform efforts often falls on teachers.

District departmental authorities and non-governmental groups point to teachers' negative attitudes, cultural factors, and insufficient development as hindrances to their improvement. Teachers, in turn, attribute their challenges to the inefficiency of the school district and its administration (Mestry et al., 2009). The impact of professional development varies among teachers, and some teachers may be more affected than others (Borko, 2004). Consequently, it may seem that the issues in South African schools have not undergone significant changes. The Department of Basic Education's 2019 Action Plan acknowledges visible and modest improvements, but it emphasizes the need for accelerated change, recognizing that some reforms in the school system take longer than others (South Africa, DBE, 2015b). It is crucial for professional development to align with teachers' willingness to change their practices. Therefore, this study aims to investigate how professional development supports the pedagogical content knowledge of Life Science teachers, facilitating the integration of EE/ESD into the Life Science curriculum.

2.8.4 Strategies teachers use to integrate EE/ESD in schools

Teaching strategies, as highlighted by Sikhosana (2019), are methodologies employed by teachers to facilitate learning and the acquisition of subject-specific knowledge by learners. According to Gonazalez (2021), teaching strategies aligned with Education for Sustainable Development (ESD) provide teachers with robust opportunities to deliver instruction in innovative, collaborative, and relevant settings. Freiburg (1996) conceptualized "teaching strategies" as a plan of action for teaching and learning activities, ensuring that both teachers and learners achieve their targeted results. I believe that incorporating a variety of teaching methodologies in ESD education can play a significant role, benefiting teachers and accommodating learners with different learning styles. Consequently, this study views teaching techniques as instructional strategies comprising a structure, method, and guidelines that teachers can utilize in the process of integrating Environmental Education (EE) and ESD into the Life Sciences curriculum.

Teachers can enhance teaching and learning by integrating EE/ESD into various instructional strategies. As noted by Roseberg (2009), when selecting a teaching technique, teachers must assess both the quality of instruction and the achievement of the intended learning outcomes. This study aims to explore the advantages and disadvantages of several teaching styles, including outdoor learning and fieldwork, group discussion and debate, the textbook approach, problem-based learning, interactive methods, and the lecture method.

2.8.4.1 Outdoor learning and field work

According to Gonazalez (2021), outdoor learning refers to engaging in hands-on activities outdoors or utilizing resources provided by nature, exploring the natural environment, and learning about habitats in close contact with them. Although outdoor learning occurs outdoors, some aspects, such as explaining fundamental concepts and preparing materials, may take place in the classroom (Mundlarto & Pamulari, 2017). Outdoor education also encompasses field trips that expose students to change agents and sustainability experts, allowing them to understand the challenges and rewards of these professions. As outlined by Shillibeer (2012), visits to locations outside the classroom are employed to achieve outcomes that cannot be attained within the classroom. This approach prioritizes experiential learning, learning by doing, learning through experience, as well as discovery and explanation.

2.8.4.2 Group discussions and Debates

Cashin (2011) contends that the discussion method, designed to facilitate students in processing knowledge rather than simply receiving it, should be incorporated into all educational domains. In alignment with this perspective, Gonzalez (2021) suggests that discussions can revolve around past or present sustainability issues or recent events, encouraging everyone in the room to express their ideas, opinions, and values on the subject. Effective class discussions necessitate learners engaging in polite debates, presenting alternative viewpoints, and defending their own perspectives with well-reasoned arguments. In the context of class discussions, the teacher assumes various roles, serving as the chair, guide, initiator, summarizer, and mediator.

Zvavanhu (2010) argues that discussions contribute to enhanced critical thinking and communication skills, providing individuals with an opportunity to collaborate and share knowledge. The time commitment required for the discussion approach is cited as a reason why some teachers choose not to prepare lessons in favour of its use. The apprehension about losing control of the classroom is a common concern among teachers, making them hesitant to adopt this teaching method.

2.8.4.3 Textbook method

The significance of textbooks in the teaching and learning process cannot be overstated. Textbooks serve as a crucial instructional resource for teachers, acting as course creators, and for learners, providing essential information (Gak, 2011). They serve as a source of information for the formal study of a particular subject, and what one teacher may perceive as a drawback, another might consider a benefit (Graves, 2000). While certain textbooks incorporate tests, evaluation tools, and self-assessment features, the textbook method allows teachers the opportunity to assess their students' work. Basturkmen (2010) highlights the usefulness of the textbook method, pointing out that textbooks often include supplementary content such as teacher's guides, videos, and worksheets. However, Graves (2000) notes that one drawback of the textbook method is its failure to consider learners' prior knowledge, and some teachers rely solely on textbooks without incorporating other teaching tools, resulting in outdated content in some textbooks.

2.8.4.4 Problem solving method

The problem-solving approach is a methodology that employs problem-solving strategies to facilitate the education of learners. This approach is recognized as a learner-centred instructional method that utilizes real-world challenges to stimulate and guide learning. The problem-solving methodology can significantly contribute to ESD by organizing research and inquiry around authentic and real-world issues. According to Barrows (1994), authentic real-world experiences promote active learning, facilitate knowledge creation, and integrate school learning into real-life situations. This strategy prioritizes problem-solving over the rote memorization of environmental knowledge or practical processes. The problem-solving method plays a role in developing the learner's reasoning abilities, application of scientific information, critical thinking, and fostering a positive outlook. A positive attitude toward science is essential for individuals to live in harmony with nature.

According to Wilson's (2018) problem-solving process, students initiate the problem-solving cycle by identifying and describing the problem, which aids in developing a deeper understanding of their surroundings. Subsequently, students engage in self-directed study, collaborating and utilizing various information sources to enhance their understanding of the problem and potential solutions. After formulating an action plan, students choose the most suitable solution to the problem and implement it. This method concludes with students reflecting on and evaluating the decisions and actions throughout the entire cycle (Nilson, 2010).

2.8.4.5 Lecture method

The lecture method represents a unidirectional mode of communication that places the teacher in a position of authority. In this method, learners primarily listen and occasionally make note of relevant content-related information (Farroq, 2012). As noted by Paris (2014), the lecture approach simplifies the teaching and learning process for the teacher because it compels learners to pay attention and take important notes. Given the authoritative role of the teacher, they exercise complete control over shaping the entire lesson. However, as highlighted by Bonwell (1996), the lecture technique lacks adequate mechanisms for providing feedback to teachers regarding their students' learning. Furthermore, it is not suitable for fostering higher-order thinking skills, such as analysis, evaluation, or application of knowledge. There is no inherent mechanism to ensure that learners actively engage intellectually with the learning material, and passive students are prone to rapid forgetting of information.

2.8.4.6 Interactive teaching strategy

An interactive approach actively involves both educators and learners, incorporating thought-provoking questions and hands-on experiences to address challenges (Yakovleva, 2014). These techniques foster critical and reflective thinking, research, and evaluation, empowering students to take positive actions to safeguard and promote their own and others' health, safety, and well-being (Senthamarai, 2018). The development of personal and social capabilities enables students to collaborate in learning activities, recognize their strengths and abilities, and enhance interpersonal skills such as communication, negotiation, teamwork, and appreciation for diverse perspectives (Senthamarai, 2018). Interactive instructional strategies facilitate two-way communication, allowing both students and instructors to adapt their behaviour, simplifying the teaching and learning process. Active engagement with the instruction enhances the learning experience, and teachers can assess learners' comprehension. Despite these advantages, Moraru (2014) notes that an interactive strategy poses challenges for teachers in discerning whether learners are discussing school-related topics.

2.8.5 Other role players in ESD integration in Life Sciences

2.8.5.1 Subject advisers

According to Stephen (2018:6), a subject advisor is a "subject specialist based in a district office or circuit office tasked with facilitating curriculum implementation and improving the teaching environment," as well as the learning process. Sithole (2020) further defines the subject advisor as a formally appointed teacher providing leadership in curriculum and serving as a senior teacher involved in developing and implementing curriculum policies at the school level. This study adopts Stephen's (2018) definition and identifies a Life Science subject advisor as a specialist in facilitating Life Science curriculum implementation and enhancing teaching and learning processes.

As per the Educational Labour Relations Council (ELRC) collective agreement of 2017, the subject advisor's purpose is to "interpret, monitor, implement policies in schools, and render support and development to teachers" (ELRC, 2017:9). Additionally, the DBE (2020:24) emphasizes the subject advisor's primary role, including the Life Science subject advisor, in "supporting curriculum implementation" and ensuring quality teaching and learning in schools. The DBE and DHET (2011) outline subject advisor duties, such as visiting schools for guidance, training, and professional development through workshops and the establishment of Professional Learning Communities (PLCs). In South African education, curriculum implementation also involves integrating EE/ESD into the Life Science curriculum. The role of the Life Science subject advisor is to assist teachers in implementing EE/ESD by providing guidance on achieving this objective (DBE, 2020). This can be achieved through professional development, including EE/ESD-related workshops and the establishment of EE/ESD PLCs. The Life Science subject advisor also assists teachers in interpreting, monitoring, and implementing environmental policies (ELRC, 2017).

The literature reviewed for this study indicates that teachers often struggle to integrate EE/ESD due to a lack of knowledge on how to incorporate EE/ESD content into their lessons (Damoah & Adu, 2020). Consequently, the Life Science subject advisor plays a crucial role in supporting teachers through PCK workshops, facilitating discussions on EE/ESD topics, and guiding them on effective integration into their curricula. Subject advisors also assist teachers in utilizing new technologies, such as smartphone and tablet apps, virtual field trips, and interactive videos about the environment. Therefore, Life Science subject advisors play a vital role in helping teachers integrate EE/ESD content into their classrooms through professional development.

2.9 Research Gap

The initial call for integrating Environmental Education (EE) across the curriculum was made during a conference in Stockholm in 1972 (UNESCO, 1972). Since then, various scholars have investigated the integration of EE/ESD into school curricula. In the Philippines, Lleno-Peñalba and Janer (2019) conducted a study to assess the integration of EE concepts in Earth and Life Science for Grade 11 by science teachers in the 1st District of Sorsogon during the school year. The findings indicated that teachers possessed the capability to integrate EE into their lessons, attributed to their participation in EE/ESD training and their high level of education. Additionally, facilitators and teachers utilized diverse instructional materials to teach EE/ESD.

Kimaro (2018) explored the perspectives and perceptions of education stakeholders regarding the integration of environmental education into primary school education in Tanzania. The study revealed that teachers lacked competence and motivation due to factors such as a shortage of resources and limited professional development. Similarly, Masemene and Msezane (2021) conducted a study to assess the environmental literacy level of teachers and learners in rural primary schools, finding a lack of environmental literacy competencies among teachers, impacting the development of self-efficacy crucial for sustainable behavioural change.

In South Africa, Damoah and Adu (2020) investigated the challenges teachers face when integrating EE into their respective subject areas of expertise. The results showed that teachers lacked awareness of how to integrate EE/ESD into the school curriculum, and policy documents failed to offer clear guidance on the integration process. Damoah and Omodan (2022) conducted a study on the effectiveness of environmental education policy in South African schools. The findings revealed a lack of practical, structured policies for EE in schools, with only a few schools having school-level environmental education policies provided by the school governing body. These findings align with scholars such as Hebe (2021), Damoah and Adu (2019), and

Gilbert (2019), who highlighted the absence of clear guidelines on how EE and ESD should be implemented in schools.

In a quantitative study exploring teachers' perceptions of the value of continuous professional development in the Gauteng Province of South Africa, Lessing and de Witt (2007: 56) emphasized the importance of ongoing professional development. Another study by Munasi and Madikizela (2020) in a South African context highlighted the limited availability of continuous professional development for teachers, which is essential for interpreting subject curricula and developing personal professional agency. However, existing research did not provide insights into how to support Life Sciences teachers in integrating EE/ESD into the classroom, despite acknowledging ongoing challenges in this regard. The findings reveal a gap in assisting teachers' pedagogical content knowledge through professional development for integrating EE/ESD into their subject curriculum. This study aims to address this gap by developing guidelines to aid Grade 11 Life Sciences teachers in teaching EE/ESD topics in their subjects.

2.10 Chapter Summary

This chapter delves into the existing literature on the incorporation of Environmental Education (EE) into school curricula. The literature review spans the global/international perspective, the African perspective, and the specific South African context. Notably, teachers encounter obstacles such as time constraints, insufficient environmental knowledge, and a lack of support and training, hindering their efforts to integrate EE/ESD into their teaching. These challenges are identified as factors contributing to the reluctance of teachers to incorporate EE into their lessons. Additionally, the chapter underscores the importance of enhancing teachers' knowledge through professional development to equip them with the skills and knowledge necessary for effective integration of EE/ESD into their teaching. Chapter 3 will further explore the theoretical framework that forms the foundation of this study.

CHAPTER 3: THEORETICAL FRAMEWORK

3.1 Introduction

A review of literature in Chapter 2 charts the evolution of Environmental Education (EE) and Education for Sustainable Development (ESD), transitioning from a global to a South African perspective. Commencing with the definition of the environment, the chapter progresses to explore the history of EE/ESD, delving into sustainable development, ESD, and the intricate relationship between EE and ESD. Within Chapter 2, the researcher further investigates literature pertaining to the integration of EE/ESD and the challenges faced by teachers in merging these elements from an international to a South African context. Additionally, the chapter addresses the professional development of teachers and examines diverse strategies for integrating EE/ESD. The thorough review of this literature in Chapter 2 not only informs the reader but also identifies and discusses the research gap within the same chapter.

In Chapter 3, attention is directed towards the theoretical foundations underpinning the study. Guided by Grant and Osanloo's (2014) notion that a theoretical framework serves as the blueprint for a study and should be directly linked to the research problem, the researcher explores the philosophical, epistemological, metaphysical, and ontological dimensions. The primary research question, "How is Life Science teachers' pedagogical content knowledge supported through professional development to enhance the integration of EE/ESD into the Life Sciences curriculum?" steers the selection of a combined theoretical approach, incorporating pedagogical content knowledge (PCK) theory, educational change theory, and social learning theory.

These three theories are chosen for their collective contribution to understanding the rationale behind integrating EE/ESD into the Life Sciences curriculum. PCK theory serves as a framework, delineating the knowledge, skills, teaching strategies, and classroom management required for Life Sciences teachers to effectively incorporate EE/ESD into their subject curriculum. Addressing the identified gap, this theory illuminates the teaching strategies supporting the integration. Fullan’s educational change theory is embraced due to its elucidation of the sequential events leading to educational system transformation. Its utility lies in providing a structured framework for the steps required during the implementation of EE/ESD into the Life Sciences curriculum. This theory further explicates the factors influencing the implementation of educational change, assisting the researcher in filling gaps related to challenges faced by Life Sciences teachers.

Bandura's social learning theory, acknowledged for its flexibility in explaining behaviour and learning, is applied to assess whether a Life Sciences teacher's behaviour in integrating EE/ESD would change when subject advisors facilitate an alteration in their environment. This theory addresses the gap concerning how subject advisors support teachers in integrating EE/ESD into the Life Science curriculum, aligning with the research question about available professional development initiatives for supporting teachers in this integration. Next, the study delves into a discussion of the three theories employed in this research.

3.2 Pedagogical content knowledge (PCK) theory

The inception of Pedagogical Content Knowledge (PCK) can be traced back to Professor Lee Shulman and his colleagues in 1986, marking a pivotal moment that underscored the significance of investigating teacher knowledge. Shulman (1987) defined PCK as the amalgamation of teacher content knowledge (also referred to as teacher subject matter) with their pedagogical knowledge. He underscored its significance as the defining characteristic distinguishing someone with content knowledge (CK) from a teacher capable of representing ideas to facilitate understanding, comprehension, and skill development. PCK, as noted by Hashweh (2005), is distinctly tailored to teachers and is not rigid, as its application is influenced by various factors, including context and interaction with learners (Park & Oliver, 2008).

Kimaryo (2011) further elaborated on PCK, characterizing it as the knowledge that teachers must cultivate to empower learners in the learning process. Consequently, PCK emerges as a fusion of what teachers teach and how they convey the information. Shulman's introduction of Content Pedagogy Knowledge (PCK) in 1986 encapsulates a nuanced understanding of this complex knowledge, incorporating both knowledge and skills essential for the effective transmission of content pedagogy knowledge (Shulman, 1986), as depicted in Figure 1 below:

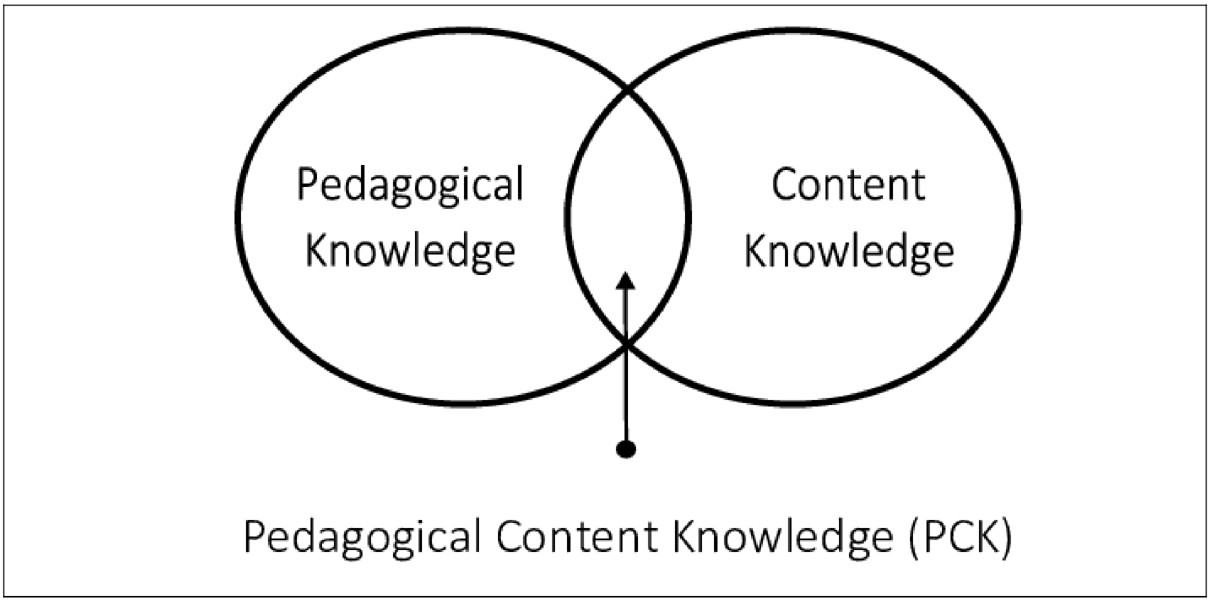

Figure 3.1 Combination of Content Knowledge and Pedagogical Knowledge Produces Pedagogical Content Knowledge (PCK), (Adapted from Shulman, 1986)

Content knowledge (CK) constitutes what teachers comprehend about the subjects they instruct. Kultsum (2017) emphasized that CK encompasses the essential knowledge teachers need regarding a specific subject. On the flip side, pedagogical knowledge (PK) pertains to what teachers understand about the art of teaching. This involves the principles and methods teachers employ to impart knowledge and facilitate student learning (Shulman, 1986). The amalgamation of PK and CK yields Pedagogical Content Knowledge (PCK), depicted in Figure 3.1, a crucial framework for teachers in the teaching and learning process. Building upon Shulman's groundwork, numerous researchers [Grossman (1990); Rollnick, Bennett, Rhemtula, Dharsey, & Ndlovu (2008); Cochran, DeRuiter, and King (1993); Gess-Newsome (2015); Carlson & Daehler (2019)] have proposed diverse PCK models.

3.2.1 Grossman's Model of PCK

Grossman (1990) outlined four primary components integral to Pedagogical Content Knowledge (PCK): (1) knowledge and beliefs regarding the rationales for teaching a subject across various grade levels; (2) understanding of students, encompassing their comprehension, conceptions, and potential misconceptions related to specific topics within a subject; and (3) curricular knowledge, involving familiarity with curriculum materials available for teaching a particular subject. According to Grossman's (1990) PCK model, the rationale for teaching a specific topic significantly influences how educators conceptualize their students' comprehension of the subject, the content they select for instruction, and the methods employed to convey the topic effectively to their students.

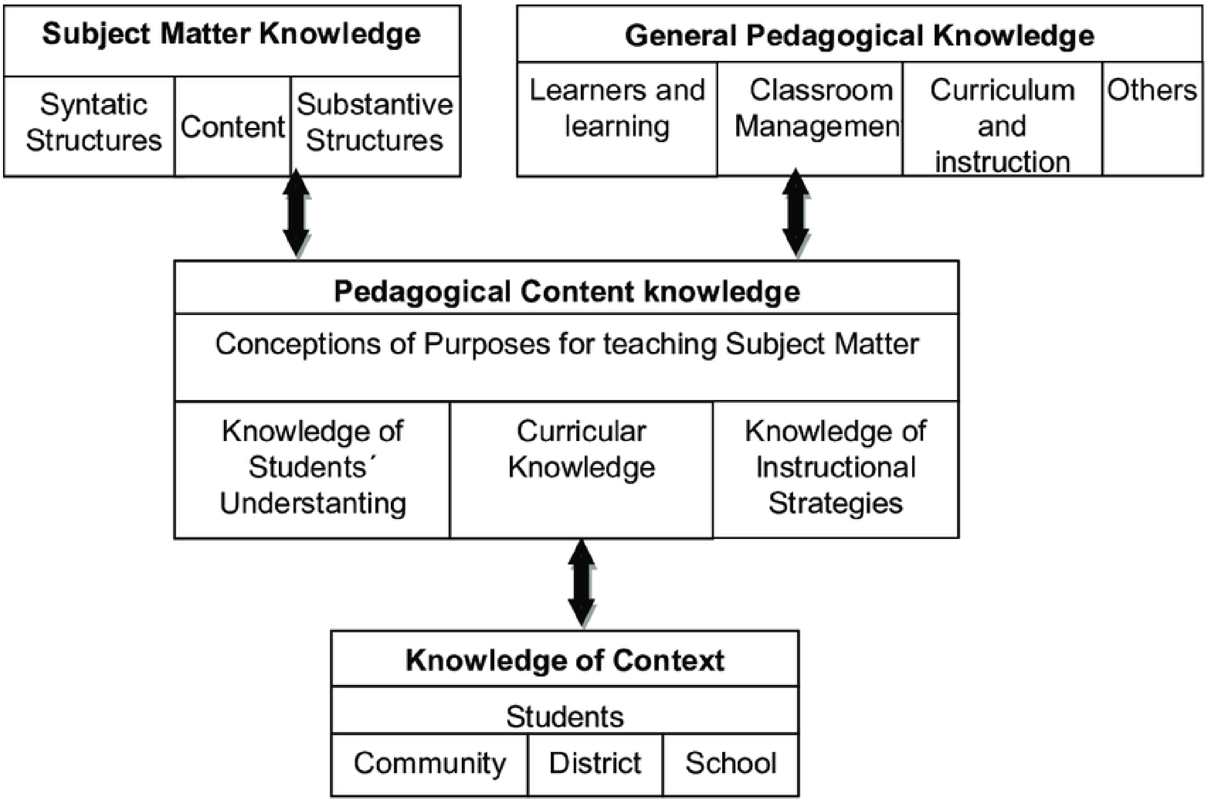

Figure 3.2: Model of Teacher Knowledge (Grossman, 1990) [Adapted from Júnior & Fernandez (2013)]

Among the four components of Pedagogical Content Knowledge (PCK), the paramount one is "Concepts and goals for teaching subject matter." This component elucidates the methods of teaching, encapsulating "knowledge and ideas about why a subject is taught at different grade levels" (Grossman, 1990:8). In the realm of integrative PCK research, Grossman's model has faced scrutiny, with some challenging the notion of treating these components as distinct entities. Contrary to Grossman's segmented perspective, Fernández-Balboa and Stiehl (1995) argue that teachers perceive PCK components as interconnected and interdependent, functioning harmoniously to constitute PCK. According to this perspective, teachers enhance their effectiveness in the classroom by seamlessly integrating all facets of PCK.

3.2.3 Cochran's model of PCK

The PCKg model, introduced by Cochran et al. (1993), introduces a dynamic perspective to Pedagogical Content Knowledge (PCK). In this model, PCKg serves as an interchangeable term for PCK. The addition of the "g" in the revised term "PCKg" underscores the notion that PCK is not static; instead, it can undergo further development through four distinct areas of knowledge. These areas encompass knowledge of the subject matter, general pedagogical practices, the learning environment, and insights into the students themselves. In this model, PCK is portrayed as an expanding circle, emphasizing the continuous evolution and interaction of these knowledge domains.

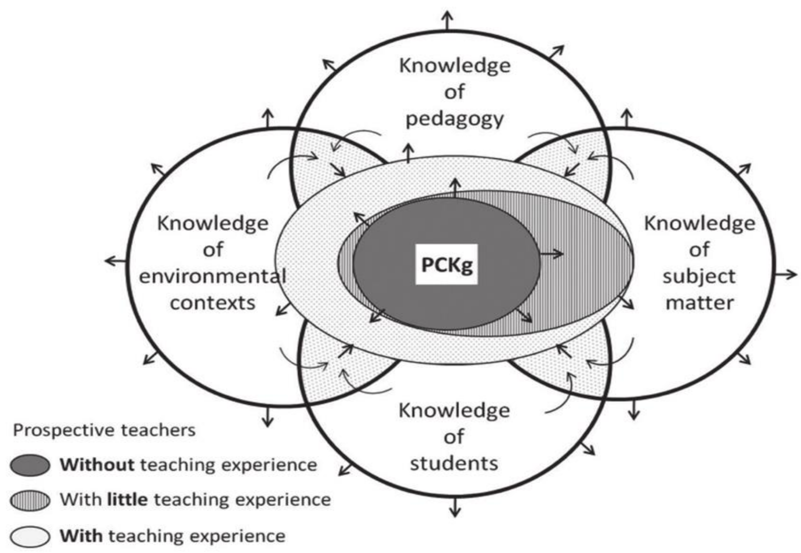

Figure 3.3: A Developmental Model of Pedagogical Content Knowing (PCKg) [adapted from Cochran, DeRuiter, and King (1993)]

Teachers acquire the four categories of knowledge independently, drawing from their teaching experiences and employing various instructional techniques. Because these four knowledge domains are interconnected and exert mutual influence, teachers' Pedagogical Content Knowledge (PCK) is in a constant state of evolution. Within this paradigm, PCK and other types of teacher knowledge are described as "theoretically so intertwined that they can no longer be considered distinct" (Cochran et al., 1993: 267). This model vividly illustrates the dynamic nature of PCK and its expansion through the integration of the four forms of teacher knowledge. Notably, this model does not explicitly delineate boundaries between PCK and other teacher knowledge categories, nor does it present specific PCK components when viewed as an amalgamation of various knowledge types.

3.2.4 Refined Consensus Model of PCK

In the realm of science education, there is widespread discussion about the Refined Consensus Model (RCM) of Pedagogical Content Knowledge for teaching science, as illustrated in Figure 3.4 below. This innovative model, recently developed by Carlson and Daehler (2019), identifies three distinct types of PCK: Collective PCK (cPCK), referring to shared and published PCK; Personal PCK (pPCK), representing an individual teacher's acquired PCK learned independently; and Enacted PCK (ePCK), the manifestation of PCK in a concrete teaching situation.

The model visually represents teachers' knowledge and skills within a specific context to achieve desired student outcomes, termed as enacted PCK (ePCK). Throughout this process, teachers allocate time for planning, teaching, and reflecting on learners' needs, instructional strategies, representations, and pedagogical reasoning (Nordine et al., 2021). Conversely, teachers' personal pedagogical content knowledge (pPCK) and collaborative abilities with students, colleagues, and other stakeholders are cumulative and dynamic. Each teacher refines their pPCK through teaching experiences, ongoing education, and professional sharing, with pPCK evolving in diverse learning scenarios.

The broader landscape of teacher professional knowledge, as described by Carlson and Daehler (2019), encompasses various knowledge bases, including subject knowledge, pedagogical knowledge, student knowledge, curriculum knowledge, and assessment knowledge. This collective professional knowledge, along with contributions from numerous science educators, constitutes the shared and published cPCK, which further incorporates topic-, discipline-, and concept-specific PCK.

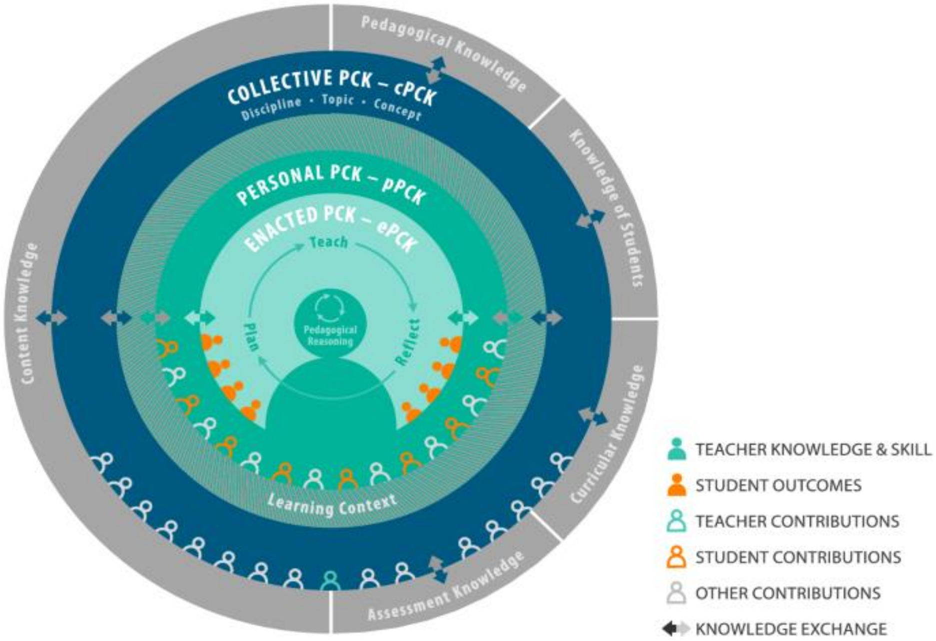

Figure 3.4: The Refined Consensus Model (RCM) of pedagogical content knowledge (PCK) for teaching science (adapted from Hume et al., 2019)

The Refined Consensus Model (RCM) is visually represented as concentric rings, positioning the plan-teach-reflect cycle of enacted PCK (ePCK) at the core. This central cycle is embedded within the teacher's personal pedagogical content knowledge (pPCK) and is surrounded by collective PCK (cPCK), as depicted in Figure 3.4. This visual representation effectively communicates the interdependence and reciprocal influence of various PCK domains.

According to Carlson and Daehler, (2019) the PCK spectrum described for cPCK, encompassing discipline-, topic-, and concept-specific PCK, is deemed universal. PCK, in this context, can be conceptualized as a continuum, ranging from a more comprehensive perspective to a more specialized (sub-field) one, specifically concept-specific. The skill levels within the spectrum of PCK exhibit a broad range, particularly between personal PCK (pPCK) and enacted PCK (ePCK) (Nordine et al., 2021). Among the various models available, this study adopts Shulman's (1986) theory of PCK. Shulman's theory is favoured due to its capacity to provide a more extensive perspective on specific topics, facilitating the identification of teacher knowledge.

3.2.5 Shulman’s components of Pedagogical content Knowledge

The development of teachers' pedagogical content knowledge necessitates the integration and transformation of other essential types of knowledge, namely teachers' subject matter knowledge (SMK), pedagogical knowledge (PK), and knowledge of the instructional context. These components are further explored below.

3.2.5.1 Content Knowledge

The term "content knowledge" (CK) pertains to the comprehensive body of knowledge and information that educators impart in a specific subject or topic, as outlined by Education Reform (n.d.). In this study, CK will be used interchangeably with subject matter. According to Abell (2007), CK is the essential knowledge that a teacher must possess to organize concepts, facts, principles, and theories within a specific discipline. It also encompasses an understanding of the norms of evidence and proof required to generate and validate knowledge claims within a subject or content area. In the context of teaching EE/ESD issues, Life Science teachers must have a profound understanding of the fundamentals of environmental studies, as environmental studies are an integral component of Life Sciences incorporating EE/ESD topics into their lectures.

Darling Hammond (2008) emphasizes that teachers' content knowledge (TCK) is a fundamental requirement for effective teaching in any subject. TCK, being more likely to influence teaching and learning processes, significantly impacts learners' achievements. This underscores the importance of Life Sciences teachers possessing environmental studies CK to successfully integrate EE/ESD into the teaching and learning of environmental studies topics. Insufficient CK in environmental studies could adversely affect the teaching and learning of these topics, consequently impacting learners' achievement in acquiring EE/ESD knowledge.

Kimaryo (2011) asserts that TCK is initially established through the accumulation of education and performance in each field. Therefore, teachers in South Africa are required to have a high school diploma or a bachelor's degree in their subject, especially for secondary school teachers who must possess a bachelor's degree and preferably a B.Ed. or B.A. in two or more courses. For Life Sciences teachers, expertise in the subject matter, preferably as a Life Science specialist, is crucial. After completing the necessary qualifications, including a year-long postgraduate certificate in education (PGCE), teachers can become qualified and registered with the South

African Council for Education (SACE). Initiatives like Fundisa for Change support the development of TCK through Professional Learning Communities (PLCs) that focus on fields such as Geography, Life Orientation, and the Life Sciences.

TCK primarily concentrates on teaching practices, requiring teachers to have a robust expertise in the subject they teach, particularly in the case of Life Sciences. The integration of EE/ESD into their lessons becomes challenging if teachers lack subject knowledge and environmental literacy, as indicated by research conducted by scholars such as Sikhosana (2019), Hebe (2020), and Damoah and Adu (2019). Msezane's (2020) study further supports the importance of professional development programs, such as those provided by the Fundisa for Change Programme, in enhancing Life Sciences teachers' content CK. Participating teachers reported benefits, including acquiring new knowledge on contemporary concerns related to the effects of human activities on biodiversity and climate change.

However, in my perspective, teacher CK alone is insufficient for effective teaching; teachers also require knowledge on how to teach CK to learners effectively. This knowledge, known as pedagogical knowledge (PK), is discussed in the next section.

3.2.5.2 Pedagogical knowledge

Shulman (1987) defines Pedagogical Knowledge (PK) as the "knowledge, theory, and belief about the act of teaching and the process of learning that guides the teacher's techniques in delivering a subject." Effective teaching, according to Schmidt et al. (2008), requires teachers to possess expertise in pedagogical procedures such as lesson preparation and student assessment. Teachers' Pedagogical Knowledge (TPK), as outlined by Abell (2007), encompasses knowledge of instructional concepts, classroom administration, student learning and development, and curricular goals. According to Darling-Hammond, and Bransford (2005), effective content delivery demands teachers to be well-versed in instructional theory, classroom management strategies, student learning styles, the teaching and learning process as a whole, and the overall goals of education.

PK, as a vital resource integrating subject matter and teaching strategies, holds a central position in the teaching profession. It exemplifies how educators merge subject matter and pedagogical approaches, structure lessons, and tailor them to students' individual needs and interests (Shulman, 1987). The growth of TPK relies on factors such as education, classroom experience, professional development opportunities, and feedback from peers. The ability of educators to create an efficient learning environment for their students also contributes to PK.

The experience of teachers plays a crucial role in developing PK aptitude. For instance, Gatbonton (2008) conducted a study comparing the pedagogical knowledge of experienced and new teachers, revealing that experienced teachers have a better understanding of how their students think and act compared to new teachers. This underscores the influence of teaching experience on a teacher's knowledge of teaching and learning, which is built upon what they have learned in school. Kultsum (2017) further emphasizes the importance of teacher training in enhancing teacher quality, helping them learn effective teaching methods and master their subjects. Ongoing professional development allows experienced teachers to continuously improve their skills and professionalism.

Teachers' pedagogical knowledge is crucial as it combines content with teaching methods to assist students in understanding how classroom themes, problems, and issues are organized, presented, and modified according to each student's interests and skills (Saleh et al., 2018). Additionally, teachers must engage in continuous research on pedagogical ideas to stay abreast of advancements in teaching methods and create a conducive environment for teaching and learning (Zakaria and Ahmad, 2021). These abilities can also be harnessed to train other teachers.

3.2.5.3 Knowledge of context

Another crucial knowledge base for teachers influencing their ability to translate pedagogical content knowledge into effective instruction is context knowledge. Contextual knowledge encompasses information about the community, school, learners' backgrounds, the broader context (such as the district), and the physical environment (Grossman, 1990). In my view, having knowledge about the community, physical environment, and school setting enhances the integration of EE/ESD because it enables teachers to understand their subject better, facilitating the use of teaching strategies like outdoor activities to incorporate EE/ESD into their classes. I believe that without knowledge of the community, Life Science teachers may face challenges in implementing instructional tactics such as outdoor activities, as selecting an appropriate location or employing effective teaching methods may become challenging. Understanding the learners' prior knowledge enhances teachers' ability to integrate EE/ESD, as it guides them in determining where to commence teaching environmental studies concepts and which teaching strategies to employ in integrating EE/ESD into their lessons.

Teachers' knowledge of context allows them to contextualize the subject being taught, making learning meaningful and relevant to the real world. According to Palmer (1998), education about, in, and for the environment are the three most effective methods of environmental education teaching and learning. Hence, teachers' knowledge of the context is pivotal to the EE/ESD curriculum (Kimaryo, 2011). The success of a teacher is contingent on understanding the context, as the students' surroundings form the foundation of their teaching. Many teachers become ineffective due to a lack of understanding of the context. For example, Kimaryo (2011) reported that social studies teachers in Tanzania struggle to teach the topic "Our Ward," which requires teaching learners about the ward where the school is located. Teachers cite a lack of resources and uncertainty about what to teach, leading them to teach the ward as presented in the textbook instead.

3.3 The Educational Change Theory

Michael Fullan introduced a concept of educational change, distinguishing it from a theory of education in 1999. Within the realm of educational change, the focus has primarily been on understanding the knowledge required to bring about significant transformations in education, particularly those leading to widespread improvements in learning outcomes. Initially, Fullan posited that the key to change involves a blend of capacity building and responsibility (Fullan, 2007). For teachers to effectively assist students in cultivating the skills and competencies related to knowledge creation, they must excel in building professional knowledge. Fullan (1991) outlined three distinct phases in the change process: initiation, implementation, and institutionalization. The success of each subsequent phase hinges on the accomplishment of the preceding one, necessitating different strategies for each stage. In essence, if change is not initiated and successfully implemented, it cannot be institutionalized. In the context of this study, educational change specifically refers to the integration of EE/ESD into the Life Sciences curriculum. The three phases of the change process are illustrated in Figure 3.5 below.

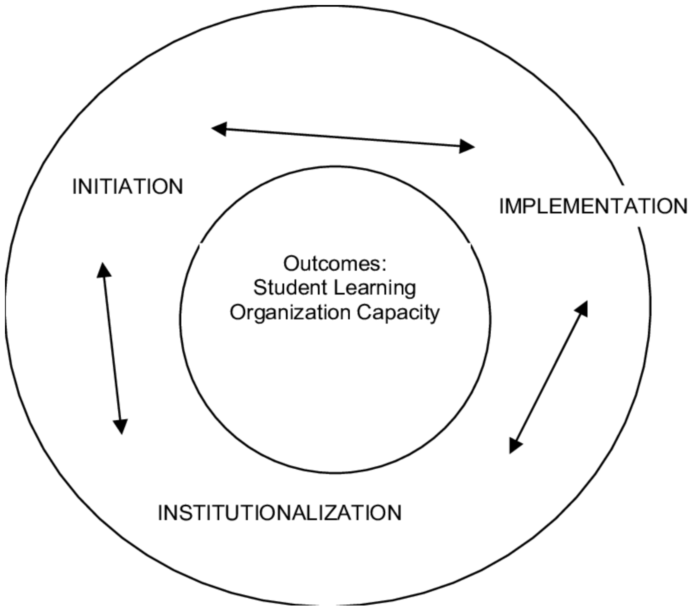

Figure 3.5: A Simplified Overview of the Change Process [adapted from Fullan (2007)]

3.3.1 Initiation Phase

Initiation, as outlined by Fullan (2007), marks the initial phase in any change process, initiating the introduction of EE/ESD into the classroom. At this juncture, it is crucial to mobilize people and resources around the idea, as the success or failure of the innovation may hinge on this stage (Fullan, 1991). This phase aligns with the initial aspect of PCK, which emphasizes subject-matter teaching. To commence, it is vital to set in motion the changes that are primarily anticipated and desired. Assuming the project receives approval, the next step involves individuals implementing it (Fullan, 2007). The ultimate step towards institutionalization occurs when the majority of stakeholders accept and embrace the change initiative. Given the DBE's previous mandate for EE/ESD integration across all subject areas from R-12, the groundwork for this study has already been established (Abell, 2007).

3.3.1.1 Factors affecting initiation phase

Numerous variables may influence the initiation of a change program, as identified by Fullan (2007: 70). These factors encompass the existence and quality of innovation, accessibility to innovation, advocacy from central administration, teacher advocacy, external change agents, community pressure/support/apathy, new policy, and problem-solving and bureaucratic orientations.

3.3.2 Implementation Phase

The second phase in the theory of educational change is implementation, a pivotal stage in curriculum modification (Fullan 2001). During this phase, teachers put new concepts into practice, such as integrating EE/ESD into their curriculum. Fullan (2001: 38) emphasizes that the implementation of educational change necessitates a "change in practice" along three dimensions for it to have a chance of impacting an outcome: (1) the potential use of new or revised materials, including instructional resources like curriculum materials or technologies; (2) the potential adoption of new teaching approaches; and (3) the potential adjustment of beliefs, such as the pedagogical assumptions and theories underlying new policies or practices. The implementation phase of this study will be shaped by teachers incorporating EE/ESD into their subject curricula.

3.3.2.1 Factors that affect the implementation of an educational change

Fullan and Stigelbauer (1991) pinpointed three factors influencing the implementation of educational change. As outlined by Fullan (2001), these factors include: first, the characteristics of educational change; secondly, local characteristics; and thirdly, external factors. These factors are elaborated upon below.

(a) Characteristics of educational change.

There are four factors related to educational change - need, clarity, complexity, and quality/practicality (Fullan, 2001).

Need: This factor revolves around whether implementers see value in the advocated program. For example, do teachers, as line implementers, genuinely value the EE program? People must find meaning in any reform for it to have a meaningful impact. In the context of EE/ESD, teachers need to be convinced that integrating EE is worth their time and effort. The prominence of EE/ESD-related topics in the Grade 11 Life Sciences examination should motivate teachers to integrate such content into their lessons.

Clarity: Clarity about goals and means is a perennial problem in the change process. Even if many agree that changes are needed, when changes occur, there may be confusion about what teachers should do differently. In the case of EE/ESD, literature reveals a lack of clear guidelines in the CAPS document on how teachers should integrate it into their lessons. This study aims to develop guidelines to provide clarity on how Life Sciences teachers can integrate EE/ESD into their lessons.

Complexity: Complexity refers to the difficulty and extent of change required for implementation. An excessive level of complexity can hinder program adoption. The processes involved in implementing a new program, such as EE/ESD, should be simplified to enhance effective implementation. Policy documents must contain clear guidelines on how teachers should implement EE/ESD, and subject advisors must support teachers to ensure successful integration into the Life Sciences curriculum.

Quality and Practicality: Connected directly with the nature of change is the quality and practicality of the change project. The quality involves the commitment directed at the initiative in terms of resources and time. Stakeholders need to allocate sufficient attention and resources to the implementation of EE/ESD, ensuring effective integration into the subjects' curriculum. The Theory of Educational Change (Fullan, 2007) emphasizes the need for support (human and material) in program implementation, similar to effectively integrating EE/ESD into the curriculum. Adoption decisions based on political necessity without adequate time for development can result in substandard quality and the unavailability of materials and resources.

(b) Local factors

The School District: To make significant progress, the district-level implementation process must be prioritized. Central administrators, including the Chief Executive Officer (CEO) of schools, play a crucial role in demonstrating support for the initiative and understanding the practical considerations involved (Fullan, 2007). The district, as a change element in this study, must ensure that subject advisors have sufficient resources to assist Life Sciences teachers in incorporating EE/ESD into their classrooms. The success of collaborative change in education depends on the district's ability to comprehend and actively manage the factors and processes outlined in this chapter.

The Principal/Subject Advisor: The principal is pivotal in shaping the organizational conditions necessary for success, such as developing shared goals, collaborative work structures, and monitoring procedures (Fullan, 2007). While most principals may not traditionally play instructional or change leadership roles, subject advisors can significantly influence change by supporting teachers in integrating EE/ESD into their lessons. In this study, subject advisors play a crucial role in providing guidance and assistance to teachers, contributing to the overall success of the change initiative.

The Role of Teachers: Teachers are central to the implementation, specifically the integration of environmental education into their subject, Life Sciences. The actions of teachers in this process are crucial, and their support by subject advisors can enhance their ability to carry out their duties effectively. Teachers' personalities, influenced by past experiences and career stages, impact their self-actualization and efficacy, influencing their commitment to successful implementation. Subject advisors play a vital role in supporting and empowering teachers to integrate EE/ESD into their subjects.

(c) Intangible factors

Government and Other Agencies: The societal setting of the school or school district is influenced by government and other agencies, with the Department of Basic Education (DBE) and the Department of Higher Education and Training (DHET) being the two primary government agencies in South Africa. Historically, government agencies have often focused on creating new policies and programs without sufficient consideration for the challenges and procedures involved in implementation (Fullan, 2007). In the context of the Republic of South Africa, where the integration of EE/ESD into the school curriculum has been accepted, the government must actively play its role as the initiator, supporter, and assessor of the challenging implementation process (Fullan, 2001). The government can fulfil this role by directing districts and subject advisors to initiate in-service workshops. These workshops would serve as a means of developing and supporting teachers in integrating EE/ESD into their subject curricula. This proactive involvement by the government is crucial for the successful implementation of EE/ESD integration initiatives.

3.3.4 Institutionalization

The third and final phase in the theory of educational change is institutionalization, a stage in which the gains of an innovation become accepted by members of a community (Couros, 2003). Institutionalization signifies the settling, continuity, and permanence of the implementation process. The terms "institutionalization" and "sustainability" are often used interchangeably in the literature, suggesting that the EE/ESD program becomes an integral part of the school's core activities.

In the context of this study, institutionalization means that teachers are now proficient in integrating EE/ESD into their subject curriculum. The success of institutionalization can be observed through changes in attitudes, students' learning outcomes, satisfaction among teachers and other school personnel, acquisition of new skills, and enhanced problem-solving capacity within the school as an organization (Fullan, 2007).

Through successful institutionalization, when EE/ESD is effectively integrated into the school curriculum, students are expected to develop a positive attitude and a sense of responsibility towards the environment. This achievement aligns with the overarching goal of EE, aiming to produce environmentally literate citizens capable of sustaining and caring for their environment in the long term.

3.3.4.1 Factors affecting institutionalization/continuation

The factors hindering continuity resemble those that fuelled the initial implementation, though their specific roles become more evident over time. Numerous programs face termination due to a lack of enthusiasm from district administrators or their inability to allocate funds for "special projects." Additionally, insufficient resources for ongoing training and support for instructors contribute to the discontinuation of many initiatives (McLaughlin & Berman, 1977). Another factor influencing the discontinuation of projects is the absence of enthusiasm and support from the central district office.

3.4 Social learning theory

Social Learning Theory, also known as observational learning, was formulated by Bandura (1986). Bandura's theory provides a valuable framework for understanding how students learn through observing and modelling. He posited that individuals have a natural inclination to learn through observation, where they watch others, retain the information, and later replicate the observed behaviour. Recognizing that direct reinforcement alone couldn't explain all types of learning, Bandura incorporated a social element into his theory, suggesting that people learn by observing others (Nabavi, 2012).

According to Bandura, learning involves interacting with the environment and making a lasting change in knowledge or behaviour to enhance human performance (Driscoll, 1994). In Bandura's view, learning occurs in a social context through observation, and it also encompasses cognitive processes. Learners internalize and make sense of what they observe to reproduce the behaviour themselves. In the context of Life Sciences education, teachers should observe subject advisors during professional development gatherings, workshops, and meetings focused on integrating EE/ESD into the Life Sciences curriculum. During these sessions, teachers observe subject advisors presenting potential ways of integrating EE/ESD, retain that information, and later implement these strategies in the classroom when teaching EE/ESD concepts.

The Social Learning Theory revolves around three interconnected underlying themes: environmental, personal, and behavioural factors. The diagram below illustrates these three themes of the social learning theory.

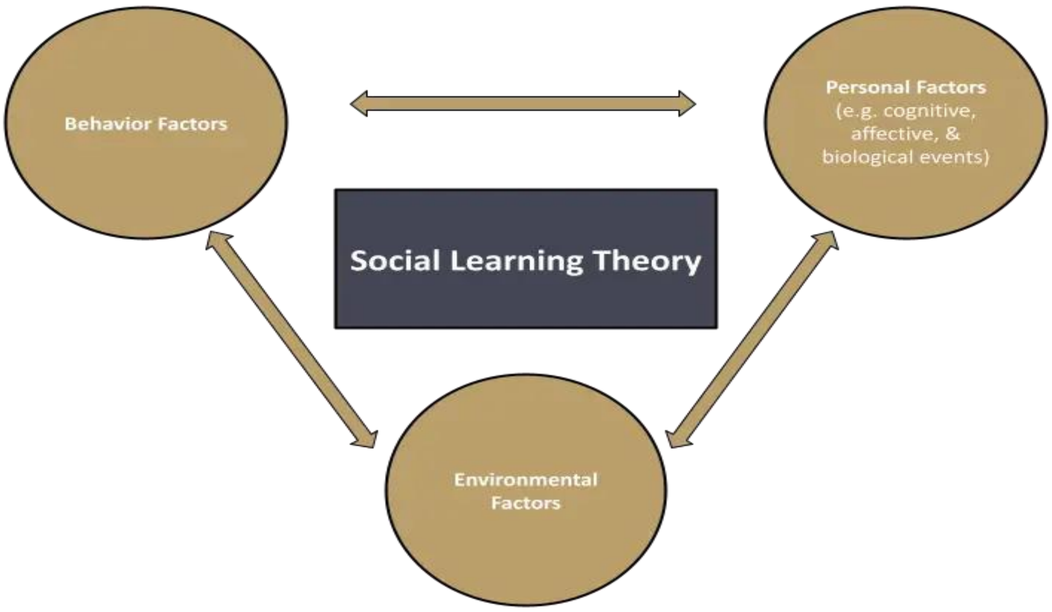

Figure 3.6: Social Learning themes (adapted from Bandura, 1977)

Bandura outlined four stages involved in this type of learning – attention, retention, reproduction, and motivation. The four elements of Bandura's Social Learning Theory are attention, retention, reproduction, and motivation.

Attention: Bandura (1986) emphasized that the imitation of an observed behaviour requires the observer to first notice the behaviour and pay attention to it. Individuals must be attentive to the model's behaviour to learn something new. Subject advisors should introduce innovative strategies that capture the attention of teachers for integrating EE/ESD into their lessons. Conversely, Life Science teachers will pay attention to these strategies to learn or enhance their ability to integrate EE/ESD into their lessons.

Retention: The observer needs to remember the behaviour they have observed and store it in their memory for later access (Nabavi, 2012). For a learned experience to have a lasting impact, the observer must recall it later. Life Sciences teachers should remember what they learned during initiation strategies like EE/ESD workshops and training to use those experiences/strategies for integrating EE/ESD into their lessons. The study will recommend various methods for teachers to remember the integration of EE/ESD into their subjects.

Reproduction: At this stage, the observed behaviour is replicated (Nabavi, 2012). Teachers need to demonstrate what they have learned during professional development meetings. Lack of PCK may be a challenge for teachers to replicate what they observed. The study will report on how subject advisors support Life Sciences teachers in integrating EE/ESD into their subject curriculum.

Motivation: For behaviour to be replicated, the observer must be motivated (Bandura, 1978). Reinforcement and punishment impact motivation. Teachers need motivation to integrate EE/ESD content into their subjects, which subject advisors can facilitate. Motivation can be achieved by awarding certificates to teachers for using EE/ESD, such as in maintaining a clean school environment.

3.5 Chapter summary

This study employs Shulman's Pedagogical Content Knowledge (PCK) theory, Fullan's educational change theory, and Bandura's Social Learning Theory as the theoretical framework. This combination of frameworks allows for an examination of how professional development supports the pedagogical content knowledge of Life Science teachers and enhances the integration of EE/ESD into the Life Sciences curriculum. Utilizing these frameworks facilitates a rigorous and systematic analysis of data gathered from various sources. The following chapter provides a detailed explanation of the methodology.

CHAPTER 4: RESEARCH METHODOLOGY

4.1 Introduction

This chapter presented an overview of the research methodology employed in the study. According to Goundar (2012), research methodology outlines the procedures for conducting research. The discussion on research methodology provided insights into how the study was executed and how the research findings were attained. Initially, the chapter elucidated the research paradigm and its underlying philosophical assumptions guiding the methodology. It subsequently delineated the research approach and design employed in this study. Elements of research methods utilized were introduced, considering Mishra and Alok's (2022) definition, which encompasses all techniques and procedures necessary for conducting research. The research methods in this study encompassed population and sampling strategies, data collection methods, techniques for data analysis and interpretation, and ethical and regulatory considerations. Figures 4.1 and 4.2 below illustrate the research methodology and research methods adopted in this study.

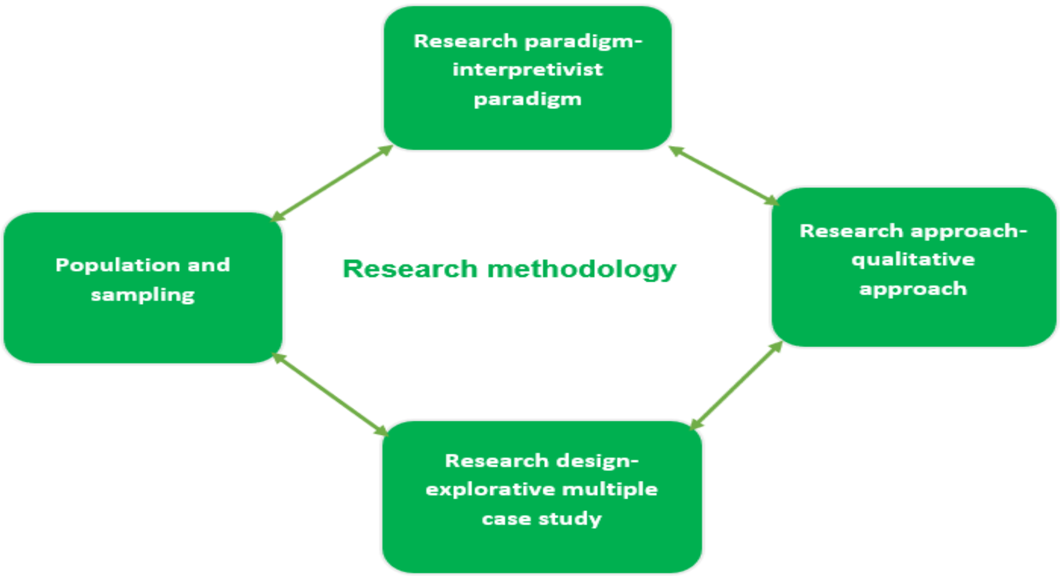

Figure 4.1: Research methodology (Source: Author)

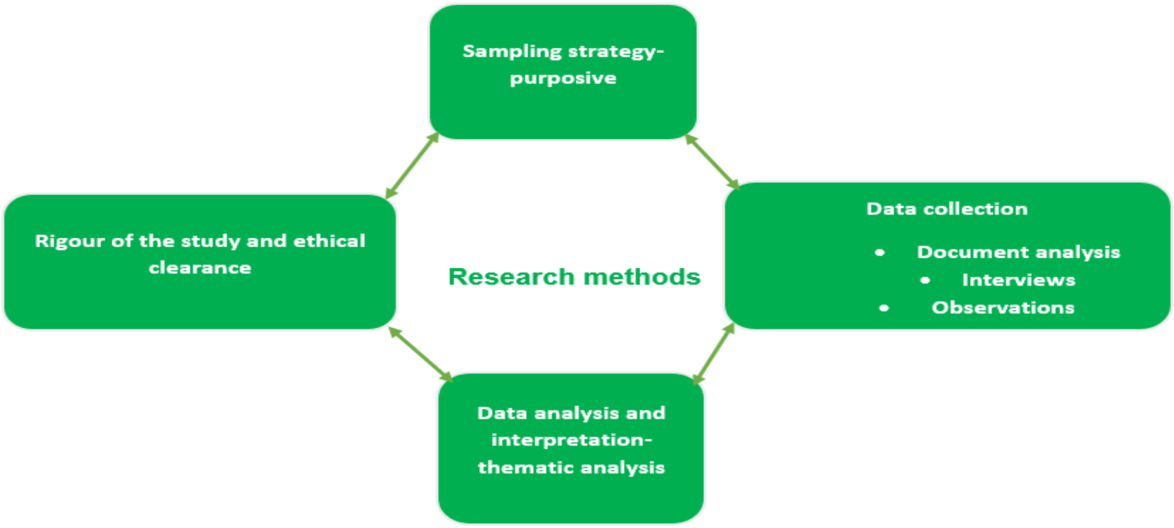

Figure 4.2: Research methods (Source: Author)

4.2 Research Paradigm

Snape and Spencer (2003:2) emphasize that choosing a research paradigm is a crucial initial step in any study. Mackenzie and Knipe (2006) posit that the research paradigm reflects the researcher's perspective. Similarly, Lather (1986) contends that the researcher's stance toward the community in which they reside and plan to stay is evident in the chosen paradigm. The researcher's underlying philosophy, shaped by the selected research paradigm, guides every stage of the research process, from methodological choices to the actual conduct of the study.

According to Lincoln and Guba (1985), a research paradigm comprises four components: ontology, epistemology, methodology, and axiology. Ontology, a branch of philosophy, concerns the assumptions underlying our belief in the coherence or reality of something (Scotland, 2012). It serves as a description of the researcher's beliefs about the nature of truth and how truths exist. For instance, a positivist ontology asserts the existence of something observable, verifiable, and discoverable. According to Scotland (2012), positive reality or truth is objective and independent of the researcher. Epistemology focuses on the study of how knowledge is acquired. Cohen et al. (2018) define epistemology as a philosophy of how knowledge is obtained and communicated. Knowledge can be acquired objectively or subjectively, depending on the epistemological assumptions (Guba and Lincoln, 1995).

The "methodology" of a paradigm pertains to the research design, methods approach, and procedures employed in a well-planned investigation to explore a specific subject (Keeves, 1997). Kivunja and Kuyiini (2017) provide examples of methodology components, such as data gathering, participants, instruments used, and data analysis. Axiology refers to the ethical considerations that must be taken into account when planning research. Mackenzie and Knipe (2006) identified five major research paradigms, including positivist, constructivist, interpretivist, transformative, and pragmatic perspectives. In this study, the interpretivist paradigm was employed to comprehend the universe of human experience. This paradigm was chosen due to its alignment with the study's goal, exploring the extent of EE/ESD integration within the Life Science curriculum in selected schools. The interpretivist paradigm is further discussed in the following section.

4.2.1 Interpretive paradigm

The interpretivism paradigm gives precedence to qualitative research methods, focusing on human perspectives, insights, and reasoning over quantitative approaches to comprehend social interactions (Hoffman and Nickerson, 2021). Its aim is to understand the subjective world of human experiences and meanings, particularly those of Life Science teachers, in what individuals communicate (Cohen et al., 2018). Ontologically, interpretivism posits that there is no singular reality, and individuals construct their own worlds. Epistemologically, it asserts that reality must be interpreted, and knowledge can be acquired through value-laden social and subjective interpretation. Methodologically, interpretive paradigms heavily rely on naturalistic methods such as interviews and observations, facilitating meaningful dialogues between researchers and those they interact with to collaboratively construct meaningful realities.

According to Benjamin (2019:273), interpretive research, when addressing qualitative questions, necessitates framing research questions with a focus on "how" and "why." Saunders et al. (2012) agree that an interpretative approach is essential for researchers as social participants to understand the nuances between them. Tuli (2010) states that studies within the interpretivist paradigm may utilize various techniques, including narrative study, case study, and ethnography, offering in-depth life experiences of narrators who construct their culture.

However, the interpretivism paradigm faces criticisms, primarily related to its subjective nature and the potential for bias on the part of the researcher. Data generated within an interpretive paradigm lacks generalizability due to its heavy reliance on personal viewpoints and values. On a positive note, interpretivism allows for in-depth exploration, and data in such studies tends to have a high level of validity as it is perceived as trustworthy and honest. This study adopted the interpretivist paradigm to explore how professional development supports Life Science teachers' pedagogical content knowledge for enhancing the integration of EE/ESD into the Life Science curriculum. The knowledge in this study was derived through the interpretation of participants' responses collected during the study.

4.3 Research Approach

As stated by Creswell (2014), the research approach refers to the framework and strategy a researcher employs to gather evidence. Defined by Creswell and Creswell (2018), the research approach encompasses the plan and procedures for research, encompassing steps from broad assumptions to detailed methods of data collection, analysis, and interpretation. Depending on the researcher's ontological and epistemological assumptions, a research process can be qualitative, quantitative, or a mixed-methods approach.

Scholars like McMillan and Schumacher (2010), Creswell and Creswell (2018), and Cohen et al. (2018) categorize research methodologies into three major types: qualitative, quantitative, and mixed approaches. According to Newman and Ridenour (1998), a researcher aiming for objective knowledge grounded in scientific facts would opt for a quantitative technique, while one seeking to comprehend how people make sense of the world would favor a qualitative approach. Instead of empirically assessing impacts, as would be done in a quantitative study, this research employed a qualitative approach to gain insight into the experiences and perspectives of participants concerning the research issue. The qualitative methodology is detailed in the following section.

4.3.1 Qualitative approach

As per Cohen et al. (2018), the qualitative approach involves gathering data on naturally occurring phenomena, with the obtained data presented in the form of words rather than statistical figures. Similarly, Creswell & Creswell (2018:51) characterize the qualitative approach as a method for investigating and comprehending the meaning individuals or groups attribute to a social or human situation. Bhandari (2023) highlights one of the advantages of qualitative research as its adaptable data collection and analysis methods, allowing for flexibility as new ideas or patterns emerge. He describes it as a flexible approach and emphasizes that data in qualitative research is collected in naturalistic or real-world contexts.

In this study, the qualitative approach was employed to explore the behaviors and attitudes of teachers and subject advisors regarding the integration of EE/ESD into their lessons. According to Sutton and Austin (2015), the qualitative approach is a method that involves understanding human behavior and the reasoning that governs it. This approach enables researchers to access the opinions and beliefs of participants, providing a deeper understanding of how Life Science teachers' pedagogical content knowledge was supported through professional development to enhance the integration of EE/ESD into the Life Science curriculum.

4.4 Research design

Creswell and Creswell (2018) suggest that the research design encompasses data collection, data analysis, and report writing, serving as the framework that ties together all elements of the research study. According to Jahoda, Deutch, and Cook (1951), research design is the arrangement of conditions for collecting and analyzing data in a manner that seeks to combine relevance to the research purpose with efficiency and procedure. Zikmund (2013) similarly defines research design as a master plan specifying the methods and procedures for collecting and analyzing the necessary information. Consequently, research design acts as the conceptual framework within which research is conducted, providing a blueprint for data collection, measurement, and analysis.

McMillan and Schumacher (2010) also emphasize that research design is a plan outlining how to intervene and collect data. In the qualitative approach, various research designs can be adopted for research purposes, including case study, phenomenology, grounded theory, participatory action research, and a narrative research approach, among others. In its exploration of how Life Science teachers' pedagogical content knowledge is supported through professional development to integrate EE/ESD into their curriculum, this study adhered to a case study design.

4.4.1 Case study design

The case study design proves particularly valuable when a comprehensive understanding of a specific issue, event, or phenomenon within its natural real-life context is sought (McOmber et al., 2021). Described as a form of qualitative research, a qualitative case study diverges from quantitative research, which focuses on numerical data and employs statistics to address research questions.

In the qualitative case study, researchers employ various data sources to investigate a phenomenon within its context (Baxter & Jack, 2008). This design ensures that data is not analyzed through a singular lens but is approached from multiple perspectives, unveiling and comprehending various facets of the phenomenon. According to Yin (2014), a case study design should be chosen when:

(a) The focus of the study is to answer ‘’How’’ and ‘’why’’ questions.

(b) You cannot manipulate the behaviour of those in study.

(c) You want to cover contextual condition because you believe they are relevant to the phenomenon under study or

(d) The boundaries are not clear between the phenomenon and context.

Baxter and Jack (2008) suggest that once the research question to be addressed using a qualitative case study is identified, consideration should be given to the type of case study to be employed. Yin (2014) classifies case studies into explanatory, exploratory, or descriptive categories. Stake (1995) further distinguishes case studies as intrinsic, instrumental, or collective. Additionally, Yin (2017) mentions single, holistic, and multiple case studies. Therefore, this study specifically adopted an exploratory multiple-case study design.

4.4.1.1 Exploratory Case study

Exploratory case studies delve into data at both a surface and a deeper level to elucidate phenomena (Yin, 2017). The aim of an exploratory case study, as outlined by Yin (2017), is to explore novel, intricate areas that lack comprehensive understanding and to formulate hypotheses or ideas that can be evaluated in future research. In exploratory case research, cases are selected based on their potential to provide comprehensive and diverse data about the subject of interest. The focus is on discovery, aiming for an empirically grounded understanding of the structure, dynamics, and context of the study's topic (Chopard & Przybylski, 2021). Exploratory case studies are particularly valuable for generating hypotheses, addressing research questions, and exploring design alternatives for subsequent, more focused and in-depth studies.

This study utilized exploratory case studies to investigate a singular phenomenon, namely how professional development supports the pedagogical subject knowledge of Life Science teachers to enhance the integration of EE/ESD into the Life Sciences curriculum. Consequently, this study employed a exploratory case study design, featuring four from Life Sciences teachers and three district officials who are subject advisors.

4.5. Sampling and population of the study

This section of sampling and population of the study describes the process of selecting and defining the group of participants from which data will be collected and analyzed.

4.5.1 Population of the study

A study's population refers to the entire set of individuals, whether it constitutes a nation or a group sharing common characteristics. Essentially, any shared feature can be considered a population. Shukla (2020) defines population as "the set or group of all the units on which the findings of the research are to be applied." Creswell (2014) similarly asserts that a population is a collection of people who possess certain characteristics. In the context of this study, the population consisted of 208 Life Science teachers and 5 Life Science subject advisors from Vhembe East District.

Chadwick et al. (2017) point out that it is impractical or impossible to collect data from every member of the population. Consequently, the researcher in this study did not collect data from all Life Science teachers and subject advisors in Vhembe East District but opted for a sample of the population that was the focus of the study and a manageable size for data collection. The sampling strategies selected for this study will be discussed in the following section.

4.5.2 Sampling strategies

Polit and Hungler (1999) define "sampling" as the process of selecting a small portion of a population to represent the entire population. The choice of sampling strategies depends on the research approach employed in the study, be it quantitative, qualitative, or a mixed methods approach (Creswell, 2013). Creswell (2013) highlights a significant distinction between quantitative and qualitative sampling, noting that the former adheres to probability methods, while the latter utilizes non-probability methods. Mohammed (2016) adds that the sample size in a study is contingent on the study's purpose, research problem, data collection requirements, and data availability. Quantitative samples are typically large and conducive to statistical analysis, while qualitative samples are generally small (McMillan and Schumacher, 2010:325).

Various strategies for both quantitative and qualitative sampling are identified by McMillan and Schumacher (2010), including random sampling and stratified sampling for quantitative approaches, and purposive sampling, quota sampling, convenience sampling, and snowball sampling for qualitative approaches. In this study, purposive sampling was employed.

4.5.2.1 Purposive sampling

Purposeful sampling serves as a qualitative research method aimed at identifying individuals capable of providing extensive and detailed insights into the subject under investigation. This approach is highly subjective, with the qualitative researcher defining specific criteria that participants must meet to be considered for the research study. Patton (2001) emphasizes that in purposive sampling, researchers select participants who possess rich information and potential knowledge about the phenomenon being studied.

Described as a method for selecting participants based on specific characteristics, purposive sampling was employed in this study to identify individuals with comprehensive information on how professional development supports the pedagogical content knowledge of Life Science teachers, ultimately enhancing the integration of EE/ESD into the life science curriculum. Four schools from the Vhembe East District were purposefully chosen, representing three different circuits. From each school, one Grade 11 Life Sciences teacher was specifically selected.

Grade 11 teachers were targeted because EE/ESD content in Life Sciences is primarily covered in Grade 11. According to the CAPS document, Grade 11 Life Sciences comprises four strands: life at the molecular, cellular, and tissue level; life processes in plants and animals; diversity, change, and continuity; and environmental studies (DBE, 2011). Within these strands, EE/ESD content falls under environmental studies. This subject is taught for 7 weeks in Grade 11 during Term 4, contributing 47% of the content for the final exam Paper 2 (DBE, 2011:72). Additionally, three subject advisors were purposively selected to gain in-depth insights into how they support Life Science teachers through professional development for the integration of EE/ESD into their lessons.

4.6 Data collection methods

Creswell (2003:81) defines data collection as the "process of gathering and measuring information on variables of interest in a systematic way that enables one to answer the research question." The data collection method is a strategic, long-term, practical, and competitive approach chosen to achieve scholarly research objectives (Ganesha & Aithal, 2022). The selection of an appropriate data collection method depends on several factors, including i) the type of research question, ii) the research philosophical paradigm, iii) the research approach, iv) the time available for data collection, v) the resources accessible for data collection, and vii) the researcher's competence.

In this study, the researcher chose a data collection method based on the aforementioned characteristics influencing data collection. Ganesha and Aithal (2022) suggest that researchers understand their competence, research environment, and support system before finalizing a data collection method. As a scholar, the researcher demonstrated competence in data collection and familiarized themselves with the research environment (schools and district or circuit office) by visiting the area before collecting data.

Various methods can be employed to select an appropriate data collection method, such as mono-method choice, which involves using a single method to answer a research question. Mixed-method choice involves using two or more data collection methods simultaneously to address the research question. Multi-method choice entails a broader selection of data collection methods to answer a single research question. Consequently, this study utilized multi-method data collection by employing three different methods to answer a single research question. Creswell (2015:30) notes that multi-method research for data collection involves using various qualitative data collection methods, such as interviews and observations.

The primary goal of using multiple methods for data collection is to triangulate the obtained information. Mik-Meyer (2020) indicate that employing different qualitative data collection methods, all grounded in the same epistemological perspective, enhances the quality of the research by allowing different nuances and angles to be considered. In this study, data was collected through a combination of document analysis, interviews, and observation. Mik-Meyer (2020) acknowledges that it is common to combine interview studies with various observation methodologies and data analyses. This combination of different qualitative data collection methods provides rich accounts, deepens understanding, and unifies analysis.

4.6.1 Document analysis

McMillan and Schumacher (2010:361) categorize documents into three types. First, there are personal documents such as diaries and letters. Second, there are formal documents, including policy statements and statistical data. Thirdly, there are objects and symbols suggesting social meaning and value. These records may be created to serve a practical purpose. Bowen (2009:27) defines document analysis as "a systematic procedure for reviewing or evaluating documents." He emphasizes that document analysis, like other qualitative research analytical methodologies, requires the analysis and evaluation of data to extract meaning, gain comprehension, and generate empirical knowledge. Various documents related to teacher professional development, the CAPS document, and textbooks will be examined in this study (Cohen et al., 2018).

To analyze a document, one needs to collect information present on an official test, study and analyze its content, and process the understanding of the document's content to draw conclusions. Yin (2017) suggests that documents are valuable sources of information that complement other methods of obtaining information. Therefore, in this study, document analysis was used in conjunction with interviews and observations. Ritchie et al. (2003) describe document analysis as the careful study of documents with the aim of gaining an in-depth understanding of their content. In this study, document analysis aimed to achieve an in-depth understanding of the current coverage of EE/ESD content in the Life Sciences curriculum.

Official documents, including the CAPS document for Grade 10–12, textbooks for Grade 11 used at each school, and ATPs for Grade 11 from 2021-2023, were analyzed in this study. The focus of the review was on Grade 11 coverage due to its inclusion of more EE/ESD content. The CAPS document was downloaded online and printed for accessibility in hard copy. Textbooks and ATPs were requested from participants as different schools may prefer different textbooks for the grades. Bell (2010) advises researchers to selectively extract only relevant information from documents. In this study, the CAPS document for Life Sciences grades 10–12, textbooks for Grade 11, and ATPs were examined. The researcher used a document analysis checklist (appendix P) to review the content of the CAPS document, textbooks, and ATPs, identifying the EE/ESD topics covered in Grade 11 Life Sciences.

4.6.2 Interviews

Interviews serve as the most effective means of gathering data in various qualitative inquiries, particularly for delving into people's worldviews (Kvale & Brinkmann 2018). A detailed interview facilitates a better understanding of each participant's perception of their personal experience. The interview is an interactive initiative guided by the interviewer to obtain relevant information about the issue under investigation (Creswell, 2014). Interviews can take various forms, such as formal, highly structured, or unstructured (Cohen et al. 2018). This study opted for a semi-structured interview method due to its high objectivity, richness of information, and flexibility in discussion (Creswell, 2014). Although this method may consume more time, it unveils in-depth information challenging to obtain through other means.

Abawi (2017) defines interviews as data collection through questioning, involving listening to individuals, recording or filming their responses, or a combination of these methods. There are four types of interviews: structured, semi-structured, unstructured, and group interviews (Abawi, 2017). This study conducted semi-structured, one-on-one interviews to allow participants to comfortably express their views with only the researcher present. An interview guide, arranged from simple to complex questions, was used for teachers (appendix M) and subject advisors (appendix N) separately. Teacher interviews explored challenges faced when integrating EE/ESD into the Life Science curriculum, while subject advisor interviews addressed supportive mechanisms for teachers. Prior to interviews, participants were contacted by phone, seeking permission to record their responses with an audio recorder. Audio recording facilitated thorough consideration of questions during the interviews. Probing questions were used to elicit comprehensive information, and the recorded interviews were later transcribed during data analysis.

Adhabi and Anozie (2017) highlight advantages of interviews that align with the qualitative research paradigm. Interviews offer flexibility for participants to explain issues based on their understanding, and semi-structured interviews allow the researcher to interject when necessary. They also enable the use of interpersonal skills to explore significant issues raised by participants. However, qualitative interviews have drawbacks, including being costly and time-consuming (Doyle, 2005). Face-to-face interviews are constrained to a specific geographic region, and immediate responses are required. Despite these limitations, a semi-structured, in-depth interview was deemed most suitable for qualitative data collection in this study.

4.6.3 Observation

Creswell and Creswell (2018:302) define qualitative observation as the process of recording individuals' actions and behaviors at a research site. According to Cohen et al. (2018), observation involves systematically looking and noting details about people, events, behavior, settings, artifacts, routines, and more. Wellington (2015:247) emphasizes the value of observation as a research process, offering investigators the chance to collect live, first-hand data. Clarke et al. (2009) note that observation provides rich contextual information, captures mundane routines and activities, and documents aspects of life that are verbal, non-verbal, and physical, showcasing strong face validity.

Observation, as described by Ekka (2021), is a method for collecting data primarily in qualitative research by observing behavior, events, or physical characteristics in their natural contexts. This can be overt, where the subject is aware of the observer's presence, or covert, where the subject is unaware of being observed and the observer is concealed. Due to ethical considerations, this study opted for overt observation, making teachers aware that they were being observed.

In this study, each of the three Life Science teachers was observed during a session lasting 45 minutes to an hour, in accordance with the school timetable. The observation focused on a Life Science class where teachers were teaching a topic on environmental studies, aiming to identify the teaching strategies employed to integrate

EE/ESD into their lessons. An observation guide (appendix O) was utilized, and with the teachers' consent, the observations were audio recorded. Field notes were maintained to facilitate data collection, and these notes served as a guide during post-observation interviews with teachers, delving into the reasons behind the observed strategies.

Begum (2015) delineates four levels of researcher-participant during field observation: complete participant, complete non-participant, participant as an observer, and observer as a participant. In this study, I assumed the role of a complete non-participant (complete observer) during field observation. This approach allowed an impartial observation of teaching strategies for EE/ESD integration, enabling the identification of factors influencing these strategies without influencing or interacting with daily activities at the different schools (Lodico et al., 2010). Descriptive field notes were employed as observation tools to control for bias, and observations extended to the school environment to assess its impact on EE/ESD integration.

4.7 Data analysis

Magi (2010) characterizes data analysis in research as the systematic process of dissection, categorization, ordering, and summarization of data to address the research question. Kabudi (2004) concurs, defining data analysis as the transformation of gathered information into answers relevant to the initial research question. In this qualitative study, thematic data analysis was employed. Thematic analysis, as described by Dawadi, Shrestha, and Giri (2021), is a qualitative research method facilitating the systematic organization and analysis of extensive data. Maguire and Delahunt (2017) elaborate that thematic analysis involves identifying patterns or themes within qualitative data. This study utilized the six-step framework outlined by Braun and Clarke (2006) for thematic analysis, chosen for its simplicity and practicality.

Braun and Clarke's six-step framework consists of:

a) Becoming familiar with the data

b) Generating initial codes

c) Searching for themes

d) Reviewing themes

e) Defining themes

f) Writing up

Maguire and Delahunt (2017:3354) note that these steps are not strictly linear, allowing researchers to move back and forth in the process. The initial analysis focused on documents (CAPS document, textbooks, and ATPs), read comparatively to comprehend their contents before interviews and observations. This sequential approach aimed to prepare for subsequent data collection activities.

The second step involved generating codes from the documents concerning the research question on the current coverage of EE/ESD content in the Life Sciences curriculum. Maguire and Delahunt (2017:3355) acknowledge that this analytical method is more theoretical than inductive, aligning with the researcher's pre-existing research question.

The third step was the identification and creation of themes by grouping similar codes and finding consistent information across the documents. This phase aimed to discern patterns and relationships within the entire data set.

In the fourth step, themes were reviewed, compared across documents, and refined for internal and external consistency. This helped organize themes systematically and refine their presentation.

Similar procedures were applied to interview data, with transcriptions as the initial step. Transcriptions were initiated immediately after each interview to maintain accuracy. Codes were developed during the transcription process, and the same thematic analysis steps were followed as with the documents. Observations underwent a similar analysis, generating additional codes, and the entire dataset was compared for comprehensive findings.

Steps 5 and 6 involved interpreting findings and deriving meaning by comparing all datasets in relation to the main research question on how life science teachers' pedagogical content knowledge is supported through professional development to enhance the integration of EE/ESD into the life science curriculum.

4.8 Data interpretation

Data interpretation, as defined by Lincoln and Guba (1985), entails deriving meaning or the "lesson learned" from the collected data. Creswell (2012:257) further explains that in qualitative studies, data interpretation involves the researcher stepping back and constructing significant meanings about the phenomenon, drawing on personal perspectives, comparisons with prior studies, or a combination of both. Typically, the interpretation of data is presented in the final chapters of the study under headings like "discussion," "conclusions," or "implementations" (Creswell, 2012).

In the context of this qualitative study, the data interpretation process adhered to the five steps proposed by Creswell (2012):

- A summary of the major findings is presented to provide readers with an overview of the study's key outcomes.
- The researcher offers personal reflections, providing insights into the broader meaning derived from the collected and analysed data.
- Comparisons with the literature are made, where the researcher evaluates the findings in relation to existing literature or prior studies focused on the integration of EE/ESD into the school curriculum.
- The limitations of the study are acknowledged, addressing challenges encountered throughout the research process.
- Recommendations for future studies are made, emphasizing the utilization of the findings for practical applications or highlighting areas that warrant further research.

4.9 Ethical issues

The paramount objective of research ethics is to safeguard the well-being of study participants (Terre Blanche, et al., 2006). In this study, strict adherence to the prescribed ethical principles was maintained to ensure the safety and dignity of all participants. These principles included treating participants with respect, honesty, and ensuring that their involvement did not result in any physical or emotional harm. Ethical clearance for data collection was obtained through a series of applications, demonstrating a comprehensive commitment to ethical standards.

The ethical clearance process unfolded as follows:

- Initial approval was secured through the University of South Africa, College of Education Ethics Review Committee (Appendix B).
- Following this approval, permission was sought from the Limpopo Department of Education to conduct research in the Vhembe East District involving teachers and subject advisors (Appendix C). The department granted the necessary permission (Appendix D).

- Subsequently, permission was sought from the three circuit managers overseeing the identified circuits (Appendix E). The circuit managers approved the study to be conducted in the respective schools (Appendix F).
- Permission was then sought from school principals to conduct research within their institutions (Appendix G). The principals granted their approval for the study (Appendix H).
- Teachers of Life Sciences responsible for teaching environmental topics in Grade 11 were approached to participate (Appendix I), and their consent was obtained (Appendix J).
- Additionally, subject advisors were invited to participate (Appendix K), and all three subject advisors willingly consented to take part in the study (Appendix L).

The consent form sent to the participants comprehensively outlined the purpose and objectives of the study. Participants were encouraged to seek clarification by posing questions to the researcher. Transparency and honesty were maintained throughout, ensuring participants were well-informed about every aspect of the study. Participants were assured of the strict confidentiality of their information and the protection of their privacy. Importantly, participation in the study was voluntary, allowing participants to withdraw at any stage. To mitigate any potential risks, the interview questions were designed to be friendly, and interviews were scheduled during the day at various school locations, as well as in different neighbourhoods and districts where subject advisors were situated.

4.10 Rigour of the study

Thomas and Magilvy (2011) emphasize that in qualitative research, rigor is a crucial method for instilling trust and confidence in the study's findings. Aladejebi (2020) further elucidates that achieving rigor in qualitative research involves the meticulous and thorough execution of all steps undertaken by the researcher throughout the study to ensure its trustworthiness.

4.10.1 Trustworthiness

Baillie (2015) asserts that trustworthiness in qualitative research is indicative of the quality of findings, contributing to the rigor of the research process, relevance, and confidence in the research outcome. The research involved selecting four secondary schools in the Vhembe East District as data collection sites. Each school had one teacher participating in the study. Additionally, three Life Sciences subject advisors from the Vhembe East District were chosen to participate in this research.

4.10.2 Credibility

Daniel (2019) contended that enhancing the credibility of qualitative studies involves a meticulous description of the data analysis process and a rigorous verification of data sources. Thomas and Magilvy (2011) suggest that credibility is assured by identifying similarities within and across all participants' transcripts. Daniel (2019) highlights member checking, the use of verbatim quotes, and triangulation as methods to ensure credibility. To bolster the credibility of this study, the researcher employed member checking, providing participants with transcripts of the interviews for verification. Triangulation was achieved through diverse data collection sources, including document analysis, semi-structured interviews, and observations. Data triangulation further occurred when the researcher compared information from the same inquiry across two participant categories: Life Science teachers and Life Science subject advisors.

4.10.3 Transferability

Thomas and Magilvy (2011: 121) emphasized transferability as the "ability to apply findings or methods from one group to another," while Guba (1981) equated transferability to the concept of reliability in quantitative methods. According to Trochim (2006), transferability is the degree to which qualitative research findings can be applied or transferred to different contexts, and he contrasts it with the external validity or generalizability of quantitative studies. To ensure transferability, this study employed the same data collection method across all three selected schools and utilized identical interview questions for all teachers and distinct interview questions for all three subject advisors. Each participant was recorded during the interview, allowing their responses to be transcribed from audio to text. Subsequently, participants' actual words were incorporated as much as possible when presenting the findings. These precise measures ensured that the obtained results could be applicable to other contexts or research sites.

4.10.4 Dependability

Dependability, akin to reliability in quantitative research (Kimaro, 2018), can be seen as providing readers with assurance regarding the integrity of the findings. Gasson (2004) suggests that achieving dependability involves the researcher meticulously outlining "all the steps that demonstrate how the study was conducted." To secure dependability in this study, the researcher comprehensively documented the process, encompassing research design, approach, sampling, data collection, analysis methods, and trustworthiness strategies employed in the study. This meticulous documentation was undertaken to ensure that future researchers could replicate the work, potentially yielding similar results. Gasson (2004) also emphasized that the thorough coverage enables readers to develop a comprehensive understanding of the applied methods and their efficacy.

4.10.5 Confirmability

Adhering to confirmability necessitates that the researcher avoids personal beliefs or biases and accurately represents the study's findings (Gasson, 2004). Confirmability, as defined by Trochim (2006), refers to the extent to which results can be validated by others, and the recommended approach is for the researcher to document procedures for checking and rechecking the data throughout the project. In this study, confirmability was ensured by anchoring the research findings solely in participants' responses, free from any researcher bias. The researcher meticulously documented each step of the data analysis process to allow for verification by interested parties, and direct excerpts from participants were incorporated to support the presentation of findings.

4.11 Limitations and Delimitations

The objective of this study was to investigate the extent of the integration of EE/ESD into the Life Science curriculum within specific schools. Consequently, a limitation of the study is its focus solely on one subject area, omitting information about other school subjects, despite the overarching goal of integrating EE/ESD across the curriculum. Considering that Life Sciences are exclusively taught in secondary schools, the study concentrated on this educational level. Due to constraints in time, resources, and funding, the research was limited to examining three secondary schools situated in the Vhembe East District. The chosen sample size precluded the utilization of a quantitative approach; hence, the data was presented descriptively using qualitative methodology. The study specifically focused on Grade 11 Life Sciences, involving only teachers from this grade in the selected three schools. Employing purposeful sampling, one teacher per school was selected in accordance with the outlined procedures in the sampling methods section.

4.12 Chapter summary

This chapter elucidates the qualitative research methodology employed in the present study. Commencing with an exploration of the research paradigm and the underlying philosophical assumptions, the chapter delves into the chosen research approach and design. Furthermore, it introduces the constituent elements of the research methodology. The selected methods for data collection and methodologies align with the tenets of a qualitative research strategy and are extensively examined. The chapter also provides a comprehensive explanation of the measures implemented to ensure the trustworthiness of the gathered data. Lastly, ethical considerations, measures, and constraints are thoroughly discussed, concluding the chapter. The subsequent chapter will center on the presentation and analysis of the research data.

CHAPTER 5: DATA PRESENTATION

5.1 Introduction

In Chapter 4, the research methodology for integrating EE/ESD into the Life Sciences curriculum was expounded. Drawing from the discourse in the preceding chapter, this study aligns with the interpretivist paradigm, employs an explorative multiple-case study design, and adopts a qualitative approach for guiding data collection. Primary data were gathered through interviews and participant observation, while document analysis was employed for secondary data. This chapter aims to present the findings derived from document analysis, interviews, and observation to address the principal research question: How is the pedagogical content knowledge of Life Science teachers reinforced through professional development to advance the seamless integration of Environmental Education and Education for Sustainable Development (EE/ESD) into the Life Science curriculum? This overarching question is substantiated by five pertinent sub-questions that will be addressed in this section:

- What is the existing extent of coverage of Environmental Education and Education for Sustainable Development (EE/ESD) within the Life Science curriculum?
- Which teaching strategies are presently employed by teachers to integrate EE/ESD into the Life Science curriculum?
- What are the primary challenges encountered by teachers when integrating EE/ESD into the Life Science curriculum?
- Which professional development initiatives are currently accessible to support teachers in integrating EE/ESD into the Life Science curriculum?
- What key elements should be incorporated as guidelines for Life Science teachers to proficiently integrate EE/ESD into their lessons?

Initiating with the biographical details of the participants who consented to participate in this study, this chapter provides a concise exploration of the data preparation process. Following this, the substantive findings are unveiled, organized around themes and sub-themes derived from the analysis of the data.

5.2 Biography information of the participants in the study

This segment provides the biographical details of the participants selected for the study. A purposive sample of seven participants was chosen, comprising four Life

Science teachers and three subject advisors for Life Sciences. Table 5.1 displays the biographical data of the participants, presenting their pseudonyms, gender, years of experience as teachers and subject advisors, and academic qualifications.

Table 5.1: Biography information of the participants in the study

Participants	Gender	Job incubation	Years of experience as teacher	Years of experience as subject advisor	Highest Academic Qualification	Teaching subjects
Mr Sabawa	M	Teacher	11 years	_	BEDFET (Life Science and English)	Life Sciences and English
Mr Makhokha	M	Teacher	9 Years	_	BEDFET	Life Sciences and Natural Science
Mr Nkhumeleni	M	Teacher	4 Years	_	BED honours	Life Science and Mathematics
Mrs Mususmeli	F	Teacher	11 Years	_	BEDFET	Life Science and Natural Science
Mr Shonisani	M	Subject advisor	20 years	6 years	Honours Botany	Life Science
Mrs Rose	F	Subject advisor	33 Years	6 years	BBA	Life Sciences
Mr Joseph	M	Subject advisor	20 years	6 years	Bed Education	Life Sciences

As indicated in Table 5.1, a total of seven participants from the Department of Basic Education (DBE) took part in this study. Teachers involved in the research bring forth teaching experiences spanning 4 to 11 years, offering insights from both novice and seasoned educators. Subject advisors contribute a wealth of experience, with tenures ranging from 6 to 20 years, showcasing their extensive knowledge and proficiency in guiding and supporting the Life Sciences curriculum. The academic qualifications of participants vary, encompassing degrees such as BED FET, BED honours, Honours in Botany, and BBA, contributing to a diverse understanding of educational practices. The teachers' expertise in subjects like Life Sciences, English, Natural Science, and Mathematics, along with the subject advisors' focus on Life Sciences, highlights their collective mastery in this field.

5.3 Presentation of the findings

In this section, the results obtained through document analysis, semi-structured interviews, and observations are presented. Table 5.2 provides a concise overview of the themes and sub-themes that surfaced during the qualitative data analysis process (Refer to section 4.7).

Table 5.2: Themes and sub-themes

Themes	Category/ Sub-theme
1. Coverage and adequacy of EE/ESD in the Life Sciences curriculum	1.1 The coverage of EE/ESD in the Life Sciences CAPS documents, ATPS, and textbooks 1.2 Teachers and Subject advisors Perceptions of adequacy in covering EE/ESD topic in Life Sciences Curriculum.
2. Understanding and Importance of Environmental Education (EE) and Education for Sustainable Development (ESD)	2.1 Teachers' and subject advisors' Understanding of EE and ESD

3. Teaching Strategies and Resources for Integrating EE/ESD into the Life Science Curriculum	3.1 Teaching Approaches and Methods 3.1.1 Theoretical vs. Practical Teaching 3.2 The use of Teaching Resources 3.2.1 Use of Teaching and Learning Resources
4 Challenges Faced by Teachers in Integrating EE/ESD into the Life Science Curriculum	4.1 Curriculum and Pedagogical Challenges 4.1.1 Time Constraints and Curriculum Challenges 4.1.2 Pedagogical Challenges 4.1.3 Exam-Oriented Teaching 4.2 Support Related Challenges 4.2.1 Lack of Financial Support for School Trips 4.2.2 Lack of Support from Subject Advisors and the DBE (Department of Basic Education) 4.2.3 Lack of Support from School and colleagues
5 Professional Development Mechanisms for Integrating EE/ESD into the Life Science Curriculum	5.1 Need for Professional Development 5.2 Professional Development Opportunities
6 Guidelines for Effectively Integrating EE/ESD into Life Science Lessons	6.1 Utilization and Awareness of Existing Guidelines 6.2 Professional Development and Teacher Support

	6.3 Comprehensive Guidelines and Resource Allocation

Following the themes and sub-themes presented in table 5.2, a detailed presentation of key findings is provided below.

5.4 The coverage of EE/ESD in the Life Sciences CAPS documents, ATPS, and textbooks

This section presents findings related to the inclusion of EE/ESD topics in the Grade 11 Life Science curriculum. While the primary focus of this study is on how Life Science teachers receive support for integrating EE/ESD into their lessons through professional development, an examination of the coverage of EE/ESD topics in Grade 11 is deemed essential. This exploration is significant in understanding whether and to what extent EE/ESD is addressed in the Grade 11 curriculum. The objective is to gain insights into the coverage of EE/ESD in Grade 11, providing a foundation for identifying areas where teachers' Pedagogical Content Knowledge (PCK) can be further supported through professional development. This section specifically addresses the sub-question: What is the existing extent of coverage of Environmental Education and Education for Sustainable Development (EE/ESD) within the Life Science curriculum?

The documents subjected to analysis in this section include the Life Science CAPS document for Grades 10–12, with a specific emphasis on the coverage of EE/ESD in Grade 11. Additionally, the analysis extends to the ATPs for Grade 11 spanning from 2021 to 2023, along with the Grade 11 textbooks used by the four teachers interviewed in this study. The scrutiny of the textbooks focuses on EE/ESD-related topics within the environmental studies strand, specifically exploring themes such as population ecology and human impact on the environment: current crises.

5.4.1 Analysis of the Life Science CAPS document

According to the Department of Basic Education (DBE, 2016), the National Curriculum Statement for Grades R–12 (NCS) outlines the policy on curriculum and assessment within the school system. In an effort to enhance implementation, the National Curriculum Statement underwent amendments, which became effective in January 2012 (DBE, 2016). These amendments prompted the development of a comprehensive single Curriculum and Assessment Policy Statement (CAPS) for each subject, replacing subject statements, learning program guidelines, and subject assessment guidelines in Grades R–12 (DBE, 2016).

The introduction of this curriculum marked a significant departure from the previous curriculum. As noted by Msezane (2020), the changes brought about by this curriculum not only impacted its structural aspects but also influenced the coverage, teaching methods, and examination procedures of environmental topics within the curriculum. Consequently, this study delved into how professional development supported the Pedagogical Content Knowledge (PCK) of Life Science teachers in teaching EE/ESD topics in Grade 11. Life Sciences, as a subject, is organized into four strands in grades 10–12, encompassing life at the molecular, cellular, and tissue level; life processes in plants and animals; diversity, change, and continuity; and environmental studies, as illustrated in Table 5.3 below.

Table 5.3: Life Science: concepts and content progression

Strands	Life at molecular, cellular, and tissue level	Life processes in plants and animals	Diversity, change and continuity	Environmental studies
Grade 10	• Chemistry of life ✓ Inorganic Compounds ✓ Organic compounds • Cell - unit of life • Cell division (mitosis) • Plant and animal Tissues	• Support and transport systems in plants • Support systems in animals • Transport system in Mammals	• Biodiversity and classification • History of life on Earth	• Biosphere to ecosystems
Grade 11		• Energy transformations	• Biodiversity - classification of	• Population ecology

		to support life: Photosynthesis • Animal nutrition • Energy transformations : respiration • Gas exchange • Excretion	microorganisms • Biodiversity - plants • Reproduction - plants • Biodiversity - animals	• Human impact on environment: current crises
Grade 12	• DNA code of Life • RNA and protein Synthesis • Meiosis	• Reproduction in vertebrates • Human reproduction • Nervous system • Senses • Endocrine system • Homeostasis	• Darwinism and Natural Selection • Human evolution	• Human impact on environment: current crises Grade 11

Adapted from CAPS document, (DBE, 2011: 10)

The content framework outlined in Table 5.3 above emphasizes ideas, skills, and concepts, as well as their interconnections, rather than providing a mere list of facts and procedures to be memorized. It refrains from prescribing specific teaching strategies or methodologies, granting teachers the flexibility to expand on concepts and design learning experiences based on their local circumstances and available resources (DBE, 2011:10). Consequently, teachers are tasked with selecting appropriate strategies or methodologies based on local conditions and resource availability when teaching specific concepts. However, this raises the question of whether teachers are effectively choosing and employing the most suitable teaching methods or strategies for various topics in Life Sciences.

Given that the focus of this study centres on grade 11, with a primary emphasis on the coverage of EE/ESD topics in grade 11, Table 5.3 illustrates that these topics are incorporated under the strand labelled Environmental Studies. This strand introduces content in grade 10, covering Biosphere to Ecosystem, followed by grade 11, which delves into population ecology and human impact on the environment: current crises. In grade 12, the CAPS document reveals continuity, with the environmental studies strand retaining the same topic as in grade 11, focusing on human impact on the environment: current crises. Notably, this topic is designated for assessment in grade 12 without being formally taught during that grade. Consequently, the analysis of EE/ESD content coverage will specifically concentrate on grade 11.

The CAPS curriculum for grades R–12 includes a section mandating the integration of environmental content across all subjects. This integration aligns with the overarching aim of the CAPS document, which strives to produce learners capable of using science and technology effectively and critically while demonstrating responsibility towards the environment and the well-being of others. These principles and the CAPS curriculum's aim for Grades R–12 are congruent with the desired outcomes for learners studying Life Sciences (DBE, 2011):

- an understanding of the ways in which humans have impacted negatively on the environment and organisms living in it;
- a deep appreciation of the unique diversity of past and present biomes in Southern Africa and the importance of conservation;
- an awareness of what it means to be a responsible citizen in terms of the environment and life-style choices that they make (DBE 2011: 8).

As per the CAPS document, the study of Life Sciences serves three distinct purposes (DBE, 2011:12):

1) the development of Scientific knowledge and understanding
2) the development of scientific process skills; and
3) the development of an understanding of science’s role in society

These three objectives of studying Life Sciences significantly contribute to shaping and enhancing learners' environmental awareness, emphasizing the importance of learning Life Sciences. For example, the initial objective of fostering scientific knowledge and understanding elaborates further that:

Scientific knowledge and understanding can be used to answer questions about the nature of the living world around us. It can prepare learners for economic activity and self-expression and it lays the basis of further studies in science and prepares learners for active participation in a democratic society that values human rights and promotes acting responsibly towards the environment (DBE, 2011:12)

The aforementioned objective indicates that Life Sciences will empower learners to acquire scientific knowledge, equipping them for economic and social endeavours, enabling active participation in society, and fostering a positive attitude toward the environment. This objective is consistent with the goals of Environmental Education (EE), aiming to impart knowledge about the environment's significance and instil a sense of responsibility for its protection and preservation (EPA, 2017). Life Sciences encompass three subject-specific aims that align with the goal of science education. These are:

1. Knowing Life Science
2. Investigating Phenomena in Life Sciences
3. Appreciating and Understanding the History, Importance and Applications of Life Sciences in Society

In addition to outlining the purpose and specific aims of studying Life Sciences, the CAPS document specifies the time allocations for Life Sciences from grade 10 to 12 and the required resources for each topic. The designated time allocation for Life Sciences is 4 hours per week in Grade 10-12 (DBE, 2011:19). Resources essential for Life Sciences are detailed alongside each topic to aid in planning and preparation.

Table 5.4 below presents an analysis of the total number of topics covered in Life Sciences, highlighting the total number of topics containing EE/ESD-related concepts in Grade 10-12 Life Science. The table includes information on time allocation for environmental studies, mark allocation, percentage of time, and the percentage covered in examinations.

Table 5.4: Coverage of Topics in Life Science CAPS document Grade 10-12

Coverage of Topics in Life Science CAPS document Grade 10-12			
	Grade 10	**Grade 11**	**Grade 12**
Total number of topics	10	11	12
Total number of environmental studies topics	1	2	1
Time allocation for all topics (weeks)	32 weeks	32 weeks	28 weeks
Time allocation for environmental studies	6 weeks	11 weeks	3 weeks
Mark allocation of environmental studies	60/300	106/300	25/300
Percentage page of marks allocation	20%	35%	8%

Source: Author

The data presented in Table 5.4 above indicates that Life Sciences in grades 10 and 12 have only one environmental studies topic each. In grade 10, the topic is Biosphere to Ecosystem, slated to be taught for 6 weeks, constituting 60 out of 300 marks, or roughly 20%. For grade 12, environmental studies comprises a single topic designated for 3 weeks. The CAPS document specifies that "human impact on the environment must be completed in grade 11, but this topic will be examined in both grade 11 and in the National Senior Certificate at the end of grade 12" (DBE, 2011:51). The allocated 3 weeks are intended for revision with the learners. This environmental topic contributes 25 marks in Paper 1, making an 8% contribution to the overall grade. In contrast, environmental topics in grade 11, as per Table 5.4, are more extensive.

This strand in grade 11 consists of two topics: population ecology and human impact on the environment: current crisis. These topics in grade 11 are allocated 11 weeks for teaching. Environmental studies in grade 11 encompass 106 marks out of 300, constituting 35%, surpassing the combined coverage in grades 10 and 12. In terms of assessment in grade 11, according to DBE (2011), it is divided into 36 marks in Paper 1 and 70 marks in Paper 2. Consequently, the table illustrates that environmental studies is more comprehensively covered in grade 11 compared to other grades in the FET bands. This section analyses the coverage of EE/ESD topics in grade 11.

5.4.1.1 Coverage of EE/ESD related topics in the Grade 11 CAPS document

This section delves into an analysis of the coverage of EE/ESD topics in grade 11. The CAPS document is structured to present content under specific strands, with each strand featuring time allocations, topics, content details, investigation aspects, and recommended resources. In grade 11, EE/ESD-related topics predominantly fall under Strand 3: Environmental Studies, covered during terms 3 and 4. The CAPS document outlines the content, investigations, and resources for effective teaching.

Within Strand 3, the CAPS document emphasizes that learners should explore the impact of people on their environments, fostering environmental awareness and encouraging solutions to local environmental issues (DBE, 2011: 49). The documented topics related to EE/ESD in grade 11, term 3, include population ecology, allocated four weeks for teaching. The content covers population size, involving terms like immigration, emigration, mortality, and mortality rate. The CAPS document provides guidance on investigations, indicating the need for teachers to employ technological, pedagogical, and content knowledge (TPAC). For instance, during the population ecology investigation, teachers are advised to determine population size using quadrant or simple sampling, simulated mark or capture, and other methods. The CAPS document also lists essential resources for teaching the topic, such as textbooks, reference books, posters, charts, brochures, DVDs, newspapers, magazines, and watching nature programs on TV (DBE, 2011:49).

Strand 3 extends into term 4, covering the topic "Human Impact on the Environment." EE/ESD-related content within this topic includes the atmosphere and climate change, with detailed discussions on various aspects, including causes and consequences of carbon dioxide emissions, carbon footprint, deforestation, greenhouse effect, global warming, desertification, drought and floods, methane emissions, and ozone depletion. Additionally, water-related content is addressed, encompassing availability, quality, pollution, diseases, eutrophication, algal bloom, thermal pollution, and the need for water purification and recycling. Other contents under this topic include food security, loss of biodiversity, and solid waste disposal. The CAPS document provides thorough guidance for investigations during term 4, including practical observations of local human influences on the environment, reading articles about rhino poaching, and visiting municipal landfill sites. Resources stipulated for this topic include textbooks, reference books, media reports, and share-net booklets.

While the CAPS document comprehensively outlines what to teach, when to teach it, and resources to use, it lacks specific guidance on how teachers should teach EE/ESD-related topics. Therefore, this study has developed guidelines to assist teachers in effectively integrating EE/ESD-related topics into their lessons.

5.4.2 Analysis of the Life Science Annual Teaching Plans (ATPs)

Life Science teachers commonly refer to the Annual Teaching Plans (ATPs) as an essential resource. Developed by the South African Department of Basic Education, these plans function as comprehensive guidelines for teachers engaged in long-term lesson planning across various subjects. The ATPs, aligned with the national curriculum, provide a structured roadmap indicating key concepts, skills, and recommended teaching periods. They empower teachers to make informed decisions about what to teach and when to teach it (CAPS 123, 2023). However, the global onset of COVID-19 disrupted education systems, resulting in reduced teaching time and substantial learning setbacks. In response, the Department of Basic Education revised ATPs for all grades and subjects, offering teachers guidance on interpreting and applying these revisions in their specific teaching contexts.

The ATPs are organized to specify the terms, weeks, and days allocated for covering particular concepts. They also include references to CAPS topics and page numbers for easy alignment with the CAPS document. Core concepts, skills, and values, coupled with pre-knowledge requirements, provide a comprehensive guide for topic coverage. For example, when teaching population ecology, teachers are prompted to review ecology in grade 8 and biodiversity in grade 10 as pre-knowledge. The ATP further details necessary resources and, significantly, incorporates provisions for both informal and formal assessments. Within this section, examples of informal assessments help teachers gauge learner understanding, while formal assessments are outlined for administration after covering each topic.

This study scrutinizes ATPs from 2021 to 2023 to evaluate the coverage of EE/ESD-related topics. The analysis, encompassing three ATPs, seeks to identify consistencies or changes that might impact EE/ESD coverage. The focus centres specifically on grade 11 and the environmental studies strand, concentrating on terms 3 and 4, as these terms encapsulate environmental studies content.

5.4.2.1 Coverage of EE/ESD related topics in the grade 11 Life Science Annual Teaching Plans (2021-2023)

Figure 5.1 presented below illustrates the ATP for term 3 from 2021 to 2023. The emphasis in this figure will be on examining the inclusion of environmental studies topics during term 3 for grade 11.

2021 Annual Teaching Plan Template

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2021 Annual Teaching Plan – Term 3: Life Sciences: Grade 11

Term 3 52 days	Week 1 13 – 16 July (4 days)	Week 2 19 – 23 July (5 days)	Week 3 26 – 30 July (5 days)	Week 4 02 – 06 August (5 days)	Week 5 10 – 13 August (4 days)	Week 6 16 – 20 August (5 days)	Week 7 23 – 27 August (5 days)	Week 8 30 Aug.– 03 Sept (5 days)	Week 9 06 – 10 September (5 days)	Week 10 13 – 17 September (5 days)	Week 11 20 – 23 September (4 days)
CAPS Topic	**(CAPS pg. 46) Gaseous exchange**			**(CAPS pg. 48) Excretion in humans**			**(CAPS pg. 49) Population Ecology**				
Core Concepts, Skills and Values	Difference between cellular respiration, breathing and gas exchange Requirements of efficient gas exchange organs	Human gas exchange – structure, location, functions and adaptations of the ventilation system	Ventilation of the lungs Homeostatic control of breathing	Excretion in various organs	Urinary system-position of organs, structure and functioning of kidney Structure and functioning of nephron	Homeostatic control of water and salts; role of ADH and aldosterone	Population size: Immigration, emigration, mortality, natality; fluctuations and limiting factors	Logistic and geometric growth curves with phases	Interactions in the environment – predation, competition, specialisation, parasitism, mutualism, commensalism	Human population	
Requisite Pre-Knowledge	Revise respiratory system from Grade 9, revise cellular respiration from Grade 11			Revise excretory system from Grade 9, animal tissues from Grade 10			Revise ecology (Grade 8) and biodiversity (Grade 10)				**Consolidation and revision**
Resources (other than textbook) **to enhance learning**	Models, wall charts, DVD's or videos, hand lenses. Watch Telematics video on homeostatic control of breathing at: https://bit.ly/2nN5uEm			Models, wall charts, DVD's or videos, hand lenses, sheep kidney from butcher, dissecting knives. Watch Telematics video on homeostatic control of water and salts at: https://bit.ly/2nN5uEm			Reference books, wall charts, magazines, videos, DVD's				
Informal Assessment	• Worksheets on: structure, location, functions and adaptations • Demonstration/explanation/worksheet on breathing using a model of the human breathing system (pg. 46 and 47 in CAPS) • Informal test			• Worksheets on: drawings and labels with functions of kidney & nephron • Informal test			• Worksheets: determine population size • Complete case studies e.g. culling • Worksheet to interpret different human population • Informal test				
SBA (Formal Assessment)	**TASK 5: PRACTICAL TASK (minimum 30 marks) - SBA Weighting: 10%**						**TASK 6: FORMAL TEST (minimum 50 marks) - SBA Weighting: 20%**				

Figure 5.1: Term 3 2021 annual teaching plan

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2022 Annual Teaching Plan – Term 3: Life Sciences: Grade 11

Term 3 52 days	Week 1 19 – 22 July (4 days)	Week 2 25 – 29 July (5 days)	Week 3 01 – 05 August (5 days)	Week 4 10 – 12 August (3 days)	Week 5 15 – 19 August (5 days)	Week 6 22 – 26 August (5 days)	Week 7 29 – 02 Sept (5 days)	Week 8 05 – 09 Sept (5 days)	Week 9 12 – 16 September (5 days)	Week 10 19 – 23 September (5 days)	Week 11 26 – 30 September (5 days)
CAPS Topic	(CAPS pg. 46) Gaseous exchange			(CAPS pg. 48) Excretion in humans			(CAPS pg. 49) Population Ecology				Consolidation and revision
Core Concepts, Skills and Values	Difference between cellular respiration, breathing and gas exchange Requirements of efficient gas exchange organs	Human gas exchange – structure, location, functions and adaptations of the ventilation system	Ventilation of the lungs Homeostatic control of breathing	Excretion in various organs	Urinary system- position of organs, structure and functioning of kidney Structure and functioning of nephron	Homeostatic control of water and salts; role of ADH and aldosterone	Population size: Immigration, emigration, mortality, natality; fluctuations and limiting factors	Logistic and geometric growth curves with phases	Interactions in the environment – predation, competition, specialization, parasitism, mutualism, commensalism	Human population	
Requisite Pre-Knowledge	Revise respiratory system from Grade 9, revise cellular respiration from Grade 11			Revise excretory system from Grade 9, animal tissues from Grade 10			Revise ecology (Grade 8) and biodiversity (Grade 10)				
Resources (other than textbook) to enhance learning	Models, wall charts, DVD's or videos, hand lenses. Watch Telematics video on homeostatic control of breathing at: https://bit.ly/2nN5uEm			Models, wall charts, DVD's or videos, hand lenses, sheep kidney from butcher, dissecting knives. Watch Telematics video on homeostatic control of water and salts at: https://bit.ly/2nN5uEm			Reference books, wall charts, magazines, videos, DVD's				
Informal Assessment	• Worksheets on: structure, location, functions and adaptations • Demonstration/explanation/worksheet on breathing using a model of the human breathing system (pg. 46 and 47 in CAPS) • Informal test			• Worksheets on: drawings andlabels with functions of kidney &nephron • Informal test			• Worksheets: determine population size • Complete case studies e.g. culling • Worksheet to interpret different human population • Informal test				
SBA (Formal Assessment)	TASK 5: PRACTICAL TASK (minimum 30 marks) - SBA Weighting: 10%						TASK 6: FORMAL TEST (minimum 50 marks) - SBA Weighting: 20%				

Figure 5.2: 2022 Term 3 Annual teaching plan

2023/24 ANNUAL TEACHING PLANS: LIFE SCIENCES: GRADE 11 (TERM 3)

TERM 3	WEEK 1	WEEK 2	WEEK 3	WEEK 4	WEEK 5	WEEK 6	WEEK 7	WEEK 8	WEEK 9	WEEK 10	WEEK 11
CAPS TOPICS	**ORIENTATION**	**GASEOUS EXCHANGE (CAPS P. 46)**			**EXCRETION IN HUMANS (CAPS P. 48)**			**POPULATION ECOLOGY (CAPS P. 49)**			
CORE CONCEPTS, SKILLS AND VALUES	Revise relevant body systems from Grade 9 and ecology from Grade 8	**Gaseous exchange** Distinguish between cellular respiration, breathing and gas exchange Requirements of efficient gas exchange organs: Large surface area, thin, moist, well ventilated, protected, transport system	**Human gas exchange:** The structure (macro and tissue level), location, adaptations and functioning of the ventilation system: Trachea, epiglottis, bronchi, bronchioles, lungs, ribs, intercostal muscles, diaphragm, alveoli Ventilation of the lungs: • Gaseous exchange in alveoli • The transport of gases around the body • Gaseous exchange in tissues • Composition of inspired air vs. expired air – analyse data	Homeostatic control of breathing (Links with Gr 12)	**Excretion in various organs**: Brief role of the following: • The lungs • The kidneys • Bladder • The liver • The alimentary canal (gut) • The skin Substances secreted by each and the origins of these substances	**Urinary system** The structure of the: • Urinary system: Position of kidneys, ureters, bladder, urethra • Kidney: structure and functioning, removal of urea and excess water and salts, re-absorption of glucose and some salts • Nephron: structure and functioning: Ultra-filtration, re-absorption, tubular excretion, pH control, formation of urine	Homeostatic control of water and salts: Role of ADH and aldosterone (Links with Gr 12)	**Population size** influenced by: Immigration, emigration, mortality, natality, fluctuations and limiting factors carry capacity Logistic and geometric growth curves with phases	**Interactions in the environment**: **Predation**: Two South African examples of predator-prey relationships: graphs **Competition**: Interspecific: for light, space, water, shelter and food Intraspecific: for food, access to mates, water, space, and shelter; survival is determined by access to the above, ecological niches **Specialisation**: Competitive exclusion and resource partitioning; discuss one example of co-existence in animals and one example in plants **Parasitism**: Two examples from South Africa; one species benefit **Mutualism**: Two examples from South Africa; both species benefit **Commensalism**: Two examples from South Africa	**Human population** Reasons for exponential growth: Age and gender distributions for different countries including South Africa Forecast of South Africa's population growth over the next twenty years and predict possible consequences for the environment	**Consolidation and revision**
PRE-KNOWLEDGE		**HUMAN SYSTEMS (GR 9)** **LUNGS & PULMONARY SYSTEM (GR 10)**			**HUMAN SYSTEMS (GR 9)**						
EXAMPLES OF INFORMAL/ DAILY ACTIVITIES		**Activity** Tabulate the differences between cellular respiration, breathing and gas exchange **Activity** Requirements of efficient gas exchange organs	**Activity** Diagram of the human breathing system with labels and functions Including ventilation of lungs **Activity** Analyse and interpret data showing the effects of altitude on the number of red blood cells and the consequent effect on athletes at different altitudes	**Activity** Homeostatic control of breathing	**Activity** Tabulate various excretory organs and their secretions and excretions Include the substances secreted and their origin where applicable	**Activity** Diagram of the urinary system of the human with labels and functions **Activity** Longitudinal section through the kidney. Label and functions **Activity** Diagram of nephron with labels and functions Use arrows to indicate the direction of urine production	**Activity** Homeostatic control of water and salts: role of ADH and aldosterone	**Activity** **Case study**: Rationale for culling, e.g., elephants in the Kruger National Park as an example of an application of estimating population size	**Activity** Population size including graphs on logistic and geometric growth **Activity** Tabulate interactions in the environment **Activity** Draw a life cycle of the bilharzia parasite or tapeworm (simplify larval stages)	**Activity** Human population	

Figure 5.3: 2023/24 Term 3, Annual teaching plan

Based on the information presented in Figure 5.1, the environmental studies topic related to EE/ESD covered in term 3 for grade 11 is population ecology, as explicitly indicated on page 49 of the CAPS document. The key concepts encompass the dynamics of population size, including immigration, emigration, mortality, natality fluctuations, and limiting factors. Additionally, the curriculum covers logistic and geometric growth curves with phases, along with exploring the interaction between the environment and the human population. The designated duration for covering these topics is four weeks, specifically during weeks 7–10 of term 3, as outlined in the ATPs for 2021 and 2022. However, a noteworthy change is observed in the 2023 ATP, where the time allocated for this topic has been reduced from four to three weeks. Furthermore, the content of logistic growth and geometric growth has been integrated with the population size content, yet the time allocated for teaching population size has not been extended.

The ATPs also underscore prerequisite pre-knowledge by specifying topics that teachers are expected to revisit before introducing new content. For instance, in the 2021 and 2022 ATPs, teachers are advised to review ecology (grade 8) and biodiversity (grade 10) before delving into the mentioned topics. However, the 2023 ATP lacks the identification of pre-knowledge for the topics discussed. Notably, the 2021 and 2022 ATPs provide teachers with additional resources beyond textbooks to enhance learning, including reference books, wall charts, magazine videos, and DVDs. Unfortunately, the 2023 ATP does not include a list of such resources. Across all three years, the ATPs incorporate both informal assessments and formal assessments as integral components of the teaching plan. The subsequent section presents the ATPs for term 4.

2021 Annual Teaching Plan – Term 4: Life Sciences: Grade 11

Term 4 47 days	Week 1 05 – 08 October (4 days)	Week 2 11 – 15 October (5 days)	Week 3 18 – 22 October (5 days)	Week 4 25 – 29 October (5 days)	Week 5 01 – 05 November (5 days)	Week 6 08 – 12 November (5 days)	Week 7 15 – 19 November (5 days)	Week 8 22 – 26 November (5 days)	Week 9 29 Nov – 03 December (5 days)	Week 10 06 – 08 December (3 days)
CAPS Topic	**(CAPS pg. 51) Human impact on the environment (current crises)**				**Consolidation and revision**	**FINAL EXAMINATION** **PAPER 1** **Marks: 150** **Time: 2½ hours** *Learners must answer all 3 questions.* **Topics and marks:** *Photosynthesis – 32* *Animal nutrition -32* *Respiration – 22* *Gaseous exchange – 32* *Excretion – 32* **PAPER 2** **Marks: 150** **Time: 2½ hours** *Learners must answer all 3 questions.* **Topics and marks:** *Biodiversity and classification of microorganisms- 29* *Biodiversity in plants and reproduction – 29* *Biodiversity of animals -18* *Population ecology - 37* *Human impact - 37* **Cognitive levels:** **Knowing science - 40%; Understanding science - 25%; Applying scientific knowledge - 20%;** **Evaluating, analysing and synthesising science knowledge - 15%** **Degrees of difficulty for examination and test questions:** **Easy - 30%;** **Moderate - 40%;** **Difficult - 25%;** **Very difficult - 5%**				
Core Concepts, Skills and Values	The atmosphere and climate change	Water availability and Water quality	Food security	Loss of biodiversity Solid waste removal						
Requisite Pre-Knowledge	Revise balance in ecosystems from Grade 8 and 10									
Resources (other than textbook) **to enhance learning**	Reference books, media reports, internet, magazines, newspapers. Watch Telematics video on human impact on the environment at: https://bit.ly/2ITaRk0									
Informal Assessment	• Worksheets: Interpret case studies, tables and graphs • Practical observation of ONE example of human influence on the environment in local area; write a report • Interpret articles e.g. rhino poaching • Conduct a solid waste analysis • Informal test									
SBA (Formal Assessment)	**SBA Weighting: 60%**					**End of year Examinations: Weighting: 40%**				

Figure 5.4: 2021 Term 4 annual teaching plan

basic education
Department: Basic Education
REPUBLIC OF SOUTH AFRICA

2022 Annual Teaching Plan – Term 4: Life Sciences: Grade 11

Term 4 47 days	Week 1 11 – 14 October (4 days)	Week 2 17 – 21 October (5 days)	Week 3 24 – 28 October (5 days)	Week 4 31 – 04 Nov (5 days)	Week 5 07 – 11 November (5 days)	Week 6 14 – 18 November (5 days)	Week 7 21 – 25 November (5 days)	Week 8 28 – 02 December (5 days)	Week 9 05 – 09 December (5 days)	Week 10 12 – 14 December (3 days)
CAPS Topic	**(CAPS pg. 51) Human impact on the environment (currentcrises)**				**Consolidation and revision**	**FINAL EXAMINATION**				
Core Concepts, Skills and Values	The atmosphere and climate change	Water availability and Water quality	Food security	Loss of biodiversit y Solid waste removal		**PAPER 1** **Marks: 150** **Time: 2½ hours** *Learners must answer all 3 questions.* **Topics and marks:** *Photosynthesis – 32* *Animal nutrition -32* *Respiration – 22* *Gaseous exchange – 32* *Excretion – 32*		**PAPER 2** **Marks: 150** **Time: 2½ hours** *Learners must answer all 3 questions.* **Topics and marks:** *Biodiversity and classification of microorganisms- 29* *Biodiversity in plants and reproduction – 29* *Biodiversity of animals -18* *Population ecology - 37* *Human impact - 37*		
Requisite Pre-Knowledge	Revise balance in ecosystems from Grade 8 and 10					**Cognitive levels:** **Knowing science - 40%; Understanding science - 25%; Applying scientific knowledge - 20%;** **Evaluating, analyzing and synthesizing science knowledge - 15%** **Degrees of difficulty for examination and test questions:** **Easy - 30%;** **Moderate - 40%;** **Difficult - 25%;** **Very difficult - 5%**				
Resources (other than textbook) to **enhance learning**	Reference books, media reports, internet, magazines, newspapers. Watch Telematics video on human impact on the environment at: https://bit.ly/2ITaRk0									
Informal Assessment	• Worksheets: Interpret case studies, tables and graphs • Practical observation of ONE example of human influenceon the environment in local area; write a report • Interpret articles e.g. rhino poaching • Conduct a solid waste analysis • Informal test									
SBA (Formal Assessment)	**SBA Weighting: 60%**					**End of year Examinations: Weighting: 40%**				

Figure 5.5: 2022 Term 4 annual teaching

2023/24 ANNUAL TEACHING PLANS: LIFE SCIENCES: GRADE 11

2023/24 ANNUAL TEACHING PLANS: LIFE SCIENCES: GRADE 11 (TERM 4)

TERM 4	WEEK 1	WEEK 2	WEEK 3	WEEK 4	WEEK 5-10
CAPS TOPICS	**HUMAN IMPACT ON THE ENVIRONMENT (CAPS P. 51)**				
CORE CONCEPTS, SKILLS AND VALUES	Causes and consequences of the following (relate to conditions and circumstances in **South Africa**): **The atmosphere and climate change** • Carbon dioxide emissions • Concept of "carbon footprint" and the need to reduce the carbon footprint • Deforestation • Greenhouse effect, enhanced • Greenhouse effect and global warming: desertification, drought and floods • Methane emissions • Ozone depletion	**Water availability** • Construction of dams • Destruction of wetlands • Poor farming practices • Droughts and floods • Exotic plantations and depletion of water table • Boreholes and effects on aquifers • Wastage • Cost of water **Quality** • Water for domestic use, industry, agriculture and mining: Pollution, diseases, eutrophication and algal bloom • The effect of mining on quality of water • Thermal pollution • The need for water purification and recycling • Alien plants e.g., *Eichhornia* **Food security** (link with population ecology dynamics) • Human exponential population growth • Droughts and floods (climate change) • Poor farming practices: monoculture, pest control, loss of topsoil and the need for fertilisers • Alien plants and reduction of agricultural land • The loss of wild varieties: Impact on gene pools • Genetically engineered foods, wastage	**Loss of biodiversity** (the sixth extinction) • Habitat destruction: Farming methods, e.g., overgrazing and monoculture, golf estates, mining, urbanisation, deforestation, loss of wetlands and grasslands • Poaching, e.g., for rhino horn, ivory and "bush meat" • Alien plant invasions: Control using mechanical, chemical and biological methods • Indigenous knowledge systems and the sustainable use of the environment e.g., devils' claw, rooibos, fynbos, the African potato (Hypoxis) and Hoodia **Solid waste disposal** Managing dumpsites for rehabilitation and prevention of soil and water pollution The need for recycling Using methane from dumpsites for domestic use: Heating and lighting Safe disposal of nuclear waste	Revision paper 1 and 2	**FINAL EXAMINATION (Two papers)** **PAPER 1** **Marks: 150** **Time: 2½ hours** **Topics and marks:** *Photosynthesis – 32* *Animal nutrition – 32* *Respiration – 22* *Gaseous exchange – 32* *Excretion – 32* **PAPER 2** **Marks: 150** **Time: 2½ hours** **Topics and marks:** *Biodiversity and classification of micro-organisms – 29* *Biodiversity in plants and reproduction – 29* *Biodiversity in animals – 18* *Population ecology – 37* *Human impact on the environment -- 37* **Cognitive levels** Knowing science - 40% Understanding science - 25% Applying scientific knowledge - 20% Evaluating, analysing and synthesising science knowledge - 15% **Degrees of difficulty for examination and test questions** Easy - 30% Moderate - 40% Difficult - 25% Very difficult - 5%
PRE-KNOWLEDGE	**ECOSYSTEMS GRADE 10**				
EXAMPLES OF INFORMAL/ DAILY ACTIVITIES		**Activity** Case study on rhino poaching and suggestions on how it can be prevented			
INVESTIGATIONS/ EXPERIMENTS		**INVESTIGATION** Analyse the solid waste generated in the household in one week, including paper, metals and plastic Estimate the percentage that could be recycled or reused			
INFORMAL TESTS		**Informal test**			
SBA (FORMAL ASSESSMENT)	**SBA**				**End-of-year examination**
DATE COMPLETED + SIGNATURE					

Figure 5.6: 2023/24 Annual Teaching Plan—Term 4 Life Sciences

Figures 5.4-5.6 depict that, according to the ATP for term 4, the EE/ESD-related topic covered is "human impact on the environment: current crises." This topic spans from October to December and includes various EE/ESD-related subtopics such as atmosphere and climate change, water availability and quality, food security, and loss of biodiversity and solid waste removal. In the ATPs for 2021 and 2022, each of these subtopics is allocated one week (four days). However, in 2023, as previously mentioned, the number of weeks has been reduced from four to three. The 2023 ATP has amalgamated the concept of food security with the concepts of water availability and quality, resulting in a reduction in the number of weeks allocated for teaching the topic of human impact on the environment. The necessary pre-knowledge for this topic involves revising the balance in ecosystems in grades 8 and 10. Resources other than textbooks that teachers can utilize to enhance learning include reference books, media reports, the internet, magazines, newspapers, and watching telematics videos on human impact on the environment.

As this is the final topic in grade 11, the ATP also provides the final examination framework. In this framework, the two topics, population ecology and human impact on the environment, contribute a combined total of 74 marks out of 300. This translates to 37 marks for population ecology and 37 marks for human impact on the environment. It indicates that the overall contribution of environmental studies, the strand containing EE/ESD-related concepts in grade 11, constitutes almost half of the Life Sciences paper 2 examinations, amounting to 49.3%. However, the overall coverage of EE/ESD-related topics in grade 11 Life Sciences, as per the ATP, is now 25%. It's noteworthy that the CAPS document indicates a percentage allocation of 35% for environmental studies in grade 11. Due to curriculum adjustments, reduced teaching time, and content restructuring in response to the impact of COVID-19 from the 2020–21 school year, the total coverage of topics in Life Sciences was affected. Consequently, the total coverage of environmental studies in grade 11 was reduced from 106 marks to 74 marks due to the restructuring of concepts such as social organization and succession.

Upon comparing the figures, the 2021 ATP and 2022 ATP exhibit similar structures, indicating identical layouts for topics, core concepts, prerequisite knowledge, and resources other than textbooks to enhance learning. Additionally, the number of weeks and assessments for both term 3 and term 4 are consistent. However, the 2023 ATP introduces some changes and a slightly different structure from the 2021 and 2022 ATPs. The 2023 ATP (refer to figure 5.3 and figure 5.6) includes the CAPS topic, with the core concept providing more information than what was contained in the 2022 ATP. Notably, the 2023 ATP lacks information about resources that teachers can utilize to enhance learning.

5.4.3 Analysis of the textbooks

This research expanded its examination to the textbooks utilized by the interviewed teachers in their Life Sciences classes. The objective was to assess the inclusion of EE/ESD-related topics in these textbooks and, if present, to gauge the extent of coverage. The textbooks chosen for scrutiny were comprised of two grade 11 teachers' textbooks, one grade 11 teachers' guide, and one study guide—specifically, the materials employed during teaching Life Sciences in different schools by the participating teachers in this study. Out of the four interviewed teachers from different schools, three schools were identified as using the same textbook, titled "Understanding Life Science Grade 11," authored by Isaac et al. (2012). In two of these schools, teachers also indicated a preference for using the study guide, "Study Guide for Understanding Life Science Grade 11," authored by Isaac et al (2012). The remaining school utilized a textbook titled "Solution for All Life Science," a grade 11 learners' book authored by De Fontaine et al. (2012). This study comprehensively analysed both textbooks, the study guide, and the teacher guide, with a specific focus on the coverage of EE/ESD-related topics and environmental studies in grade 11. Table 5.5 below provides an overview of the coverage of EE/ESD-related topics in the textbooks scrutinized in this study. The examination of EE/ESD-related topics in these textbooks involved searching for articles and case studies related to EE/ESD, visuals connected to EE/ESD, the number of assessment activities, and the total number of pages addressing EE/ESD-related topics in each textbook.

Table 5.5: Coverage of EE/ESD-related topics in textbooks

Textbook	EE/ESD related topics	Articles and case studies related to EE/ESD	Visual aids related to EE/ESD (pictures, diagrams etc)	Number of assessment activities with environmental studies topics.	Total number of pages of the textbooks and study guide	Total number of pages that covers EE/ESD related topics
Solutions for all Life Science Grade 11 Learner's Book	Environmental studies- • Population ecology(Population size, Interaction in the environment, social organisation, community change over time and human population) • Human impact on the environment (The atmosphere and Climate change, Water availability, water quality, Food Security, Loss of biodiversity and solid waste disposal)	2 case study 1 passage 1 and 12 article,	61 pictures	45 class activities 6 practical activity 11 homework activity 4 enrichment activity	427	156 (36,5%) from page 270-428
Understanding Life Sciences Grade 11 Learners book	Environmental studies- • Population ecology (Population size, Interaction in the environment, social	7	39 pictures 3 diagrams	30 activities	430 391	267-391 124 32%/28%

	organisation, community change over time and human population) • Human impact on the environment (The atmosphere and Climate change, Water availability, water quality, Food Security, Loss of biodiversity and solid waste disposal)					
Study guide for Understanding Life Science Grade 11	• Population size • Interactions in the community • Social organisation • Succession • Human population • Human impact on the environment.	0	9 pictures 3 diagrams	0 activities	119 pages	76-119 43 36.1%
Understanding Life Science Grade 11 Teachers guide	Environmental studies- • Population ecology (Population size, Interaction in the environment, social organisation, community change over time and human population) • Human impact on the environment (The atmosphere and Climate change, Water	0	0	30 solutions	268	195-258 63 24%

	availability, water quality, Food Security, Loss of biodiversity and solid waste disposal)					

5.4.3.1 Coverage of EE/ESD Content in the Textbook

The three textbooks subjected to analysis, namely "Solutions for All Life Science Grade 11 Learner's Book," "Understanding Life Sciences Grade 11 Learners Book," and "Understanding Life Sciences Grade 11 Teachers Guide," contained an identical number of topics related to EE/ESD, specifically within the strand of environmental studies, totalling 10. These topics encompassed aspects such as population size, community interaction, social organization, community change over time, and human population. Additionally, they included coverage of the atmosphere and climate change, water quality and availability, food security, loss of biodiversity, and solid waste disposal.

However, "Solutions for All Life Sciences Grade 11 Learner's Book" provided more extensive coverage, featuring 12 articles, 2 case studies, and one passage related to EE/ESD or environmental studies. In contrast, "Understanding Life Science Learners Book" included 7 case studies and 0 articles, while "Understanding Life Sciences Teachers Guide" contained no case studies or articles related to environmental studies or EE/ESD-related topics, as illustrated in Table 5.5 above. Another book included in the analysis was the "Study Guide for Understanding Life Science Grade 11," which, despite covering the same number of topics, lacked both case studies and articles related to environmental studies or EE/ESD.

Table 5.5 reveals the distribution of pictures and assessment activities related to EE/ESD in the analysed textbooks. "Solution for All Life Sciences Learners Book" led with 61 environmental studies-related pictures, followed by "Understanding Life Sciences Learners Book" with 39 pictures, "Study Guide for Understanding Life Sciences" with 9 pictures, and "Understanding Life Sciences Teachers Guide" with zero pictures. Additionally, "Solution for All Grade 11 Learners' Book" presented the highest number of assessment activities with environmental studies topics, totalling 67 assessments, distributed across 47 classroom assessments, 6 practical activities, 11 homework activities, and 4 enrichment activities. "Understanding Life Sciences Learners Guide" and "Understanding Life Sciences Grade 11 Teachers Guide" both featured 30 activities, while the "Study Guide for Understanding Life Sciences Grade 11" contained zero assessments.

Furthermore, in terms of the number of pages covering EE/ESD-related topics, "Solution for All Life Science Grade 11 Learner’s Book" dominated with 156 pages, followed by "Understanding Life Science Grade 11 Learners Book" with 124 pages, "Understanding Life Science Grade 11 Teachers Guide" with 63 pages, and the "Study Guide for Understanding Life Sciences Grade 11" with 43 pages. Comparing the EE/ESD coverage, "Solution for All Life Sciences," "Understanding Life Sciences Learners Guide," "Understanding Teachers Guide," and "Study Guide for Understanding Life Sciences Grade 11" demonstrated 36.5%, 32%, 36%, and 24% coverage of Life Sciences, respectively, as depicted in Figure 5.3.

The analysis also reveals variations in the depth and breadth of EE/ESD-related topics across textbooks, teacher guides, and study guides. While textbooks provide comprehensive coverage, study guides are less intensive, lacking visual aids, case studies, or EE/ESD-related assessments. Teacher guides primarily focus on assessment guidelines and marking memoranda for content already explained in the learners' textbooks. Thus, learners' textbooks emerged as rich sources of information on environmental studies topics in the Grade 11 curriculum.

5.4.4 Teachers and Subject advisors Perceptions of adequacy in covering EE/ESD topic in Life Sciences Curriculum.

This segment delves into the viewpoints of both Life Sciences teachers and subject advisors regarding the inclusiveness and sufficiency of EE/ESD topics within the Grade 11 Life Sciences curriculum. It is further divided into two sub-sections: the first section explores teachers' perspectives on the adequacy of covering EE/ESD topics in the Life Science curriculum, while the second section delves into the perceptions of subject advisors regarding the adequacy of covering EE/ESD topics in the Life Sciences curriculum.

5.4.4.1 Teachers Perceptions

In this section, I investigated the viewpoints of Grade 11 Life Sciences teachers regarding the extent and sufficiency of EE/ESD topics in the curriculum. Consequently, teachers were queried in the field with the following questions: What is the present extent of coverage of EE/ESD in the Grade 11 Life Science curriculum, and do you believe it is sufficient? Mr. Sabawa conveyed his perspective, stating that the current syllabus does not sufficiently cover EE/ESD topics. He said that:

“ *I think the syllabus now is not covering everything”*

He further explained that he supplements the curriculum by advising learners EE/ESD topics.

> “*if we are teaching Life Sciences, we can also advise learners because they are here at school and they are also going out there where they are staying, you see. But when it comes to the curriculum itself, I do not think they* about *are covering it fully” (Mr Sabawa).*

Mr Nkhumeleni shared a similar sentiment with Mr Sabawa. He believed that the coverage of EE/ESD topics was insufficient. He said:

> *“It is not enough because the pacesetter specifies what we need to teach, and it also gives us less time to teach about EE and ESD topics”.*

Mr Nkhumeleni also highlighted that certain critical topics like climate change were missing from the curriculum:

> *“Another thing is that we are given topics that we need to cover, such as drought, solid waste, pollution, and leaving important things happening around here now such as climate change, flooding and earthquakes”*. *(Mr Nkhumeleni)*

Mr Nkhumeleni also explained that his perception was that climate change must be a topic on its own in grade 11 Life Science. When probed about what he thinks the curriculum has left out he said:

> *“Yes, climate change should have been a topic on its own in Grade 11. People lack knowledge, and some end up building their houses next to the rivers, and when heavy rain comes, their houses are washed by the water. So I think we have a shortage of topics such as climate change, flooding, and drought in grade 11.”*

When Mrs Mususumeli, was asked about the coverage of EE/ESD into the Life Science curriculum, she initially expressed that she did not believe anything was missing from the curriculum. However, she later admitted that she felt sustainable development was not adequately covered in Grade 11 and suggested that the coverage was about 80%:

> “*Mmmmmh, I would say, I do not think there is anything missing; I would say it covers about 80% about ESD, but I do not think we really do cover sustainable*

development in grade 11 at larger; we do cover a part, but I feel we are not doing justice to it."

Mr Makhokha, believed that EE/ESD topics were adequately covered in Grade 11, citing topics like animal diversity and photosynthesis. He did not find any significant gaps in the curriculum, he said that:

"I think it is also adequately covered in grade 11 because, like I said above, it covers different topics, such as animal diversity and photosynthesis. So thin it is covered in grade 11".

The responses from the teachers provided above provide a picture of teacher's perceptions on the coverage and adequacy of EE/ESD related topics into Life Science curriculum. Teachers shared mixed views on the adequacy of EE/ESD coverage in the Grade 11 Life Sciences curriculum. While some teachers believed that certain topics were missing, others felt that the curriculum was sufficient. The next subsection presents the finds about subject advisors' perceptions on the coverage and adequacy of EE/ESD related topics into Life Science curriculum.

5.4.4.2 Subject advisors Perceptions

This section focuses on presenting Life Science subject advisor's perceptions about the adequacy and coverage of EE/ESD topics in Life Sciences curriculum. The subject advisors were asked if EE/ESD related topics are integrated into Life Science curriculum and if so in which grades.

When Mrs Rose, was asked about the coverage of EE/ESD in Life Science, she believed that EE/ESD topics were well covered in the curriculum across all grades from 10 to 12.

"*Yes, they are starting from grade 10, because we have environmental studies there, and continuing to grade 12". (Mrs Rose)*

Mr Joseph also said that EE/ESD topics are covered in Life Sciences from grade 10-12. He also made emphases that in grade 12, teachers are not required to teach EE/ESD related topics, but learners will be assessed base on what has been taught in grade 11. This was one of the findings from the analysed document which is the CAPS document. When asked the question about the coverage of EE/ESD into Life Sciences curriculum, he replied:

“Yes, in grade 10-12, but in grade twelve we do not teach it but only assess it based on what has been taught in grade 11”.

Mr Shonisani emphasized that environmental education was integrated into all Life Sciences topics across grades 10 to 12.

“Yes, environmental education is integrated into all topics in Life Sciences, from grade 10-12, including plant taxonomy, animal taxonomy, photosynthesis, cellular respiration, excretion, environmental studies, and, in fact, in everything” (Mr Shonisani).

Mrs Rose also felt that there is something that needs to be added as EE/ESD topics into the Life Sciences curriculum, but she was not sure of what need to be added. When asked if she feels that what is covered in the curriculum about EE/ESD related topics was enough she said:

“I may not say it is enough, but I do not have specific factors that I think they can fit in, but basically, I think it is not enough. I may not fully know what can be fitted in to make sure that whatever we are talking about is covered”.

This led me to probe, to want to know more about what she thinks is missing in the curriculum. Mrs Rose was further asked if there is something that is not covered as EE/ESD that she thinks grade 11 learners should be taught in Life Science. She indicated:

“I do not think so, because if I were to say that they have enough knowledge, If I were to say they have enough knowledge, it would mean that they will need to do tertiary education for them to be able to transform the world with the knowledge they learned in high school, so sometimes they need to further their knowledge to show that the knowledge they obtain is not enough for them to be able to adjust to the real world after grade 12”.

The subject advisors acknowledge the coverage of EE/ESD topics in the Life Sciences curriculum but express uncertainty about the sufficiency of the current content, highlighting the potential need for additional material and the role of tertiary education in furthering learners' understanding of these topics.

5.5 Understanding and Importance of EE/ESD

This section delves into the comprehension and significance of EE/ESD topics within the Life Science curriculum for grade 11. Nonetheless, the primary focus of this study is not on understanding and the importance of EE/ESD but rather on how Life Science teachers receive support for integrating EE/ESD into their lessons through professional development. However, it was deemed crucial to examine teachers' and subject advisors' understanding of EE/ESD because it provides insights into whether teachers require support in Life Sciences Pedagogy or in comprehending EE/ESD-related topics. The understanding of EE/ESD by subject advisors also offers insights into whether subject advisors possess sufficient knowledge about EE/ESD to support teachers in integrating it into their lessons. The findings in this theme are categorized into two subthemes, as depicted in Figure 5.3 above.

5.5.1 Teachers' and Subject Advisors' Understanding of EE/ESD

This section presents findings regarding the comprehension of EE/ESD among teachers and subject advisors. Initially, it discussed the findings related to teachers' understanding of EE/ESD, followed by an exploration of subject advisors' understanding of EE/ESD.

5.5.1.1 Teachers understanding of EE/ESD

In this section, I present the findings related to teachers' comprehension of EE/ESD. To enhance their understanding of EE/ESD, teachers were queried about their interpretation or definition of the following terms: EE, sustainable development, and ESD.

When Mrs Mususumeli was asked about her understanding of EE she replied that:

> *"Is part of science that teachers teach learners about the aspects of the environment, the interactions that happen between the environment and people, and also the environment itself".*

When asked what she understand about sustainable development she replied that:

> *"I think it is development in the community; if it is about nature, it needs to sustain the environment. This is my understanding. For example, if we are constructing a building and there are trees, we need to make sure that the trees are there and also that we sustain the environment as we develop it".*

According to Mr Sabawa EE should emphasis on developing a sense for the environment and it should promote the responsible use of natural resources:

> *"I think it's all about an education that deals with the environment, something that is happening in the environment. You will see that we have different types of environments wherein we can talk about biomes. In other words, I think we have to deal with those structures when it comes to environmental education so that we can respect our environment and learn how to use our environment". (Mr Sabawa)*

Mr Sabawa also explained that sustainable development involves developing our environment without harming it. He said that:

> *"According to me, sustainable development It's like, we have to develop that environment, and at the very same time, we are not damaging the environment; the environment must remain as it is. Even though maybe we are cutting like the example that I've given before, the cutting down of trees, If we are cutting those trees now, we need not just to cut them; we also have to control them. If we are controlling it now, I think we are sustaining the environment".*

Mr Nkhumeleni's understanding of EE was that:

> *"It is when we are teaching people how to take care of our environment, such as teaching people how to take care of water in our environment so that it does not get wasted" (Mr Nkhumeleni).*

He also said that EE involves educating people about how to conserve water and maintaining biodiversity:

> *"it is about the issue of water and how we can treat our environment so that we do not harm the environment, for our biodiversity to remain clean, and also how we interact with other living organisms" (Mr Nkhumeleni).*

Mr Nkhumeleni also gave teaching about poaching as an example of EE. He said:

> *"Teaching people about poaching so that we do not have poaching in our environment so that we do not contribute to making animals to become extinct".*

When asked about what he understands sustainable development to be, Mr Nkhumeleni initially appeared to be unsure of what he thinks sustainable development is, but he it might relate to sustaining the environment and taking care of the environment. His response was:

> "*I am forgetting what sustainable development means…..mmmmmm…. is it about sustaining the environment? ja, It's about taking care of the environment, like the examples I gave above, to protect the animals from poaching and also to protect against pollution, especially water pollution, in our environment because water is life".*

Mr Makhokha defines EE as:

> *"Education that focuses on the environment and what we find in the environment. That's my understanding of environmental education. Which means I think it includes education that deals with plants and animals that we find in the environment, or, let's say, biotic and abiotic factors".*

When asked about sustainable development he mentioned that he is not sure of what sustainable development is. When Mr Makhokha was asked about his understanding ESD, he replied that he is not sure about it.

Contrary to Mr Makhokha's response to the definition of ESD, Mr Nkhumeleni defined ESD as:

> *"Education that needs to be taught to people on how they can use natural resources sustainably so that they can also be used in the future or do not perish".*

Mr Nkhumeleni also believes that ESD is a type of education that should be offered to all people regardless of age and it must not only be taught in schools but also in our communities. this is what he said when probed to ask who are the people that need to be taught about ESD:

> "Everyone *in our communities, regardless of whether the person is young or old, must learn, but we must teach everyone. This is because we all use environmental resources, so we need to learn how to use these resources sustainably so that we can preserve them for future generations. This is the education that must not only be given to learners in schools but also in our communities. We need to teach ESD every day because we have some people*

who never went to school in our homes, but we also need to educate them about sustainable development so that they do not harm the environment".

When asked how he makes sure that who never went to school learners about ESD, he said:

> *"When I teach my learners, I also encourage them to spread what they have learned in class with others at home. For example, we emphasize that to reduce water pollution, you must tell your parents not to go wash in rivers but fetch water and wash outside of the rivers to avoid soap contaminating water because it can kill some animals that leave in water. So when I teach them, I do tell them that they must pass on what they are learning to their siblings, parents, and relatives at home".*

Mrs Musumeli, understanding of ESD was not different from Mr Nkhumeleni, she said that ESD is:

> *"Information or knowledge about sustaining the environment, or education that informs people about how we can sustain our environment while there is development".*

When asked where this information or knowledge must come from she replied:

> *"from the school, from the curriculum that is designed to be taught in schools"*

In probing on how this information can reach those who are not at school or those who never went to school, she alluded that:

> *"We must have campaigns and government campaigns, and we also have to encourage people in different communities to talk about ESD in their gatherings".*

In defining ESD Mr Sabawa said that:

> *"The term education for sustainable development means that people must also be taught how to sustain the environment".*

Mr Sabawa's definition emphasises the significant of teaching individuals how to maintain and preserve both the environment and the development taking place in it. He said:

"They must be taught how to sustain the environment and that what they are developing is very important. And also the environment itself. It's also very important. In other words, both are very important. But if maybe we are dealing with development, we must see to it that we are not destroying the environment itself".

Teachers generally view EE as an educational approach that concentrates on the environment, encompassing its interactions with people, resource conservation, and instructing learners on various environmental facets. They emphasize responsible resource utilization and fostering environmental awareness among learners. Sustainable development is perceived as a form of development that avoids environmental harm and strives to sustain it during the developmental process. Teachers assert that ESD should be accessible to individuals of all ages, both in educational institutions and communities. They underscore the necessity for awareness campaigns and government initiatives to disseminate ESD knowledge beyond the classroom, emphasizing the preservation of both the environment and the ongoing development within it.

5.5.1.2 Subject advisors' understanding of EE/ESD

In this section, I delve into the viewpoints of Life Sciences advisors regarding the understanding of EE/ESD. To enhance comprehension of EE/ESD, subject advisors were questioned about their interpretation or definition of the following terms: EE, sustainable development, and ESD. Notably, only one subject advisor, Mrs. Rose, succeeded in providing definitions for all three terms, while two subject advisors, Mr. Shonisani and Mr. Joseph, managed to define EE and ESD exclusively.

When she defined EE, Mrs Rose said That:

"To me, EE is when we study all factors that are in the environment and how they relate to all the living things in the environment, whether positively or negatively, so the environment could be the living environment or the non-living environment, or the relationship between the two".

When she was asked about her understanding of sustainable development, she said:

"To me, sustainable development is when we are able to develop human beings to a level where whatever we teach them will remain for a long period of time, so that is basically what we mean by sustainable development. You develop

this person, you teach this person some skills or knowledge, and then those skills stay with them for a very long period of time".

Regarding ESD, Mrs Rose emphasizes that it involves developing individuals so that the skills and knowledge they acquire can be used in the future. This development is vital for survival in the specific environment.

> *"Mmh, ya, these are the high-order questions for me. According to me, it will mean that we are developing this individual so that whatever he attains is going to be used in the future and is going to stay with him for a long time".*

Mr Shonisani, views EE as a means of educating people about environmental conservation. He said that:

> *"…. environmental education to me, it is a kind of education where we educate people about the environment. conservation of our fauna and flora, but sometimes you might be talking about a school situation".*

When Mr Shonisani was asked to contextualise EE, for school situation, he said:

> *"My understanding of environmental education in school context is the issue that the God-given potential is enveloped in such a way that a person turns to understand his or her own potential. Unless that is achieved, or we can say that it is an environment that develops a person in such a way that he can be able to change people that will come to the same environment. Unfortunately, our environment is not producing people who can change other people who are coming behind them in such a way that the environment can remain sustainable. Environmental education has to be conducive to being able to assist all people. Either the teacher or the learners". (Mr Shonisani)*

When asked to define ESD, Mr Shonisani stared by contemplating the concept of ESD and he also made an emphasis on the significant of the role of education system in producing individuals which can address the global challenges the world is currently facing. His reply to Definition of ESD was:

> "*Mmh, it depends on what we are supposed to develop, so education in general must be able to produce people who will be able. I think it must be able to produce people who will be able to face the challenges that the world is facing, and it also helps that those who have gone through the school system must be*

innovative enough in such a way that we know the solutions to the challenges that are available. If the education system is not producing those people who will be able to stand and face the challenges and bring answers to those challenges, then it is not sustainable."

According to Mr Joseph EE is:

"…. the education or knowledge about the environment, what are the threat to the environment and how can we deal with the threat, that learners need to learner in school and in our case in Life Sciences as a subject. This education should include how we take care of our environment sustainably, to make sure that we do not deplete the resources that are available now so that even our children (future generations) can still benefit from these resources that are available now".

When defining ESD, Mr Joseph made an emphasis that ESD goes beyond exam. He said that it focuses on providing learners with information that can support them un their daily lives and communities.

"Basically, ESD is about the fact that when learners are taught at school, it is not all about passing examinations, but it is also about learners having information that can sustain them even where they live".

He further explained that:

"I am trying to answer your question, saying that my understanding is that when learners are taught, they must develop, and they must develop in such a way that they are able to sustain what they believe in even when they are no longer being taught".

Subject advisors emphasize the crucial role of education in deepening the comprehension of EE/ESD. EE is regarded as an extensive exploration of environmental elements, with a focus on sustainable resource management for the benefit of both current and future generations. ESD goes beyond traditional examinations, emphasizing knowledge that aids everyday life and fosters the capacity to creatively tackle global challenges. Their perspectives underscore the pivotal role of education in fostering environmental responsibility and empowering individuals to contribute positively to a sustainable society.

5.6 Teaching Strategies and Resources for Integrating EE/ESD into the Life Science Curriculum

The interviews with participants revealed another prominent theme: teaching strategies and resources for incorporating EE/ESD into the Life Science curriculum. This theme sought to address the following research question: Which teaching strategies are presently employed by teachers to integrate EE/ESD into the Life Science curriculum? Two sub-themes or categories surfaced from this theme: teaching approaches and methods, and the utilization of teaching resources. The results within this theme are organized based on the identified sub-themes (refer to table 5.2 above) and are interconnected with the observations made during the teachers' lesson evaluations.

5.6.1 Teaching approaches and methods

This section, which constitutes a subtheme, presents discoveries concerning the teaching approaches and methods employed by teachers to incorporate EE/ESD topics into the Life Science curriculum. Teachers participating in the study were queried about the teaching strategies and methods they employ or have employed in integrating EE/ESD into their Life Science lessons. Subject advisors were also questioned regarding the teaching strategies and methods they advocate for teachers to utilize when addressing EE/ESD-related topics within the Life Science curriculum. The findings in this section are categorized under the sub-theme of theoretical versus practical teaching.

5.6.1.1 Theoretical vs Practical teaching.

When asked about the teaching strategy and methods that he used, to integrate EE/ESD into the Life Science curriculum, Mr Sabawa mentioned that he goes to the field and points out different environmental features to his learners to learner practically:

> *"Sometimes I want to go out to the field. As I'm teaching them, I have to go to the field, then point at some sort of environment like and even to a point wherein I can pick up some of the species from the environment so that learners can learn in a practical way".(Mr Sabawa)*

On probing, Mr Sabawa was asked, about how often he goes out to teach and where he uses field trips or he uses school environment to teach, and his answer was:

> "*Yeah, it's like most of the time I use the school environment. But there are times when we can take trips, like September 18th. This year we are going to Kruger National Park to learn about these plants and animals there and how to keep the environment well".*

Mr Sabawa also made an emphasis that because of time, they only focus on Life Sciences and Geography when they plan for field trips. He said:

> *"Because of time? It's time-consuming. We have some targets. We are targeting Life Sciences and geography there. Those are our target subjects, Life Sciences as well as geography".*

When asked about the teaching method he use in the classroom, Mr Sabawa replied:

> "*Mostly That one is teacher-centered, but there are times wherein I can engage learners themselves while I'm teaching. I have to engage learners now. And there are times wherein it can be learner-centered, wherein I can take one of the learners, like when we do peer teaching concerning this one, so that we can have some experiences of learners from the environment that they used to be in".*

The teaching approach or method described by Mr. Sabawa during the interviews aligned with what I observed in his classroom. When teaching the topic on interactions in the environment, Mr. Sabawa employed a teacher-centred method, taking an active role as the primary participant in the classroom, as depicted in Picture A. This image illustrates Mr. Sabawa writing on the green board while explaining to the students the various interactions occurring in the environment.

Picture A: Mr Sabawa in front of the classroom

Source: Author

However, what Mr Sabawa also said about sometimes using learner-centred leaning was not observed during this lesson, as he used the same teaching method for the whole lesson which was one hour long. Learners were only engaged in the lesson by asking them questions and they had to raise their hands to give the answer.

Mr Nkhumeleni said that he relies on the use of pictures as teaching aids to enhance understanding. Mr Nkhumeleni mentions:

> *"I use a lot of pictures. I have a book that contains a lot of pictures that are related to environmental studies, so I make sure that I make copies for the learners so that they can see and have an idea of what I am talking about".*

The response from Mr Nkhumeleni indicates that visual aids play a crucial role in facilitating learners' comprehension of environmental concepts. When asked about the teaching methods he uses in the classroom, Mr Nkhumeleni said:

> *"I use the learner-centered method when I teach EE/ESD-related topics. What I do is ask learners first to tell me what they know about the concepts. E.g., if I am teaching about pollution, I first ask them to tell me what they know about pollution, and then I make sure that learners take an active role in managing*

> *my class. You will learn by discussing and urging, and I will just lay out conclusions".*

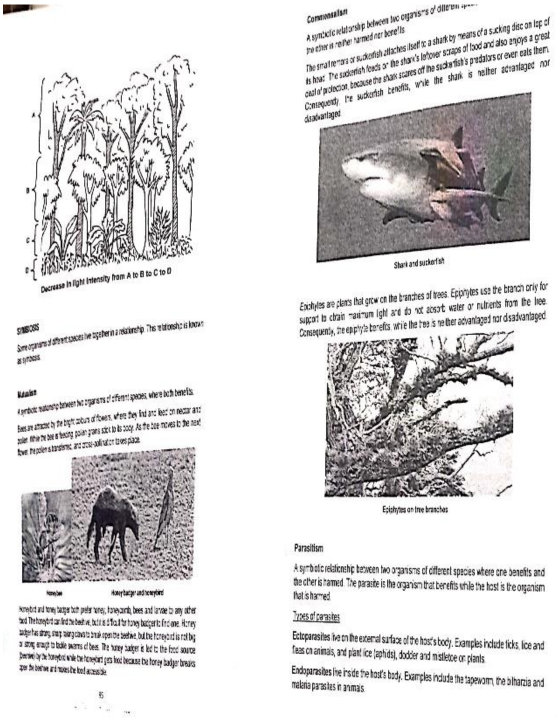
On probing Mr Nkhumeleni was also asked the effectiveness of the teaching method he use, and his response was:

> *"The strategy is working for me because it gives learners the opportunity to learn from one another and also to be active members in class. They also take part in cleaning activities around the school and educate other learners who are not doing Life Sciences. They also bring different strategies for dealing with environmental crises that they may have learned at home and share them with other learners in class. For example, you can ask learners who have boreholes in the home to say how they use the practices they are taught at home to take care of that water and why they should not waste it".*

In contrast to the teaching approach Mr. Nkhumeleni mentioned during the interview, my observation of his lesson on symbiotic relationships revealed that he employed a Lecture method. In the class, he was the sole active participant. As he previously stated, he had prepared copies of the topic for the day, featuring relevant pictures that he relies on for teaching EE/ESD-related subjects (refer to Picture B below). However, in terms of teaching methodology, Mr. Nkhumeleni utilized the lecture method. Upon entering the classroom, he inquired about where the students had left off the previous day. Subsequently, he instructed them to open the pages in the provided copies and proceeded to read and explain the content while the students sat and listened attentively (refer to Picture C below).

Picture B: copies given to learners

Picture C: Mr Nkhumeleni teaching in class



Decrease in light intensity from A to B to C to D

SYMBIOSIS

Some organisms of different species live together in a relationship. This relationship is known as symbiosis.

Mutualism

A symbiotic relationship between two organisms of different species, where both benefits.

Bees are attracted by the bright colours of flowers, where they find and feed on nectar and pollen. While the bee is feeding pollen grains stick to its body. As the bee moves to the next flower, the pollen is transferred, and cross-pollination takes place.

Honeybee

Honey badger and honeybird

Honeybird and honey badger both prefer honey, honeycomb, bees and larvae to any other food. The honeybird can find the beehive, but it is difficult for honey badger to find one. Honey badger has strong, sharp, taking claws to break open the beehive, but the honeybird is not big or strong enough to tackle swarms of bees. The honey badger is led to the food source (beehive) by the honeybird while the honeybird gets food because the honey badger breaks open the beehive and makes the food accessible.

15

Commensalism

A symbiotic relationship between two organisms of different species ... the other is neither harmed nor benefits

The small remora or suckerfish attaches itself to a shark by means of a sucking disc on top of its head. The suckerfish feeds on the shark's leftover scraps of food and also enjoys a great deal of protection, because the shark scares off the suckerfish's predators or even eats them. Consequently, the suckerfish benefits, while the shark is neither advantaged nor disadvantaged

Shark and suckerfish

Epiphytes are plants that grow on the branches of trees. Epiphytes use the branch only for support to obtain maximum light and do not absorb water or nutrients from the tree. Consequently, the epiphyte benefits, while the tree is neither advantaged nor disadvantaged

Epiphytes on tree branches

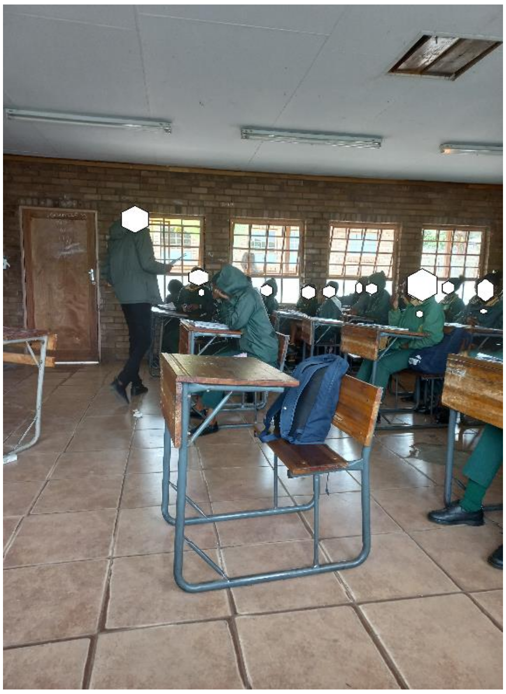
Parasitism

A symbiotic relationship between two organisms of different species where one benefits and the other is harmed. The parasite is the organism that benefits while the host is the organism that is harmed

Types of parasites

Ectoparasites live on the external surface of the host's body. Examples include ticks, lice and fleas on animals, and plant lice (aphids), dodder and mistletoe on plants

Endoparasites live inside the host's body. Examples include the tapeworm, the bilharzia and malaria parasites in animals



Source: Author

Source: Author

While Mr. Nkhumeleni provides learners with copies containing black-and-white pictures, the lack of color in the images poses visibility challenges for some students. Throughout his one-hour lesson, he only utilized the green board once, as depicted in Picture (D) below. The majority of the class time was spent with Mr. Nkhumeleni reading and explaining the content to the learners. Learners were granted limited time to ask questions during the lesson, and their primary role was to respond to queries posed by the teacher as he elaborated on the provided notes. Throughout the entire lesson, learners were assessed through questioning, with no written assessments conducted.

Picture D: Green board used by Mr Nkhumeleni for an hour Lesson

Source: Author

Mr. Makhokha mentions various teaching strategies, including practical demonstrations, field trips, and the use of visual aids. He states,

> *"I make sure that I prepare slides for my classroom so that they can see what I am teaching about. Then we can go out if that topic requires us to. But only if teaching can be found around the school premises."*

He also mentions,

> *"The strategy that I use in grade 11 to teach human impact is to take the learners out. It is obvious that there is a theory part. For instance, when we talk about deforestation, we can go around the schools and see trees being cut down, and if they are overgrazed, we can go around the schools, so that is the strategy I use to teach human impact."*

Mr. Makhokha emphasizes the importance of practical demonstrations and taking learners outside the classroom to experience the concepts firsthand. He states,

> *"I go out with the learners to the environment outside the classroom and try to show them practically what we are talking about in the parts of the flow so that they can see."*

He also mentions,

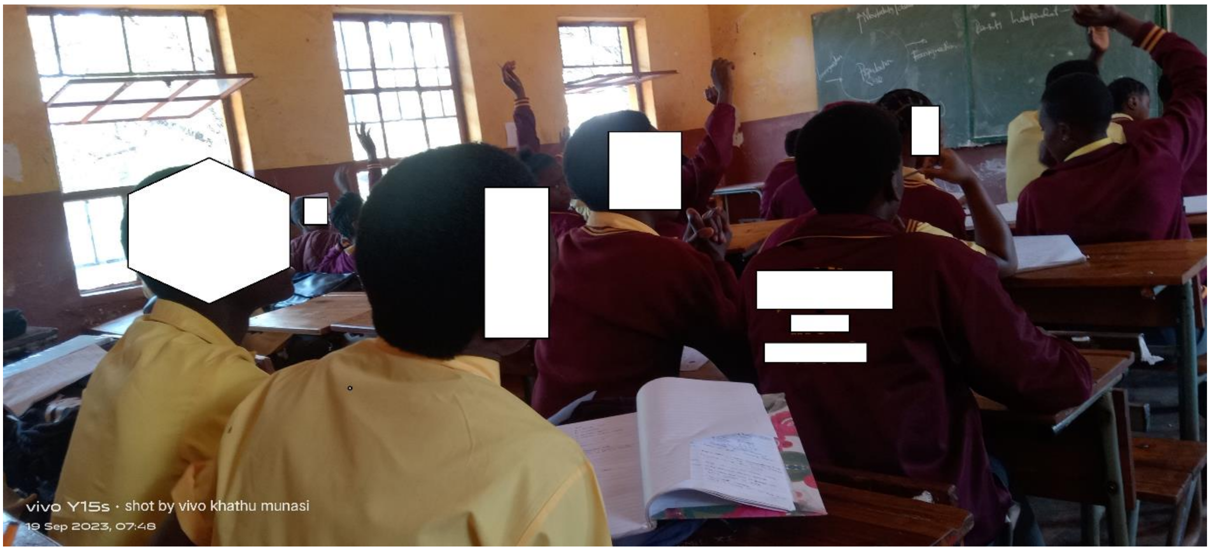
"For instance, when we talk about deforestation, we can go around the schools and see trees being cut down, and if they are overgrazed, we can go around the schools, so that is the strategy I use to teach human impact."

When asked if the strategy he is currently using is working for him, Mr Makhokha said that:

"Yes, I think they are effective because learners are able to listen to the theory part, and the moment we go outside and I explain further, they seem to grasp that even better than when you are just teaching in class".

During the classroom observation of Mr. Makhokha's lesson on environmental interactions, his teaching approach differed from what he had mentioned earlier. In the observed lesson, which lasted 45 minutes, Mr. Makhokha employed a combination of the lecture method and a teacher-centered approach. He initiated the lesson by eliciting learners' prior knowledge and establishing connections with their previous learning from earlier grades. Mr. Makhokha proceeded to teach by writing on the greenboard, with learners taking notes. Throughout the lesson, he actively engaged learners by posing questions, and those who raised their hands were given opportunities to participate, as depicted in Picture E below. However, Mr. Makhokha did not give significant attention to learners who did not participate by raising their hands.

Picture E: learners raising hands and others not raising hand in Mr Makhokha's class



Source: Author

Mr. Makhokha also fostered learner engagement by encouraging them to interact with each other, but this occurred primarily when he posed questions. He allocated two minutes for learners to discuss with their desk mates before providing him with their answers. This represented another avenue through which Mr. Makhokha facilitated learner involvement, although the learners were not actively leading the discussion, and there was no mention of activities outside the classroom, as he had previously indicated. Mr. Makhokha's lesson concluded after 45 minutes when he was summoned to assist with Grade 12 examinations during the data collection period.

Contrary to other teachers Mrs Mususumeli, said that she used lecture method to teach this EE/ESD topics in Life Sciences, and when asked why she choose to use that Method she said:

> *"Because we are talking about things you are not seeing, it's not like I am suing teaching aids or doing practical, so normally it's learning methods, just handouts, then explaining, then activities".*

When she was asked if this teaching method is working for her she said:

> *"To be honest, no learners are failing"*.

The response from Mrs Mususumeli prompted me to ask her the methods she thinks would work best to teach EE/ESD related topics and she replied that:

> *"I need to have revised the teaching method, but I think the best one that can make learners aware of the environment and also be able to participate in environmental crises will be the use of technology, such as having a projector and showing learners videos, then after that giving learners time to sit in groups and discuss. I think that would be the best method".*

Mrs Mususmeli was never observed in class because she felt sick and she was not in school until I finished data collection. This was a bad experience because when I reached out to her during final examination she was getting better.

The subject advisors in this study were also asked about the teaching strategies and methods that they recommend to teachers for effectively integrating EE/ESD into the Life Science curriculum. Mr Shonisani said that the right method to teach EE/ESD topic will be learner-centred method. He points out that this method can prove to be problematic if the teacher is not well prepared for the lesson. He said that:

"I think the right method is one that is learner centered. Where learners themselves come up with something that they know, and then teachers try and assist them in knowing what they do not know through what the teacher knows. But this method becomes problematic when the teacher is not prepared and does not know what to do. Because instead of anticipating the knowledge that the learners have, he or she just forces them to know what they know, and the learners easily get bored".

Mr Shonisani further criticizes the prevailing teacher-centered education system, which he believes hinders learners from developing their own perspectives and is resistant to new ideas from learners.

"So unfortunately, our education system is teacher-oriented; learners are not getting anything, and once a learner brings a new perception to class, they are regarded as distrusting and are advised to follow what the teacher is saying if they want to pass".

When asked if he, as the subject advisor emphasize and recommend the teaching method he mentioned to the teachers during meeting, workshops and seminars, she replied that:

"Yes, we do advise them, but the problem is that our teachers are pacesetter-oriented; maybe it's because of us. I do not know, but our teachers are running after the pacesetter, and that is not wrong; they must be channelled somehow. But we must make sure that we involve them because that's how we build them".

The response from Mr Shonisani, shows that he acknowledges that they provide advice and guidance on teaching methods during meetings, workshops, and seminars for teachers. However, he notes that many teachers tend to prioritize adhering to pacesetter oriented.

Mr. Joseph suggests that teachers should align their teaching strategies with the specific aim related to EE/ESD. He emphasizes the importance of setting clear objectives for each lesson and ensuring that these objectives are achieved.

"Teachers need to first check the specific aim that is related to environmental education, there must be something written about which teaching strategy teachers must use to teach this topic. For example, if you are going to teach

the learners, learners need to know that the main aim for the lesson is that they must know how to save water, so learners must know the objectives of the lesson and at the end of the lesson the teacher must see to it that those objectives are achieved". (Mr Joseph)

Additionally, he suggests using an interactive approach during lessons by involving learners actively. This can be achieved using coloured cards (green, red, and orange) that learners can use to indicate their understanding. This approach aims to ensure that all learners are actively engaged and understood, rather than relying solely on summative assessments or traditional hand-raising methods.

"so, you need to also make sure that you move with the learners during your lesson, you do not have to only rely on summative assessment so see if they understand. So teachers are also going to use cards now. Using cards means that learners are going to have cards with different colours like green, red and orange. Learners will use those cards to show if they understand or not and for a lesson to be active you also need to have the names of the learners or list of those learners. This is to get rid of the old fashion way of saying only those who raise their hands will speak, because only those who raise hands were the ones who understand and the other used to be left behind". (Mr Joseph)

Mrs. Rose emphasized the necessity of transitioning from conventional, teacher-centric teaching methodologies to those that are learner-centred. She advocates commencing a lesson by posing questions and involving learners in dynamic discussions before delving into the subject matter. This method encourages learners to play a more participatory role in their learning, cultivates problem-solving abilities, and instils the ability to acquire information autonomously. According to Mrs. Rose, this approach empowers learners to grasp and apply knowledge beyond the classroom, promoting a more profound comprehension of the subject matter.

"What I need to do is go to my documents; they will guide me as to what needs to be taught, then download question papers based on the topic that I am going to teach that day. And then go to the class and introduce the topic. I give learners questions so that they respond before I even teach them. I must ensure that they have the resources to get the information. So, I give them time to respond to the questions before I even dwell much on the content. And then,

after checking with them, ask them how they have responded; whether they have responded correctly or incorrectly, it is ok. Taking their response, I can address the issues where they get things, so by so doing, you teach learners how to learn. ".

Furthermore, Mrs. Rose discusses the importance of workshops for teachers, where the focus is on training them in these innovative teaching methods. The approach involves introducing topics and challenging teachers to define terms and concepts before providing solutions, fostering a sense of participation and self-directed learning among teachers. She said that:

> *"What we do, let's say it was environmental studies. We would first introduce the topic, like let's say the components of the environment as examples, and then we do not get into the details. We give them the terms to say, try to define these terms, and then we say for five minutes, define these terms, and then they will try to define the terms. After we ask for the response and when they give the response, we debate on the response, and after debating, we go back* to the *solutions. So by so doing, they have to get the information by themselves before we even go into the details of teaching so that is what we do when we workshop them. We do not come and tell them what an ecosystem is or what the components are; we just give them the terms that are relevant as an introduction. When we go to the next topic, let's say we are dealing with abiotic factors. We ask them to identify the abiotic factors from the following: maybe we give them different factors, we say identify abiotic factors, and we give a reason why these are abiotic factors. They do that; we debate, and then we bring the solution after the debate. We have realized that it involves them more, meaning if they go and apply the same method, their participation will improve, so learners will learn by themselves rather than a teacher having to teach and learners not necessarily learning".*

In addressing the practicality of these methods in society, Mrs. Rose acknowledges that the effectiveness varies from school to school. While some schools produce learners who can contribute to society, others may not adequately prepare their learners for practical applications of knowledge.

> *"It depends on the schools, so the answer to that will be yes or no. In some instances, you can see that they will be producing learners who will add value to society, and in other instances, you can see that these learners will have obtained a particular symbol, which is not necessary to be in a position to be able to apply the knowledge they have acquired to society". (Mrs Rose)*

Mrs. Rose suggests that there are mitigation measures in place, but their success is inconsistent, and the implementation of recommendations remains a challenge in some instances.

> *"Yes, but I do not think that the mitigation is working, because once we realize that we have made the recommendation, we go back and check the implementation of the recommendations and find that in other instances, implementation has been applied and in other instances, nothing has changed, so it becomes too difficult".*

5.6.2 The use of teaching resources

This section furnishes findings on the resources employed by teachers in integrating EE/ESD topics into the Life Science curriculum. These insights are derived from teacher interviews and the resources observed by the researcher during lesson observations. Additionally, the section presents subject advisors' findings regarding the resources they recommend for teachers when teaching EE/ESD-related topics. Resources play a crucial role in EE/ESD integration, akin to teaching strategies. Consequently, this section also endeavours to address the research question: "Which teaching strategies are teachers currently using to integrate EE/ESD into the Life Science curriculum?" The section is organized into two sub-categories: the utilization of teaching and learning resources and practical demonstrations and field trips.

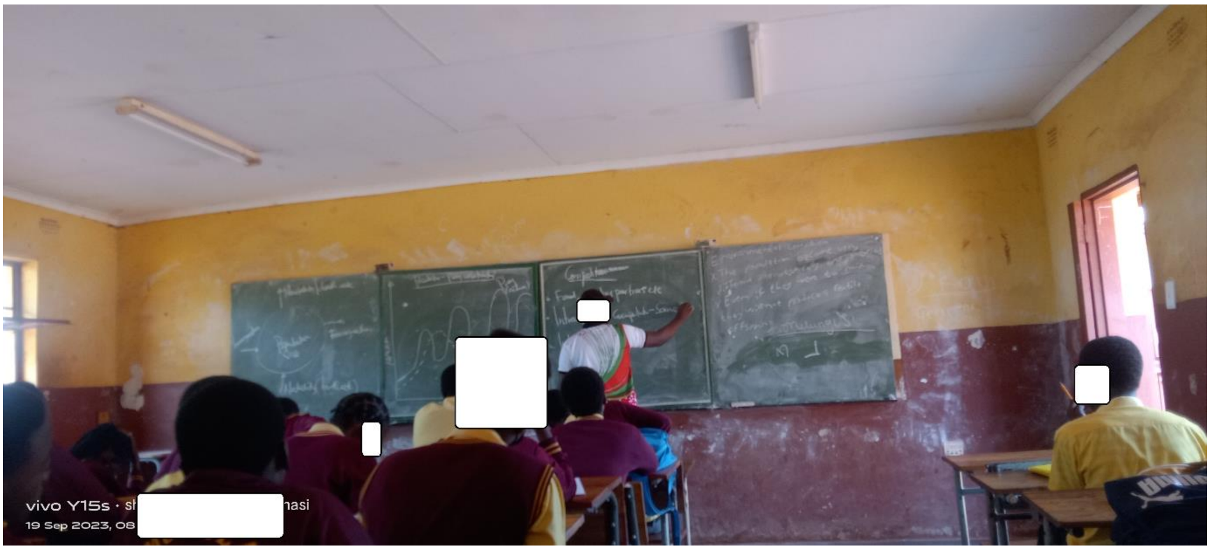
5.6.2.1 Use of teaching and learning resources

Teachers in this study were asked about the teaching and learning resources that they do use when they teach EE/ESD related topics into their lessons. Mr Makhokha said that he uses a projector and the environment outside the classroom. He replied:

> *"The only one I use is the projector, but I also do take them out to the environment, which serves as a resource on its own, according to me".*

However, even though Mr Makhokha said that he used a projector, and he also takes learners out to the environment, neither of the teaching resources he mentioned where used during the lesson I have observed. What I have observed was that Mr Makhokha used the Textbook and the greenboard as his resources during the lesson (see Picture F). the classroom that Mr Makhokha was not even conducive for the use of a project that he mentions that he does use.

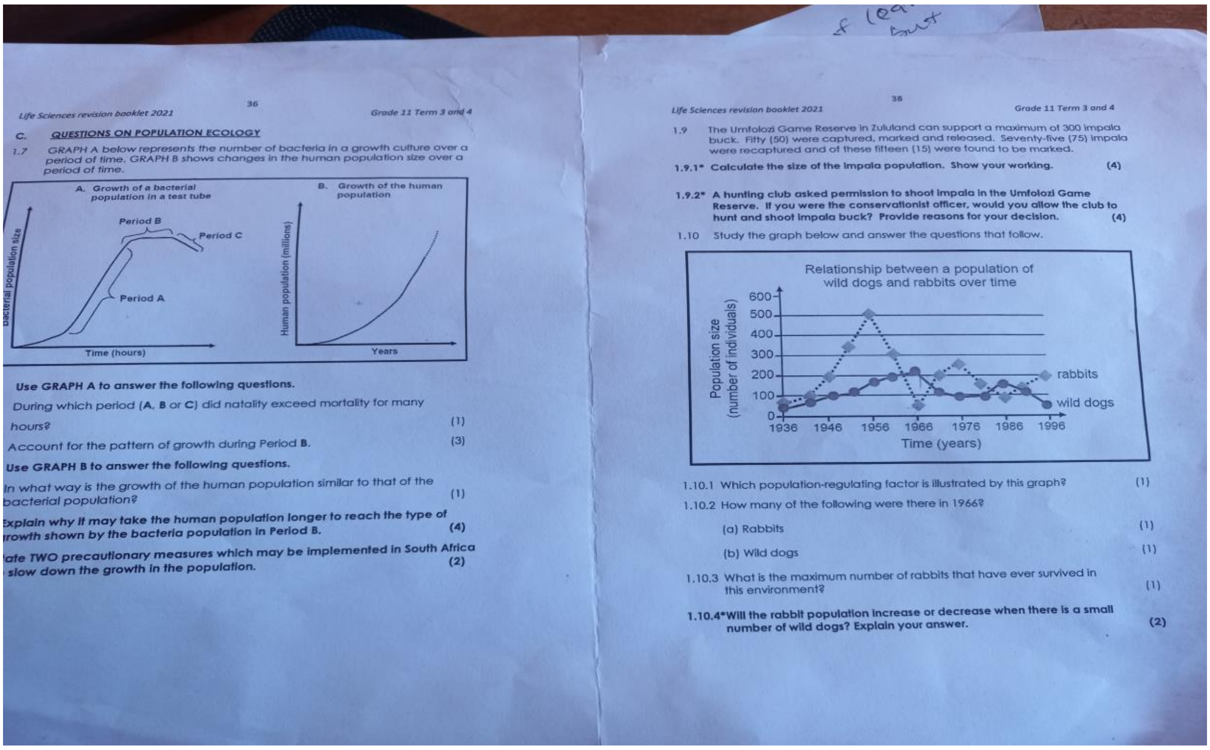
Picture F: Mr Makhokha using the greenboard/chalk board during a lesson.



Source: Author

Mr. Makhokha also employs past question papers, serving as a teaching resource. However, when questioned about teaching and learning resources, Mr. Makhokha did not include this aspect. Picture G illustrates a previous question paper distributed by Mr. Makhokha to students, utilized for informal assessment during his lesson.

Picture G: Previous question paper used to assess learners during the lesson by Mr Makhokha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C. QUESTIONS ON POPULATION ECOLOGY

1.7 GRAPH A below represents the number of bacteria in a growth culture over a period of time. GRAPH B shows changes in the human population size over a period of time.

Use GRAPH A to answer the following questions.

During which period (**A**, **B** or **C**) did natality exceed mortality for many hours? (1)

Account for the pattern of growth during Period **B**. (3)

Use GRAPH B to answer the following questions.

In what way is the growth of the human population similar to that of the bacterial population? (1)

xplain why it may take the human population longer to reach the type of rowth shown by the bacteria population in Period B. (4)

ate TWO precautionary measures which may be implemented in South Africa slow down the growth in the population. (2)

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1.9 The Umfolozi Game Reserve in Zululand can support a maximum of 300 impala buck. Fifty (50) were captured, marked and released. Seventy-five (75) impala were recaptured and of these fifteen (15) were found to be marked.

1.9.1* Calculate the size of the impala population. Show your working. (4)

1.9.2* A hunting club asked permission to shoot impala in the Umfolozi Game Reserve. If you were the conservationist officer, would you allow the club to hunt and shoot impala buck? Provide reasons for your decision. (4)

1.10 Study the graph below and answer the questions that follow.

1.10.1 Which population-regulating factor is illustrated by this graph? (1)

1.10.2 How many of the following were there in 1966?

(a) Rabbits (1)

(b) Wild dogs (1)

1.10.3 What is the maximum number of rabbits that have ever survived in this environment? (1)

1.10.4*Will the rabbit population increase or decrease when there is a small number of wild dogs? Explain your answer. (2)

Source: Author

When I probed, to see if the teaching resources he use is enough to teach EE/ESD related topics, He said that:

> *"I cannot really say that they are enough because there are some concepts that I cannot relate to or teach. For instance, if I want to teach eutrophication, that's the follow-up of chemicals to the rivers, and other concepts, they are a bit challenging".*

The response from Mr Makhokha shows that the teaching resources he is using are not enough since there are some topics that proves to be difficult for him to because he has no resources to relate to. However, when asked about the resources he need to effectively include EE/ESD topics in his lesson, Mr Makhokha said that what he needs is not classroom based but it is a field trip.

> *"To me, I think it is not classroom-based; the resources that I need are not classroom-based; I think it requires a sort of trip so that they can explore different concepts under human impact on the environment, because there are*

many concepts under this topic, so a field trip would really help to address them".

Mr Makhokha further said that he has successfully had one field trip but with grade 10 learners, where they had visited a botanical garden but he is now having financial challenges in the school when he initiate a trip for grade 11 learners. He said:

> *"So, yes, I have initiated it once, but it was for grade ten, where we went to the local botanical gardens, then we tried to show them different types of plants there. I had financial challenges in the school when I wanted to initiate the one for grade 11, so they say there is a problem".*

Mrs Mususmeli said that she only use the textbooks and question papers as resources when teaching EE/ESD related topics in Life Science.

> "*I use textbooks and question papers only."*

When asked, which resources that she does not have, but she thinks can be assistance in teaching and learning or EE/ESD related topics she said that:

> "*Maybe posters, videos, CDs, TV, and data so that we can access videos online. We do have the projector, but the video content we do not have".*

The fact that Mrs Mususumeli said that she has a projector, but she lacks video content led me to probe, and ask if she is able to download video content from google and show to the learners and her response was:

> *"The school does not have a computer; there is no school laptop; there are only a few computers that are being used by staff members; and we do not have good connectivity. You can play video online even if you have a projector and laptop. So the school will have to provide laptops."*

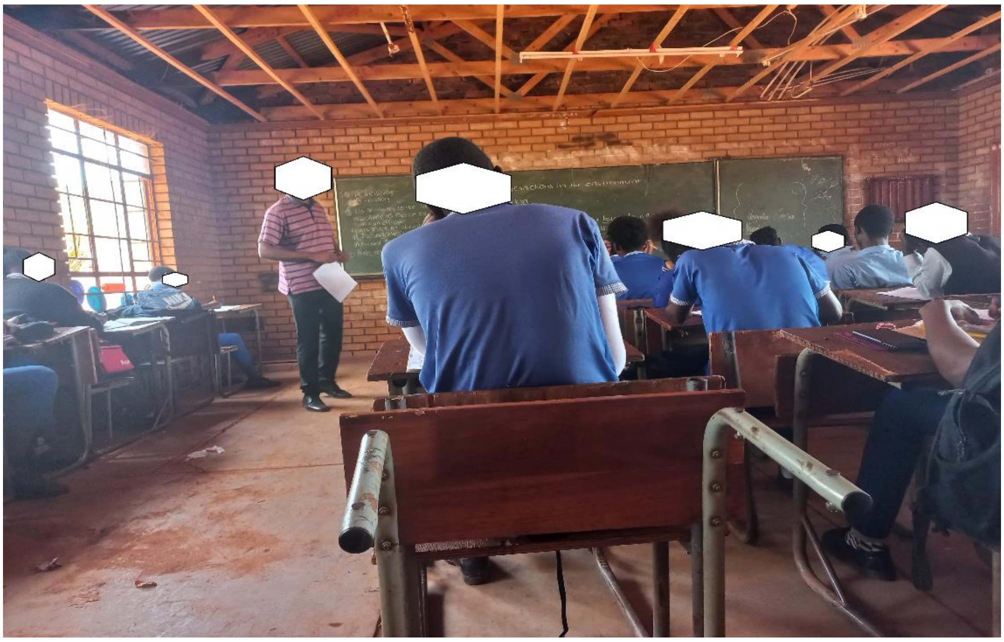
Mr Sabawa said that he uses textbooks, charts and taking learners out to the environment itself. He also indicated that his school is in the rural area, and they do not have enough resources so he also improvise and develop his own resources, such as bringing a branch of a tree or even leaves into the class and use them as resources.

> *"It's obvious. Resources like books and textbooks, I will use them. There are times when I can use some chats. as well as also , like I've indicated before that I also go out. There are all sorts of resources. Also, if maybe I can come*

up with a branch of a tree or even some leaves there, that's how I can use some of the resources".(Mr Sabawa)

During the observation of Mr. Sabawa's lesson, I noted his utilization of some mentioned resources, such as textbooks, to teach EE/ESD-related topics. However, there were no charts on EE/ESD-related topics in his classroom, and he did not bring any external resources for use during the lesson. Mr. Sabawa predominantly relied on the textbook and the handouts he provided to the students, along with the greenboard/chalkboard. Picture H depicts Mr. Sabawa holding the copy he used for teaching while explaining the content on the board to the students as they took notes.

Picture H: Mr Sabawa explaining what is written on the board while holding copy of notes he used to teach the learners.



When Mr Sabawa was asked if the resources that he do use are enough to assist him in teaching and learning of EE/ESD related topic, He said that:

"They are not enough. But it's just that we can come up with some strategies. Remember that year at school? Mostly, it is all about the fact that learners must pass it. But when it comes to knowledge, so that they can be knowledgeable enough in my 15 minutes, I can take five minutes to encourage them on how to sustain the environment. Okay, so we are still under resources".

Mr Sabawa also mentioned the Pacesetter, the ATP and Exam guidelines as some of the resources he does use. He said:

> *"Yeah, I do have the resources. Like the pacesetter. the ATP, and the exam guidelines; those are some of the documents that we are using".*

Mr Nkhumeleni said that he only use the textbooks and study guides.

> "*There is only one resource that I use: textbooks and study guides". (Mr Nkhumeleni*

The teaching method Mr. Nkhumeleni mentioned during the interview aligns with what I observed in his lesson. He creates copies of the study guide and distributes them to the students to ensure everyone has the same document. Subsequently, he elaborates on the content while students refer to the provided copies. Picture I illustrates some of the students in Mr. Nkhumeleni's class attentively focusing on the distributed copies as he reads and explains the content on the paper.

Picture I: Mr Nkhumeleni teaching while learners ready from the copy given to them.

Source: Author

When asked, whether the resources are enough to support him during teaching and learning of EE/ESD related topics, he said that:

“They are not enough. They ought to be a projector so that we can also play videos so that learners can see what we are teaching them. There is a chance that it is said that the gas killed seven people by affecting the environment. It would be better if you could show them videos on how the gas affected those people; this could really assist in changing learners perceptions about what you are teaching them. With textbooks, you only explain to the learners, and some end up going home saying the teacher is making up stories. But if they can see videos, it can be better”.

Mr. Nkhumeleni highlights the need for additional resources, specifically TV, DVD, and a projector, to support the teaching of EE/ESD-related topics. He acknowledges that these resources can compensate for the inability to conduct field trips. Mr. Nkhumeleni emphasizes that the availability of such materials can enhance the quality of teaching and learning, ultimately leading to a better understanding of EE/ESD.

“TV, DVD, and projector; they can assist. Since we are failing to go to the fields, I believe these can assist. If we do not have such materials and we do not go out, then we are disadvantaged compared to schools that have all those materials. I believe better resources make teaching and learning better and enable learners to have better knowledge”. (Mr Nkhumeleni)

Mr. Nkhumeleni underscores the difficulties and obstacles encountered by teachers in obtaining educational resources for teaching EE/ESD topics. He specifically mentions the CAPS document's suggestion of utilizing videos in instruction. Unfortunately, resource limitations in rural schools force him to overlook this recommendation. The absence of projectors and personal devices for video presentations renders it unfeasible to follow the recommended teaching methods. This predicament places rural teachers and students at a disadvantage, as some lack access to smartphones or data to independently view educational videos.

“*The Caps document does tell us that we should also use the videos, but we are forced to ignore that because we do not have projectors that we can use to show learners videos, and I cannot use my personal phone to show learners videos since it will take time to accommodate the whole class. So what I do is ignore such a request because we cannot afford it. There are schools that have materials, and they do use them to their advantage, but us teachers in rural* *areas do not have such facilities, and we are forced to ignore watching CDs or videos about environmental topics or any topic at all in general. So we normally tell learners to go play the videos at home, but you find that others do not have smartphones and others do not have data, so they end up not playing the videos. They are presented in such a way that they also give you a link to watch the video, but since we do not have the right materials or resources, we end up not using them".*

5.7 Challenges Faced by Teachers in Integrating EE/ESD into the Life Science Curriculum

The theme of obstacles encountered by teachers in incorporating EE/ESD into the Life Science curriculum was explored in alignment with the research question: What challenges do teachers encounter when integrating EE/ESD into the Life Science curriculum? This theme, focusing on challenges faced by Life Science teachers, was examined within the framework of two sub-themes that surfaced. These sub-themes encompass curriculum and pedagogical challenges, as well as issues related to timing and support. The insights into these sub-themes were derived from interviews with Life Science teachers and subject advisors, as depicted below.

5.7.1 Curriculum and pedagogical challenges

5.7.1.1 Time constrains and curriculum challenges.

One of the challenges faced by teachers in integrating EE/ESD into Life Science curriculum is the time constrains and curriculum challenges. When Mr. Sabawa was asked about the challenges he face when integrating EE/ESD into Life Science curriculum, he states that there is not enough time allocated to teach these topics He said:

"The challenge here is time... "

Mr Sabawa also felt that the time is not conducive for learners to know about topics such as osmosis and also EE/ESD related topics. He further feels that if EE/ESD can be a stand-alone subject then the issue of time would be better.

"I think that time is not conducive, maybe for the learners to know about osmosis and also as well as this environmental education itself, because it was supposed to stand on its own, you, see! In other words, I do not know how this can happen, wherein if maybe there was any topic or if there is another subject

dealing with environment only, it was going to be good. If we do have another subject that deals with environmental sciences, maybe if it is called environmental sciences even at our level, at the high school level, it is going to be better".

Similarly, Mr Nkhumeleni also indicated time as a challenge in integrating EE/ESD into Life Science curriculum. He indicated that:

"The time specified for EE/ESD topics is not enough, and as such, we are obligated to cover only a few environmental aspects and leave out the rest due to time".

Mr Makhokha acknowledged that there are EE/ESD concepts that are challenging to him when he teaches them. These concepts include Eutrophication, and what makes the teaching of these concepts more challenging is the limited time available to teach in class. He said:

"So, the other challenge, as I have said, is that there are other concepts that you cannot teach in class, and we cannot teach outside of the school environment; we just have to explain them, like eutrophication, or use the projector because we do not have enough time to cover such concepts".

Mrs Mususumeli indicated that:

"I cannot take them out just to teach them one aspect. The issue is that if I am taking them out, I have a large classroom that I cannot control, so I will need to work with learners in groups, and working with them in groups takes time and is hard to do since I am teaching the subject alone."

This indicates that the limited time available for teaching and the difficulty of managing large classrooms is a challenge to Mrs Mususumeli which hinder her ability to provide hands-on and experiential learning opportunities for the learners.

Mr Mususumeli also indicated that one of the challenges she faces is that fact that the EE/ESD topics are covered last in grade 11 which may result in learners being tired and not paying attention.

"I do not know whether it is because the learners are tired or not, but because we are moving to the end of the syllabus, learners do not pay attention. They do not focus." (Mrs Mususumeli)

This response indicates that timing of the topics within may affect the engagement and understanding of the learners.

Similarly, Mr Joseph, indicated that the challenges that teachers face in integrating EE/ESD into Life Science curriculum is the issue of timing. According to Mr Joseph, EE/ESD related topics (environmental studies) are taught towards the end of the year, when there is limited learning time due to grade 12 learners starting to prepare for their final examinations. This is because teachers who are supposed to teach these topics end up being the ones invigilating for grade 12 exams. As a result, there is lack of dedicated teaching time to this topic. He Said:

> *"First, one of the main challenges that I have observed is the timing to the topic/strand of Environmental studies. Because it comes last towards the end of the year, and towards the end of the year there is no learning to be honest with you. This is because if grade 12 starts with their exams, it means that all these learners have started with exam. Another thing is that you will find that the invigilators for grade 12 examinations are the same teachers who are to teach the same topic we are talking about in grade 11. So, they will be busy invigilating instead of teaching this topic".*

5.7.1.2 Pedagogical Challenges

Teachers also encounter pedagogical challenges. Mr. Shonisani highlighted that one of the difficulties teachers face is their own lack of practical experience and the necessary knowledge to effectively teach EE/ESD topics. He noted that this issue arises due to universities producing teachers with insufficient practical experience.

> *"Unfortunately, the teachers who are introduced now to teaching this Life Sciences are lacking the practical experience of the subject; they are too theoretical, and I think they should be doing this thing theoretically, going out and dealing with the environment…… So in simple terms, universities are now producing teachers who lack practical experience in online teaching". (Mr Shonisani)*

Mr Shonisani further indicated that teachers teach EE/ESD topics in isolation from real life situations that it addresses. He said that:

"So there are a lot of challenges because these people teach this topic in isolation from the real situation that the topic has to address. This topic is so that the learners understand the environment that they are living in, even the challenges and imbalances that can arise".

Similarly, Mr Joseph, also said that another challenge faced but teachers is the lack of knowledge and understanding of how to effectively teach environmental studies (EE/ESD) topics. He further mentioned that teachers who did not do geography face difficulties in teaching this topic.

"We had some challenges about how to teach this topic, especially from teachers who did not study geography. Because this environmental studies integrates with geography, so most teachers who did not do geography use to have challenges". (Mr Joseph)

Mr Sabawa said that lack of prior knowledge from the learners is one of the challenges that makes it difficult for him to teach EE/ESD topics effectively. He said:

"When you introduce these types of topics, you find out that when you are looking for prior knowledge of the learner, you find out that these learners know nothing about the environment. And these are the things that they should have been taught at an earlier stage. At this stage, there was supposed to be somewhere when it comes to knowledge, knowing about the environment itself. You see, and it marks it difficult to teach".

Mr Nkhumeleni sad that he has a challenge of only using theory when he teaches.

"I believe that the problem is that I teach theory and I do not have the practical part". (Mr Nkhumeleni)

He also mentions that he has challenges when he wants to relate what he is teaching to real life because it can be offending to some learners.

"*Sometimes, when you are teaching about water-borne diseases such as cholera, you might find out that in that class there is a learner whose partner died of cholera, so it will be like you are teaching that lesson to that learner". (Mr Nkhumeleni)*

Similar to Mr Nkhumeleni, Mrs Mususumeli also indicated that giving real life examples a challenge in class as it might be like she is teaching about children life or those of their parents. She said that:

> *“…using real-life examples, because you sometimes mention how family members or parents are doing at home, hence they feel offended. E.g., if I am talking about deforestation, giving examples of cutting mopani trees, you might find out that it is someone's job, you know”.*

5.7.1.3 Exam-Oriented Teaching

Another obstacle that teachers encounter when incorporating EE/ESD into the Life Science curriculum is the emphasis on exam-centric instruction rather than providing students with practical knowledge about the environment. Mr. Nkhumeleni pointed out that he frequently prioritizes assisting learners in achieving good results or passing exams, rather than instructing them on environmental care. He states:

> *"To tell you the truth, we teach learners to focus on obtaining good results or passing, but I cannot lie and say that we are teaching them to have knowledge about the environment."*

This exam-oriented approach limits the emphasis on practical application and sustainable practices.

Mrs. Mususumeli also mentioned the challenge of exam-oriented teaching. She stated:

> *" the challenge is that we are teaching them to pass."*

This indicates that the focus on exam results may overshadow the importance of teaching EE/ESD topics in a way that enables learners to apply their knowledge and skills in real-life situations.

She further mentioned:

> *"Once they learn, the aim is that they know. We have learning objectives, and one of the objectives is application, so one of the reasons for teaching is that learners should be able to apply their knowledge."*

This suggests that the current exam-oriented approach may not fully support the development of learners' abilities to apply EE/ESD knowledge in their everyday lives.

Mrs. Rose mentions that EE/ESD is often taught with a focus on exam preparation rather than promoting a deeper understanding and application of the concepts. She states,

> " *Eeehm, I think it is only taught theoretically, at a level that learners are just taught to cram, not be able to apply it in their everyday lives…..*It is just taught for exam purposes".

This suggests that teachers perceive a pressure to prioritize exam results over the comprehensive development of learners' environmental knowledge and skills. Mr. Sabawa also noted that the emphasis on exams and the pressure to ensure learners pass exams frequently overshadow the teaching of EE/ESD. He mentioned that the primary goal for learners and the education department is exam success, often neglecting the emphasis on knowledge and understanding of environmental education. He said that:

> *"Most people do not care about the environment. Because the main aim of these learners at school, even the department in itself is encouraging us that learners must pass."*

5.7.2 Support related challenges

5.7.2.1 Lack of Financial Support for School Trips

Under the theme of challenges, the sub-theme of lack of financial support for school trips emerges. Mr. Makhokha highlights the importance of field trips in teaching environmental studies but mentions the lack of financial support as a hindrance. He states that:

> *"Okay, yes, my last previous explanation is one of the challenges that I face, which is a lack of financial support from the school when we organize trips or excursions for learners that can help us unpack some concepts. Still there, we were busy organizing a trip as a circuit for Life Sciences, but we also faced challenges because, when we wrote to the district, we were told that the school has to finance the trip, and that was the end of it because the school cannot finance those particular trips".*

On probing, Mr Makhokha was asked if he has tried and address these challenges, and he further explained that he has tried and addressed these challenges with the Life Science coordinator and there was no progress.

“We tried to address these challenges with the Life Sciences coordinator in our district, but still there is no progress, even though we tried to explain to him these challenges” (Mr Makhokha)

Mr Makhokha also said that he believes that lack of financial support affect learners performance because some learners lean best by seeing and experiencing what he is teaching them so lack school trips hinders that possibility then affecting learners performance in EE/ESD related topics.

“some learners learn best by seeing other than hearing, so it does affect their performance even if I have the projector; some learners need to see and experience what we are teaching them firsthand in order to understand it, so it does affect the performance of the learners”. (Mr Makhokha)

Mr Nkhumeleni also identified lack of financial support for school trips is another challenge he faces as a teacher. He mentions that principals often consider school trips as time-wasting and do not provide funds for them. He states,

"The issue is money; principals always emphasize that learners do not have money and that it is time-wasting to take learners out on excursions or school trips, but we are located not very far from Kruger National Park".

This lack of financial support hinders teachers' ability to provide practical experiences and teach learners in the environment. Mr Nkhumeleni also believes that one way of making learners to become aware of their impact on the environment is to teach them outside the classroom.

“if we take learners to where water is polluted and ask them to drink that water, they may refuse to drink, and by so doing, they will easily relate to the idea that if they pollute water, then they themselves will suffer, but if we just teach them in class, they can just think that it is a theory without realizing that it is something happening around them and they might also contribute to it. So we need to take them out and teach them in the environment, because it will make them aware of some of the effects they have in the environment”.

However, when asked why he does not do that with his learners, he said that he has financial challenge when it comes to organising school trips. He said that this challenge has been continuous from different schools that he has taught from. He said:

"Everywhere I have ever taught, the principals are not willing to assist us with funds specifically related to the school trips; as such, it becomes hard for me as a teacher to organize school trips for Life Science learners to go and teach them outside the classroom. But I believe that is one way we can make learners aware of the environmental impacts".

Mr. Joseph also stated that ignorance within the education system restricts school trips. He highlighted that schools mainly participate in sports trips, emphasizing a lack of emphasis on environmental excursions and field trips. According to him, most school trips prioritize entertainment rather than educational purposes.

"I do not know if its ignorance or is it our education that makes us to be ignorant because we do not really go deep to the level of having environmental excursions/trips, the only excursions are soccer trips, they just call it educational tours but without any questioner or anything pertaining to leaning. its like we are living in a world where people love entertainment and dancing, that's where you find them happy. But if we were also investing on having environmental excursions is where we can pick up a lot of things".

Mr. Joseph's statement suggests that schools allocate their finances more towards sports and entertainment than educational excursions, like environmental trips, which could enhance learners' awareness of the environment and facilitate the integration of EE/ESD-related topics. In agreement with Mr. Joseph, Mr. Shonisani also noted that schools receive funds annually, but they are not directing these funds appropriately.

"I think the department has done enough; it depends on the teacher and the leadership of the school. As the department said, schools are given funds, and if they can use those funds positively, they can benefit a lot. Today we cannot say the department is not doing enough; the department is trying, but unfortunately, the one who has been given the resources (funds) to do the right thing is not doing the correct thing….. More especially now that those schools are given a budget and a lot of money, some are getting up to 2 million, some 1.5 million, so the problem is to direct the funds in the right direction".(Mr Shonisani)

When probed as to whether the money the department give the schools have categories, he said that 60% is for curriculum and another 40% the school can categorise according to the needs of the school.

> *"There are prescripts; for example, 60% must be curriculum; the rest you can categorize; in fact, you are given prescripts, but 60% is curriculum, and the teaching of Life Sciences in the class is part of the curriculum….. So if maybe the school managers can channel money yearly according to the needs of a particular subject, say this year I am focusing on geography and next year I am focusing on Life Sciences, after 5 years each subject can have the necessary resources".*

This reply indicates that by appropriately allocating the funds received from the Department of Basic Education (DBE), school management has the potential to address the financial challenges teachers face regarding school trips. This can be effectively achieved if schools allocate funds based on the specific needs of each subject, ensuring that those needs are adequately met, as suggested by Mr. Joseph.

5.7.2.2 Lack of Support from Subject Advisors and the DBE

Mr Sabawa expressed his disappointment with the lack of support from subject advisors and the Department of Basic Education. He mentioned that subject advisors mainly focus on assessment tasks and do not provide specific support on how to teach EE/ESD. Mr Sabawa said,

> *"No, there is no support. They will just come and generalize. Their support is general. They do generalize, but mostly these are natural scientists or what? Or maybe environmental studies. Most of them do not include it."*

When ask who is refereeing to by "they" Mr Sabawa said that:

> *"I mean those who come to support us. Okay, so like the subject advisors, who is the department representative"*

The results from Mr. Sabawa indicate a lack of support for Life Science teachers in incorporating EE/ESD into their lessons, particularly from subject advisors who serve as department representatives. In response to the inquiry about subject advisor visits to provide support in school, Mr. Sabawa stated that these visits primarily focus on verifying the implementation of assessments.

"Looking for maybe for Classwork the task that is the task written most of the time, okay? So one can say that they come for assessment. To assess whether the assessment tasks are being catered for"

In response to the question about whether subject advisors offer guidance on teaching EE/ESD-related topics, Mr. Sabwasa mentioned that he has not received such support. However, he expressed gratitude for the opportunity in 2023, where he was invited to attend a Mathematics, Science, and Technology workshop (MST). During this workshop, he received instruction on how to teach EE/ESD topics in Life Science. Mr. Sabwa was the sole representative from his circuit at the workshop.

"No, there's that. But I heard that in some of the subjects they can teach, and I can say yes. This year I was invited somewhere around to the MST workshop, wherein we were also being taught. We came to a point where we were taught how to teach this topic…..I was the only one from this circuit". (Mr Sabawa)

However, when probing if Mr Sabawa, shares the information with other teachers he said that:

"I was not entitled to do so. Okay. But some of my colleagues I did share".

Mrs Rose, the subject advisor indicated that they do visit schools however, she basically focusses on learners books to check for assessment. She stated:

"Basically, what we do when we visit, because usually, this is done during school support visits most of the time. So what we do is that when we arrive at the school, I will ask for the documents like CAPS, ATPs, the exam guidelines, and then also ask for the learners book to check the assessments. So based on the questions that are used in the assessment, we can check whether the questions that are used address the aspects that are indicated in the documents that I have indicated, like the ATP and the exam guidelines".

Upon inquiry, Mrs. Rose was questioned about whether she encounters teachers expressing difficulties in integrating EE/ESD into their lessons and how she assists them. She said that:

"No, no, no, because usually we will send them a questionnaire to indicate the topic that they find challenging; environmental studies is not one of them".

Even through Mrs Rose indicated that environmental studies into one of the topics that teachers find challenging, she was further asked how she support teachers after they indicated topics that are challenging via questionnaire. She indicated that:

> *"We then organize a workshop, a content-based workshop, on the topic that they would have indicated, and then we ourselves train them".*

Mrs. Rose mentioned that she organizes content-based workshops to train teachers. The researcher then inquired whether this training is provided for all grades in Life Sciences. However, she clarified that while they planned to implement this for all grades, it has only been executed for grade 12 so far.

> *"No, this time around it was only grade 12, and not for all teachers, like I said; actually, this time around, although we did send the questionnaire, our focus was on the schools that have underperformed". (Mrs Rose)*

Mr Nkhumeleni mentions that subject advisors do not provide adequate support in teaching EE/ESD-related topics. When asked about how subject advisors support him, he replied:

> *"No, there is no support from them; they will just come and tell you that what you did is not correct or is not what was required. They only worry about the performance of the learners, but if you ask them what you can do to teach a topic well, they will never offer more assistance, especially for lower grades such as 10 and 11".*

Mr. Nkhumeleni also notes that subject advisors visit his school, but this occurs only once or twice a year. Additionally, he pointed out that these visits do not specifically focus on providing support for teaching EE/ESD-related topics.

> *"They only come to visit schools maybe once or twice a year, and that visit will be based on checking the teachers and learners' files, not to support us as teachers on how to teach any topic".*

When asked, if he asked for support from subject advisor, when they come to visits, he said that:

> *"Yes, I do ask for support from them, but they always say I do not have time, and you caught me off guard".*

Mr Nkhumeleni also mentions that lack of visits by subject advisor is painful to him because when they visit him, they are also harsh without providing any support to him. He stated:

> *"It is painful, and it causes hate amongst us because they do not support us, but when they do, they come in a harsh way even though they do not offer support. They do not even support us in the arrangement of files, but they always expect us to pack them correctly".*

Mr. Mususumeli also conveyed the absence of support from subject advisors and the DBE. She pointed out that subject advisors do not visit for grade 11 and only offer support for grade 12. When questioned about receiving support from subject advisors for teaching EE/ESD topics, she mentioned that there was none:

> *"Not on this topic. They support grade 12, not grade 11. In grade 11, they just come and say the learners are failing".*

Mrs Mususmeli also mentioned that there is no support for grade 11, learners but subject advisor's support is targeted on grade 12 learners. For grade 12, she mentioned that she has received support on how to teach topics in grade 12 and she has also attended a workshop, that was grade 12 based, but nothing for grade 10 and 11. She said that:

> *"No, they do not come for grade 11; they just generalize. But in grade 12, I remember last term they did item analysis and found topics that were difficult for learners, then they came and helped us learn how to teach such topics. In grade 11, they do not come. In grade 12, I remember attending a workshop where they also covered related aspects; they taught us about the content that learners were failing, but they didn't do this in grades 11 or 10".*

The findings from Mrs Mususmeli, shows that teachers are supported to teach grade 12, however, the analysed documents (ATP), shows that the environmental studies has been removed from grade 12, which then mean that even when she is supported to teach, it does not include teaching of EE/ESD topics.

Similarly, to what Mrs Mususumeli has said about lack of support for grade 10 and 11. When asked, about the role he play in supporting Life Science teachers to integrate EE/ESD into Life Science curriculum, Mr Joseph mentioned that they do not support grade 10 and grade 11 because as subject advisors they are grade 12 oriented. He said:

> *"The issue of support in the department, is difficult, but because it is in grade 11, we do not really focus on grade 11 for support and you find that the topic is not in grade 12 formal tasks, you might just find that sometimes in June exam we put it but aaaaah. What I can say is that supports for internal grade, grade 10 and 11 is limited because as subject advisors is like we are grade 12 orientated. We mainly focus in grade 12 exam results".*

When asked, if the way he support grade 12 teachers was used to support grade 11 teachers if this can play a role in supporting Life Science teachers to integrate EE/ESD into their lessons. Mr Joseph agreed, however, he also a raised a concern that there is a limited number of subject advisors to support teachers.

> *"There would be huge difference and changes. Its just that when we talk of support you find that we do not have the numbers. We have two types of support, its onsite and when someone calls you, so when you are called you need to mind the issue of contact time".*

The results from Mr. Joseph reveal that subject advisors do not provide support for grade 11 teachers, attributing it to a shortage of advisors to assist with grade 10 and 11. Similarly, Mr. Makhokha noted a lack of support from subject advisors and the DBE. He stated that subject advisors haven't offered any support or guidance on teaching environmental studies.

> *"So, in terms of support from the subject advisors, I haven't received any support in my nine years of teaching Life Sciences. I have never received any support about how to teach environmental studies. I have to do my own research and come up with my own strategies on how to include EE/ESD in my environmental studies lessons".*

Mr. Makhokha acknowledges that he receives visits from subject advisors, but he emphasized that no support has ever been provided to him on how to teach. He said:

> *"They do visit, let me say frequently, but they have never supported me in the in terms of EE/ESD or, let me say, environmental studies. In fact, they have never supported me in learning how to teach".*

When asked, what the subject advisor focus on when they visit him, Mr Makhokha indicated:

> *"So, what they focus on is that the most important thing to them is that they check the learners textbooks to see whether we are giving them formal or informal tasks, whether they are appropriate, as stipulated on the CAPS document. They focus more on the theoretical part of the curriculum and what is done in the classroom; that's what they do".*

When questioned about whether subject advisors offer support when learners struggle with the environmental studies topic, Mr. Makhokha mentioned that he's uncertain if it qualifies as support. He explained that, as a teacher, he is tasked with devising strategies to enhance performance.

> *"I am not sure if it is support, because they only tell us about or, in fact, they ask us to come up with strategies on how we are going to improve if the learners have failed; they do not necessarily come up with suggestions, but they want them from us".(Mr Makhokha)*

Mr Makhokha also indicated that the DBE only support him with textbooks. When asked if he receive support from the DBE He said:

> *"No, that I know of, I do not think there is any support from the DBE to support teachers integrating EE/ESD; their focus may be on the theory. Maybe support it by providing textbooks".*

According to Mr Shonisani, the DBE is doing its best to support teachers he also mentions that he personally support teachers through calling them and support them one on one. He said that:

> *"From where I am working, we do workshops, we do support, and for my own, I always invite them. I have a lot of teachers that I personally invite and assist so that they see education as another area where they have been called to serve the nation because teaching is one of those professions that is very important".*

5.7.2.3 Lack of Support from School and colleagues

Teachers were queried about the support they receive from colleagues and school management in incorporating EE/ESD-related topics into their lessons. Responses varied among teachers. Mr. Nkhumeleni expressed a lack of trust from school management, especially when seeking support for trips, as they perceive it as recreational rather than educational, providing no supportive measures.

> *"There is no support that I have received. Even when you are asking for a school trip with learners, maybe to take them to Kruger National Park, people think that we just want to go play with the learners at Kruger, and they offer no support". (Mr Nkhumeleni)*

Mr. Nkhumeleni also conveyed that his colleagues do not lend support. According to him, there is a prevailing sentiment among them that as the person responsible for a subject, one should independently devise solutions to the challenges associated with that subject. He said:

> *"There is no support from my colleagues. I am saying this because if you are teaching Life Science in grade 11, everyone believes that it is your duty alone to teach that subject, and they offer no help. I remember asking for assistance on one of the topics that gives me headaches. I was told that it is my subject and I need to figure out a way to know how to teach each topic"*.

Mr Nkhumeleni also said that colleagues from other schools support him indirectly by coming and teaching learners the topics that are challenging for him during weekends upon his request. He states:

> *"Honestly speaking, they do not support me directly because I only ask them to come teach some topics that are difficult for me, so like I said, they support the learners so that they can pass, not me on how to teach a particular topic".*

When asked if he asks his colleagues for support on how to teach challenging topics, Mr Nkhumeleni said that:

> *"No, I have never tried that, but I believe that I need assistance on how to teach some of the topics related to EE/ESD so that I can also empower myself and also develop as a teacher".*

The findings from Mr. Nkhumeleni reveal that he lacks support from colleagues and school management. However, Mr. Nkhumeleni prioritizes the needs of learners by seeking assistance from colleagues in different schools to teach for him instead of providing guidance on how to teach challenging topics related to EE/ESD, even though he acknowledges the need for assistance in teaching such topics. On the other hand, Mrs. Mususumeli indicated that she does receive content support on how to teach EE/ESD-related topics in her lessons from her colleagues at school. She mentioned that she receives support from an Agricultural Sciences teacher and a Geography teacher; however, she expressed concern because one of those teachers has retired..

> *"I do receive content support from other subject teachers, such as agriculture and geography teachers, but unfortunately, one teacher retired". (Mrs Mususumeli)*

Mrs Mususmeli also mentioned that school management does not support her, she only receive support of question papers from the district. She said:

> *"There is no support from the school management, only district level; they do send question papers and notes at district level".*

Mrs. Mususmeli's response indicates a lack of supportive measures from school management. However, she acknowledges the support received from other teachers, expressing concern about the retirement of one of her supporting colleagues. Mrs. Mususmeli also recognizes the assistance provided through question papers at the district level. When asked about the support she would need from school management, she emphasized the need for support for learners rather than herself. She states:

> *"The school must seek out experienced teachers to come help the learners should I identify this topic as challenging".*

When asked if she does not need support that is related to her as a subject teacher, She indicated that:

> "*also outsourcing for me as a teacher to find someone who can come and teach me how best I can teach this topic that includes EE/ESD…..They also want to give me a chance, give me a laptop and data so that I can download videos, and also give me laptops that I will use to show videos to the learners".*

Mr Sabawa feels that his colleagues do not support him in teaching EE/ESD related topics, he said that what they do is to look at what you are doing.

> "*they do not support; they just look at what you are doing. Yeah, they just look at what you are doing". (Mr Sabawa)*

However, Mr. Sabawa also perceives that his school management is willing to support him, but they lack the necessary materials and resources to provide assistance. He said:

> "*Yeah, that one they do support, but mostly you must go to them; that's where they are going to support you*……*Yeah, they are willing, but they do not have resources; they do not have money".*

Mr. Sabawa's response indicates a lack of support from colleagues in teaching EE/ESD topics, highlighting their passive observation without active assistance. He does acknowledge some willingness from school management to provide support; however, the shortage of materials and resources hinders effective assistance from the school.

5.8 Professional Development Mechanisms for Integrating EE/ESD into the Life Science Curriculum

One of the focal themes that surfaced in this study was the professional development mechanisms aimed at integrating EE/ESD into the Life Science curriculum. This theme seeks to answer the question: What professional development initiatives are accessible to aid teachers in integrating EE/ESD into the Life Science curriculum? The findings within this theme were organized based on two subthemes that emerged during the course of this study, namely the Need for Professional Development and Professional Development Opportunities.

5.8.1 Need for Professional Development

Results from this study revealed that participants recognized the necessity for professional development initiatives. This acknowledgment stems from the participants' shared sentiment that there are currently no mechanisms in place to provide professional development support for integrating EE/ESD into the Life Science curriculum. As part of this recognition, Mr. Sabawa, when questioned about his involvement in professional development programs designed to enhance teachers' ability to teach EE/ESD-related topics, responded that:

> *"I have attended many workshops, but not with regard to environmental education specifically. They used to generalize".*

When asked what he meant by generalizing Mr Sabawa said:

“*I mean that going there is the topic that you are going to be engaged in, not environmental education”.*

Mr. Sabawa's feedback highlights the absence of professional development programs for EE/ESD-related topics, particularly on teaching methodologies. He underscores the necessity for training and collaborative efforts to successfully integrate EE/ESD into the Life Science curriculum. Mr. Sabawa proposes the implementation of workshops and training sessions to equip teachers with the essential knowledge and skills for teaching EE/ESD topics. Additionally, he emphasizes the significance of sharing best practices and case studies from diverse locations to enhance the relevance and specificity of EE/ESD teaching within the local context.

"Maybe we can have a collective workshop wherein we are taught how to teach this environmental education. That one can be better" (Mr Sabawa).

Moreover, Mr. Sabawa emphasized the significance of integrating technology into the teaching of EE/ESD topics. He proposed that teachers should receive training on effectively incorporating technological tools into their lessons. As an illustration, he cited the practice observed in private schools where teachers record lessons for learners to access, particularly when they are unable to attend classes.

"Now that we are in a technological era, we need to be trained on how to teach such topics using the technological world."

When Mr Nkhumenleni was asked if he has participated in any professional development programs that specifically aimed to improve your capacity to teach EE/ESD, He said:

“*I do not remember going to any workshop and being workshopped on how I should teach, it being any topic in Life Sciences grade 11”.*

He further said:

“If you can check this year, I have never attended any workshop or meeting for Life since grade 11. I think the workshops that have been held this year are only for grade 12, not grades 10 and 11”.

Mr. Nkhumeleni expressed his desire to attend workshops and receive training on how to teach EE/ESD-related topics effectively. He believes that workshops would provide him with new strategies and approaches to teaching these topics, as well as enhance his own understanding of the environment. He stated,

> *"Workshops are helpful, and I believe I can learn a lot from them because I can also learn new strategies and ways of approaching these topics that can be helpful to me and my learners as well."*

Mr Nkhumeleni further expressed that he would like to attend EE/ESD content related workshop or meeting, H said that:

> *"I will prefer to know more about EE/ESD and the environment before I can teach well. I need to be more aware of the context of the environment. I did methodology, so with the content, I will then be able to teach".*

Mrs. Mususmeli also pointed out the necessity for professional development programs concerning the teaching of EE/ESD-related topics. When inquired about her participation in any professional development programs for EE/ESD, she responded:

> "*No, not for this topic. But I have attended some workshops for grade 12 and not for grade 11. It was just that it was talking about life processes".*

Mrs Mususumeli was probed to find out what workshops for grade 12 focus on and she replied:

> "*Both, we were taught how to teach that topic and also what to teach our learners in that topic, and it was beneficial to me as a teacher. We were also told that learners should not forget this topic after you are done giving them concepts that are key for them to learn and master so that they will always remember them".*

Professional development programs and workshops are seen by Mrs Mususumeli as valuable in improving teaching methods and providing guidance on what and how to teach EE/ESD topics. She said:

> *"Sometimes, as teachers, we do not know how to implement the best teaching methods for this topic, so workshops can assist with that and also in terms of deciding what to teach. Like I have said above, what I can teach as an ESD is that such workshops can assist us in knowing if we are covering these concepts or not".*

Mr Makhokha also said that he does not remember attending any workshops or training which is related to EE/ESD topics. He Said:

> *"I do not remember attending or having any professional development on environmental studies; in all the works that I have attended, I do not remember one that was focused on the professional development of teaching environmental education".*

He further said:

> *"Currently, most of the Life Sciences workshops that I have attended have focused on the annual teaching plan, how the strands are structured, and how we should teach them. In their order, they are not going into details on the how part but just showing us the order in which we need to teach the strands. Then the second one, I think, was an analysis of the results. They were talking about the performance of the learners. Those are the workshops that I have attended; they focused on those themes".*

When asked the grade he replied:

> *"No, this was only concerning grade 12. They have not done anything concerning grades 10 and 11. The focus is on grade 12 only".*

Mr. Makhokha emphasized the necessity for professional development programs targeted at enhancing teachers' abilities to teach EE/ESD topics in the Life Science curriculum. He clarified that he hasn't participated in any professional development programs specifically dedicated to teaching EE/ESD. He contends that such professional development can empower teachers with the knowledge needed to effectively teach environmental studies.

He stated,

> *"Yes, I feel like they can help, because, as a person, you need to develop your knowledge and you have to get as much knowledge as possible. So I think professional development in environmental education can really aid us in having knowledge on how to teach environmental studies."*

5.8.2 Professional Development Opportunities

The findings from subject advisors and teachers reveal the presence of professional development opportunities. Mr. Joseph recognizes the availability of professional development opportunities offered by the Department of Basic Education (DBE) for Life Science teachers. He said that:

> *"With professional development opportunities, and workshops we focus on grade 12 teachers, we do not have enough capacity to have such for grade 10 and 11. If you go to lower grades then you have enough capacity. And also if you check our schools, some are small schools, you cannot call one the teacher for grade 10 then again call the same teacher for grade 11 and 12. Unless if you are going to workshop them on content, but on how to teach (pedagogy) the principles applies throughout".*

He also said:

> *"So I want to come back to the issue that the professional development are there but the facilitators sometimes do not have enough knowledge about that or it might be that teachers are not given enough time to go and attend such professional development opportunities".*

However, he mentions that these opportunities mainly focus on grade 12 teachers and there is limited capacity for workshops for grade 10 and 11.

> *"Since this topic is not in grade 12, and our workshops mainly focus on grade 12 we do not have professional development opportunities for this topic but we do have for topics covered in grade 12"*.

He suggests that more professional development opportunities should be made available for teachers at lower grades to improve their teaching of EE/ESD-related topics.

Mr. Shonisani mentions that workshops and support are provided to teachers in his region.

> *"They are a lot. Let me tell you about our region, Vhembe. We have a lot of medicinal plants. In terms of environmental impact, teachers can go out and try to research so that they can come back and equip their learners in class about this gold of medicinal plants, but unfortunately, they also do not know. So, I think that in a pedagogical way, these people have to go out and bring that kind of experience so that they can be good".*

He personally extends invitations to teachers at his residence, offering orientation to help them grasp the significance of education and their role in national service. Nonetheless, he acknowledges the need for a shift in teachers' attitudes towards workshops, as many perceive them as a disruption rather than an opportunity for personal development.

> *"Eeeh, we cannot say it is there; we cannot say it is not there. It depends on the area, because you know the problem is that we are supposed to work with them based on their needs, and unfortunately, most of the teachers feel that once it is established that there is a gap in this area, they will be looked down upon, which is not true because once you open up to say you have got this area, you will need assistance most of the time. But we cannot say we have a program, and we cannot say we do not have a program. I think after your paper, people will start to realize that this area needs to be attended to too".*

Mr. Shonisani provides an instance of assisting a teacher who initially scored a low percentage in her tutoring. With his support and guidance, the teacher surpassed expectations and achieved a higher percentage. This case underscores the significance of personalized support and mentorship for teachers. On the other hand, Mrs. Rose is unaware of any professional development opportunities offered by the Department of Basic Education (DBE) specifically tailored for Life Science teachers to enhance their teaching of EE/ESD-related topics.

> *"I am not aware of that in the department, but I know that in the teaching of higher learning, when we encourage them to register, there are instances where they can improve. But as for the department, that is not something I am aware of, because most of the time we sit down as colleagues to say how we can improve the teaching of maybe environmental studies and how we can assist teachers. Besides that, I do not know about any programs".*

She mentions that teachers may have opportunities for professional development through higher learning institutions, but there are no specific programs or workshops organized by the department.

> *"Our weakness is that we go and teach the learners, but the teacher will be observing. We do not teach the learners in the absence of the teacher. The teacher will be the one I teach, but we can see that it is not a permanent solution*

because the permanent solution will be how I should teach this teacher how to teach this particular topic because when we do the issue of teaching, the same teacher will come next year and say come and teach this topic, so we are not providing a permanent solution. Because it is not necessary to say, the teacher does not need to say I do not know how; they do not want the how part, but they will say can you come and assist me by teaching this particular topic".

5.9 Guidelines for Effective Integration of EE/ESD into the Curriculum

The last theme derived from interviews with teachers and subject advisors underscores the necessity for comprehensive guidelines to facilitate the seamless integration of EE/ESD into the Life Science curriculum. The results for this theme are categorized into three sub-themes: Utilization and Awareness of Existing Guidelines, Professional Development and Teacher Support, and Comprehensive Guidelines and Resource Allocation.

5.9.1 Utilization and Awareness of Existing Guidelines

Mrs. Rose believes that the guidelines for integrating EE/ESD into the Life Science curriculum are available in the form of policy documents, ATPs, CAPS, and exam guidelines. She said:

"…. the guidelines are the policy documents, the ATP, and the CAPS document, we even developed the Life Sciences policy document, but this document is based on the information from the ATP, the CAPS document, and the exam guideline".

However, she acknowledges that teachers often ignore these guidelines and do not fully utilize them in their teaching.

"They are well applied; like I said, we just ignore the guidelines". (Mrs Rose)

Nonetheless, she recognized that additional efforts are necessary to ensure teachers possess a thorough comprehension of how to incorporate EE/ESD into their instructional practices. Similar to Mrs. Rose, Mr. Shonisani notes the presence of annual teaching plans and policy documents outlining guidelines for instructing EE/ESD-related subjects. He contends that these guidelines are beneficial in supporting teachers but underscores the importance of teachers being inventive and employing the existing guidelines proficiently. He states, "*Even if you can develop 100 new guidelines, without teachers using them, it is nothing. So we must start with the ones we have, make sure teachers are using them, and they are also innovative."*

Mr. Joseph suggests aligning the teaching of EE/ESD with subjects like Geography to ensure consistency and avoid confusion for learners.

"If we can integrate this topic into subjects like geography, I think teachers will be able to teach this subject... We need to know the term at which this topic is covered in geography and align the two, so that learners do not think they are being taught two different things."

Mr Makhokha said that he is not aware of guidelines on how to teach EE/ESD-related topics in the ATP, pacesetter but there are some in the CAPS document. He said:

"I think they do have some guidelines of some sort, but looking at them one by one, the pace setter does not have guidelines on how we should teach, just the concepts to be taught. ATP also does not have guidelines on how to teach. I am not sure if they are there. but I do not think they are theirs".

The feedback in this segment reveals that teachers, akin to Mrs. Rose and Mr. Shonisani, recognize the existence of guidelines in diverse documents but voice apprehensions about their uniform implementation. The section underscores the necessity for heightened awareness, comprehension, and proficient utilization of these guidelines by teachers. Furthermore, it introduces recommendations like aligning EE/ESD with subjects such as Geography and addressing potential gaps in guideline coverage.

5.9.2 Professional Development and Teacher Support

Mrs. Rose emphasizes the importance of providing teachers with ongoing professional development opportunities and workshops specifically focused on integrating EE/ESD into the Life Science curriculum. She says,

"They must conduct workshops. You, it is concerning so that they can teach. The teachers are to be trained on how to teach this topic" (Mrs. Rose).

Mr. Shonisani stresses the need for teachers to be supported and trained, stating,

"I think we must be supported enough, as teachers, so that we can go and transfer that support to the learners themselves. If teachers are not supported,

sometimes learners are also not going to be supported because learners are to be supported by teachers, and if teachers are not supported, learners are also not going to be supported" (Mr. Shonisani).

Mrs. Mususumeli highlights the importance of including guidelines on how to teach EE/ESD in curriculum documents. She suggests organizing workshops per term or annually to discuss how to teach each topic and provide support for teachers in integrating EE/ESD principles into their lessons. She states,

"Maybe the department can find it easy to organize workshops per term. For instance, in the beginning of the first term, we review the content coverage of the term and how to teach each topic covered in that term" (Mrs. Mususumeli).

Mr Sabawa said:

“if we can have guidelines to support teachers on how to teach this topic. They must conduct workshops. You, it is concerning so that they can teach. The teachers are to be trained on how to teach this topic. And as well as some of the materials I've included, I've indicated materials like, As I've stated, it's the project itself”.

This section underscores the unanimous belief held by both teachers and subject advisors regarding the significance of continuous professional development and workshops tailored to the integration of EE/ESD into the Life Science curriculum. Both groups emphasize the necessity for training and support to bolster their proficiency in effectively teaching EE/ESD topics. Furthermore, there is a shared agreement on the importance of incorporating guidelines on teaching EE/ESD directly into curriculum documents. Teachers and subject advisors advocate for regular workshops to deliberate on teaching methods for each topic and assist teachers in incorporating EE/ESD principles into their lessons.

5.9.3 Comprehensive Guidelines and Resource Allocation

Mr. Sabawa emphasizes the need for guidelines and workshops specifically focused on teaching environmental education to improve teachers' capacity in this area. He states,

"Guidelines to support teachers on how to teach this topic. They must conduct workshops" (Mr. Sabawa).

He also suggests the development of specific case studies and resources for different areas.

Mr Makhokha suggests that guidelines should include the allocation of funds for environmental studies and the grouping of schools for teaching in the field. He states,

> *"So I think some of the guidelines that can be included in Life Sciences in terms of environmental education, I think the department must put a guideline where there is an allocation of funds for environmental studies in terms of the funds of the school".*

Mrs Mususumeli said that:

> *“Maybe the department can find it easy to organize workshops per term. For instance, in the beginning of the first term, we review the content coverage of the term and how to teach each topic covered in that term. I think it can be better. If they do not have time, we can do it once a year, wherein they come for grade 11 and we discuss how to teach each topic and jaa”.*

Mr. Nkhumeleni, in contrast, feels that guidelines may limit teachers' use of their own strategies. He suggests that if guidelines are to be there, they must include both theory and practical parts, like the approach in Life Orientation. He states,

> *"I think guidelines will not be okay because they will limit teachers use of their own strategies. They should include theory and practical parts like they do in Life Orientation; that should be in a written document" (Mr. Nkhumeleni).*

5.10 Chapter summary

This chapter has presented the findings of the study, commencing with the data derived from the analysis of official documents, encompassing the CAPS document, ATPs, and prescribed textbooks. Subsequently, the data gathered through semi-structured interviews has been detailed. The emerging themes, stemming from both document analysis and interviews, have been elucidated. In the upcoming chapter, a summary of the findings and an in-depth discussion will be presented. The discussion will primarily concentrate on the themes delineated and expounded upon in this chapter.

CHAPTER 6: DATA DISCUSSION

6.1 Introduction

The aim of this research is to explore how professional development contributes to the enhancement of Life Science teachers' pedagogical content knowledge for the integration of Environmental Education and Education for Sustainable Development (EE/ESD) into the Life Sciences curriculum. Chapter one of this study underscores the significance of Goal 4 of the United Nations Sustainable Development Goals (UNSDGs), emphasizing the need for EE/ESD in formal school settings and the necessity for teacher professional development to enhance education quality by 2030, as outlined in The Sustainable Development Goals Report (2019).

In order to achieve sustainable development and address global challenges like poverty, inequality, and environmental degradation, the integration and implementation of EE/ESD in formal educational contexts are deemed crucial. However, the literature reviewed in this study indicates that teachers, who play a pivotal role in this integration, are facing challenges. They are not incorporating EE/ESD into the formal educational context as mandated by the South African government, and minimal efforts have been made to support teachers in integrating EE/ESD into their subjects (refer to chapter 2).

This study employs an explorative case study design to investigate how professional development supports the pedagogical content knowledge of Life Science teachers in enhancing the integration of EE/ESD into the Life Science curriculum. The data collection methods include document analyses, semi-structured face-to-face interviews, and participant observation, with thematic analysis applied to interpret the findings. The results of the study are presented in Chapter 5, where the findings are discussed.

6.2 Discussion of findings

In this section, the findings are deliberated upon, aligning with the themes elucidated in Chapter 5 of the study. The discussion incorporates a cross-reference of the three theories that underpinned this research: the Pedagogical Content Knowledge (PCK) theory, Social Learning Theory, and Educational Change Theory, as expounded in Chapter 3, in conjunction with the literature reviewed in Chapter 2.

6.2.1 The coverage of EE/ESD in the Life Sciences CAPS documents, ATPS, and textbooks

Examining the Grade 11 CAPS document, Annual Teaching Plans (ATPs) for 2021-2023, and textbooks yields a thorough insight into the coverage and approaches employed in Environmental Education (EE) and Education for Sustainable Development (ESD) topics. The CAPS document establishes a robust foundation, emphasizing the significance of comprehending human-environment interactions. However, it falls short in providing explicit guidance on teaching methodologies for EE/ESD topics, echoing findings by Bopape, Mudau, and Msezane (2021), who also identified the absence of integration guidelines as a hindrance. Shulman's framework underscores the importance of teachers possessing strong Content Knowledge (CK), and in this context, clarity on effective teaching strategies for these topics is crucial. The deficiency in such guidance within the CAPS document underscores the need for improvement in this aspect of Pedagogical Content Knowledge (PCK).

The ATPs, influenced by the challenges posed by the COVID-19 pandemic, exhibit efforts to balance reduced teaching time with educational rigor. Kimaro (2018) noted the time constraints in implementing EE, and this study concurs, revealing a reduction in time and coverage of EE/ESD-related topics in the ATPs, particularly in 2023. This raises concerns about the depth of understanding learners can attain. It emphasizes the necessity for continuous teacher training to enhance Pedagogical Knowledge (PK) and better prepare teachers to navigate challenges in delivering comprehensive EE/ESD in schools.

The analysis of textbooks reveals variations in resource provision and coverage depth, with the "Solutions for All Life Science Grade 11 Learner’s Book" emerging as a robust resource. However, a notable gap across all documents is the absence of clear guidance on teaching methodologies. While the documents collectively establish a framework for EE/ESD education, addressing these gaps and incorporating explicit teaching strategies is imperative. Ongoing teacher training and collaborative efforts can enhance the effectiveness of EE/ESD education in Grade 11, ensuring a comprehensive and impactful learning experience for learners in the evolving educational landscape.

6.2.2 Teachers and Subject advisors Perceptions of adequacy in covering EE/ESD topic in Life Sciences Curriculum

Insights provided by Grade 11 Life Sciences teachers and subject advisors offer a comprehensive understanding of the extent and adequacy of Environmental Education (EE) and Education for Sustainable Development (ESD) themes in the curriculum. Notably, teachers like Mr. Sabawa and Mr. Nkhumeleni express apprehensions about the current syllabus, emphasizing its insufficient coverage of EE/ESD topics, particularly critical concepts such as climate change, which are merely incorporated as subtopics. This contradicts Tsotetsi's (2021) findings, suggesting that teachers struggle with EE integration due to the curriculum's broad coverage, leaving little time for extracurricular lessons. Tsotetsi's findings indicate that the coverage of EE/ESD is extensive but time-constrained, while teachers in this study contend that certain topics, like climate change, are inadequately addressed. These concerns align with the CAPS document analysis, implying potential repercussions for learners' overall understanding.

Conversely, Mrs. Mususumeli and Mr. Makhokha present contrasting perspectives. While Mrs. Mususumeli acknowledges the curriculum's coverage, she advocates for enhancements, particularly in sustainable development. On the other hand, Mr. Makhokha deems the themes adequately addressed, underscoring the subjective nature of teachers' viewpoints. This corresponds with Shulman's Pedagogical Content Knowledge (PCK) concept, emphasizing the importance of teachers' comprehension of subject matter and pedagogy for effective teaching.

Subject advisors, including Mrs. Rose, Mr. Joseph, and Mr. Shonisani, offer a positive evaluation of the curriculum's inclusion of EE/ESD in grades 10 to 12. This suggests that subject advisors, with favorable perceptions, can guide teachers in integrating EE/ESD into their lessons, aligning with the notion that subject advisors possessing strong PCK can effectively support teachers (Shulman, 1987). However, Mrs. Rose's lack of confidence in the content's adequacy and the need for potential additions echoes teachers' concerns, emphasizing the importance of ongoing examination and possible modifications to enrich the breadth and depth of EE/ESD coverage.

Overall, these diverse perspectives underscore the complexity of evaluating curricular coverage, showcasing the interplay of PCK elements among teachers and subject advisors. Teachers stress existing gaps, while subject advisors observe integration across different grade levels. This interaction highlights the ongoing collaboration needed among curriculum developers, subject advisors, and teachers to address concerns, improve content, and ensure effective integration and comprehension of EE/ESD subjects in the Grade 11 Life Sciences curriculum.

6.2.3 Teachers' and subject advisors' Understanding of EE/ESD

To gauge the understanding of Environmental Education (EE), sustainable development, and Education for Sustainable Development (ESD) among teachers and subject advisors, both groups were queried about their comprehension of these concepts. Bandura (1986) posits that imitating observed behaviour requires attention to the behaviour itself. Therefore, the understanding of EE, sustainable development, and ESD among teachers and subject advisors may prompt changes in their behaviour when integrating these concepts into their lessons.

The Environmental Protection Agency (2017) defines EE as a process enabling individuals to explore environmental issues, engage in problem-solving, and take action to improve the environment. In this study, teachers' understanding of EE aligns with this definition. For instance, Mrs. Musumelei emphasizes teaching about environmental aspects and interactions, while Mr. Sabawa, Mr. Nkhumeleni, and Mr. Makhokha highlight problem-solving and taking action to improve the environment, supporting the broader goals outlined by the EPA's definition of EE.

The study adopts Janse Van Renburg and Lotz's (1998) definition of EE as a continuous process equipping people with knowledge, attitudes, skills, and commitments to address socio-ecological issues. Teachers' understanding of EE aligns with this definition, emphasizing continuous equipping with knowledge, attitudes, and skills to address socio-ecological issues. The teachers' comprehensive approach to environmental education reflects the principles of EE (Mr. Nkhumeleni) and aligns with social learning theory, emphasizing cognitive processes and internalization (Bandura, 1986).

Subject advisors' understanding of EE aligns with the adopted definition, emphasizing studying all factors in the environment and their relationships with living things, as well as educating people about environmental conservation. This aligns with Bandura's theory of observational learning, where individuals acquire new knowledge and behaviours by observing the actions and consequences of others.

To grasp Education for Sustainable Development (ESD), the study considers the meaning of sustainable development, which involves meeting present needs without compromising the ability of future generations to meet their own needs (UNESCO, 2021; Department of Global Communications, August 2023). Teachers' perspectives align with these definitions, emphasizing sustaining nature during community development, developing the environment without causing harm, and controlling activities.

Some teachers, like Mr. Makhokha, express a lack of understanding of ESD, highlighting the importance of attention for effective observational learning (Bandura, 1986). Conversely, teachers such as Mrs. Musumeli and Mr. Sabawa provide definitions in line with UNESCO's definition of ESD as an education process for achieving human development inclusively, equitably, and respectfully. The views of Mr. Joseph, Mr. Shonisani, and Mrs. Rose align with the roles and objectives of ESD, emphasizing the development of knowledge, skills, understanding, values, and actions required for a sustainable world.

In conclusion, the study underscores the varying understanding of EE, sustainable development, and ESD among teachers and subject advisors. These findings highlight the importance of continuous education and collaboration to ensure a comprehensive understanding among educators, promoting effective integration of these concepts into the curriculum.

6.2.4 Teaching Strategies and Resources for Integrating EE/ESD into the Life Science Curriculum.

The subsequent section provides a detailed examination and presentation of data on teaching strategies and resources employed for the integration of Environmental Education (EE) and Education for Sustainable Development (ESD) into the Life Science curriculum. This section endeavours to address the question: What teaching strategies are currently employed by teachers to integrate EE/ESD into the Life Science curriculum? Two sub-themes have emerged, and they are elaborated upon below.

6.2.4.1 Teaching approaches and methods

Education for Sustainable Development (ESD)-aligned teaching approaches provide teachers with significant opportunities to deliver instruction in innovative, collaborative, and contextually relevant settings (Gonzalez, 2021). Roseberg (2009) further asserts that in choosing a teaching approach or method, teachers should assess both the quality of instruction and the attainment of the intended learning outcomes. The results of this study reveal that teachers are employing either theoretical teaching methods or practical ones. The following section delves into a discussion of both theoretical and practical teaching methods.

6.2.4.1.1 Theoretical vs Practical teaching

Examining the teaching strategies employed by teachers to integrate Environmental Education (EE) and Education for Sustainable Development (ESD) into their courses was crucial for gaining insights. Understanding the methodologies teachers use when teaching EE/ESD topics is instrumental in determining how to support teachers in incorporating EE/ESD into the Life Science curriculum. Smith (2013) emphasizes that teaching for ESD requires a transformative stance, encouraging critical thinking and contemplation of pertinent issues among learners. Similarly, the Pedagogical Content Knowledge (PCK) theory, which focuses on what teachers know about how to teach, underscores the importance of teaching methods and principles for effective learner understanding (Shulman, 1987).

The study findings indicate that teachers are knowledgeable about the strategies needed to integrate EE/ESD into their lessons. However, there exists a noticeable discrepancy between this knowledge and observed teaching practices, which often lean towards traditional and teacher-centred methods, such as lecture-based approaches. Despite Mr. Sabawa's occasional use of learner-centred approaches and emphasis on field trips, the predominant method observed in his class was teacher-centred. This preference for teacher-centred methods aligns with Nyanguza's (2021) argument that teachers tend to prioritize their own comfort and fulfilment when employing such approaches.

Observations during Mr. Nkhumeleni's class contradicted his claim of using a learner-centred approach, revealing a reliance on lecturing. This misalignment between assertion and practice suggests a possible gap in integrating Content Knowledge (CK) with Pedagogical Knowledge (PK), essential components of Shulman's PCK. Mr.

Makhokha, while supporting various teaching approaches in the interview, predominantly used traditional lecture methods during observation, indicating a similar misalignment between advocacy and practice.

Mrs. Mususumeli acknowledges using the lecture approach for teaching Life Science themes related to EE/ESD. Despite dissatisfaction with its constraints, her suggestion to integrate technology hints at a recognition of the need for a more comprehensive approach that aligns subject matter knowledge with effective teaching methods (PCK). However, Mrs. Mususumeli's class was not observed due to her ill health.

Observations reveal a preference for theoretical strategies over practical ones among teachers, neglecting recommended EE/ESD pedagogies. This preference for traditional and theoretical methods contrasts with the call for more practical approaches in the curriculum, as recommended by scholars like Shabalala (2023). Subject advisors' perspectives, while endorsing learner-centred approaches, also highlight challenges in the seamless incorporation of such methodologies due to potential pedagogical unpreparedness.

In conclusion, the study identifies a gap between teachers' theoretical knowledge of EE/ESD strategies and their practical implementation. Bridging this gap necessitates efforts to enhance teachers' pedagogical approaches through ongoing professional development and creating an environment conducive to effective EE/ESD integration. The findings underscore the importance of harmonizing theoretical knowledge with practical teaching methods for successful EE/ESD implementation in the Life Science curriculum. The recommendations from subject advisors further emphasize the need for pedagogical preparedness and the adoption of learner-centred approaches in diverse educational settings. Addressing these issues can contribute to a more effective integration of EE/ESD, aligning with Shulman's dynamic and evolving construct of Pedagogical Content Knowledge.

6.2.4.1.2 The use of learning and teaching resources

Okongo et al. (2015) state that teaching and learning resources encompass material resources, physical resources, and human resources, all of which contribute to the quality and quantity of educational materials. Material resources include textbooks, charts, maps, as well as audio-visual and electronic teaching tools such as radio, tape recorders, television, and video tape recorders (Okongo et al., 2015). Physical resources encompass faculty and staff office space, classroom space, shared learner space, and laboratories. Human resources refer to the individuals involved in the educational process, including teachers, staff, administrators, and support personnel.

The examination of the utilization of teaching and learning resources for integrating EE/ESD topics into the Life Science curriculum reveals diverse practices among the participating teachers. Insights from Mr. Makhokha, Mrs. Mususumeli, Mr. Sabawa, and Mr. Nkhumeleni shed light on the current state of resource utilization in their classrooms. Additionally, document analysis of ATP and CAPS documents, which outline the required teaching resources for Life Sciences, reveals variations across different years.

Mr. Sabawa and Mr. Makhokha, although emphasizing the use of projectors and outdoor environments, demonstrated a disparity between their claimed and observed resource utilization. Reliance on a textbook and green board during the observed lesson raises questions about the alignment between teachers' preferences and actual classroom practices. Their reliance on material resources neglects the broader range of teaching resources suggested by Okongo et al. (2015), and the use of outdated methods, as described by Nyanguza (2021), is evident in settings with limited resources.

Mrs. Mususumeli primarily utilizes textbooks and question papers but expresses a desire for diverse resources such as posters, videos, CDs, TV, and online content to enhance teaching and learning experiences. However, challenges like the lack of a school laptop and poor connectivity hinder access to online content, showcasing resource limitations. Access to more resources is identified as a need for Mrs. Mususumeli to effectively integrate EE/ESD into her lessons, aligning with Winch, Oancea, and Orchard's (2015) assertion that teachers can be motivated with adequate resources.

Mr. Nkhumeleni's emphasis on textbooks and study guides aligns with his observed teaching approach. However, his recognition of the value of additional resources like projectors, TV, and DVDs indicates a perceived inadequacy in current materials. This underscores the need for multimedia resources, especially for explaining complex topics. Similar findings were reported by Laiphrakpam et al. (2019) in India and Thailand, where a lack of resources hindered the integration of EE.

The identified resource challenges and diverse approaches among teachers highlight the need to address resource gaps in rural schools for effective integration of EE/ESD topics into the Life Science curriculum. While some teachers display creativity with available resources, the overall inadequacy poses a hurdle. This finding aligns with Loubser and Simalumba's (2016) identification of resources as obstacles that need improvement. Policymakers and school administrators should consider these findings when formulating strategies to support teachers in delivering quality environmental education in resource-constrained environments.

6.2.5 Challenges Faced by Teachers in Integrating EE/ESD into the Life Science Curriculum

This section delves into the discoveries regarding the difficulties encountered by teachers as they incorporate EE/ESD into their lessons. The examination of challenges is organized based on the sub-themes derived from this overarching theme. Two distinct sub-themes have surfaced within this theme, namely curriculum and pedagogical challenges, and challenges related to support. The exploration of these sub-themes will also be contextualized within Fullan's educational change theory. The subsequent sections elaborate on these sub-themes.

6.2.5.1 Curriculum and pedagogical challenges

The results of this investigation indicate that teachers encounter various challenges, encompassing curriculum and pedagogical difficulties, as they integrate EE/ESD into their lessons.

6.2.5.1.1 Time and curriculum challenges

According to Kimaro (2018), the challenge of insufficient time for EE integration was noted in Tanzania. Teachers participating in this study share the sentiment that incorporating EE could be perceived as time-consuming, given the existing struggles to cover syllabi adequately. Consequently, time allocation becomes a hurdle when integrating EE (Kimaro, 2018).

The study's results reveal that teachers identify time constraints as a significant challenge in the integration of EE/ESD into their lessons. Mr. Sabawa recognizes time as a current challenge, asserting that the allotted time is not conducive for effective learning of EE/ESD concepts. Mr. Nkhumeleni expresses that the allocated time for teaching EE/ESD subjects falls short, resulting in the limited coverage of topics. Mrs. Mususmeli's findings also highlight her inability to conduct outdoor lessons due to time limitations. These findings underscore that teachers face time-related constraints in integrating EE/ESD into their lessons, as the allocated time proves inadequate. This observation is reinforced by data from the analysed document (ATPS), indicating a reduction in the duration for teaching EE/ESD-related subjects from four weeks to three weeks.

These findings align with Sikhosana (2019), who revealed that teachers often omit EE from their lessons due to insufficient time. Similarly, Ashipala (2021) discovered that geography teachers in Namibia struggled to incorporate EE/ESD into their teaching due to limited time. The perception of time as a challenge resonates with Fullan's characteristics of educational change, particularly the need for innovation. If teachers perceive EE/ESD as lacking value or face obstacles like time constraints, it may impede the successful initiation and implementation of educational change.

Mrs. Musumeli further attributes the timing of the syllabus, noting that EE/ESD-related topics are taught last, when learners are fatigued. This aligns with Marques and Xavier's (2020) findings, indicating that teachers encountered difficulties in finding time to adhere to the curriculum content. Similar to Mrs. Mususumeli, Mr. Joseph, the subject advisor, also views the timing of the syllabus as a challenge. He notes that EE/ESD-related topics are taught towards the end of the year, with limited time due to grade 12 learners beginning their examinations. Teachers, who are supposed to teach these topics, end up invigilating for grade 12 exams, resulting in a lack of dedicated time for EE/ESD topics. Fullan's educational change theory emphasizes the need for clear goals and means in the change process. If teachers perceive timing as an obstacle, it indicates a potential lack of clarity in implementation (Fullan, 2007). Addressing the timing issue may require support from subject advisors and principals, as emphasized by Fullan regarding the influential role of these local factors in successful educational change.

6.2.5.1.2 Pedagogical challenges

The study's findings uncover challenges encountered by teachers, particularly in the realm of pedagogy. Booi (2018) identifies teachers' insufficient understanding of knowledge integration as a barrier to effectively imparting the principles of knowledge integration in Life Sciences. Mr. Shonisani attributes the gap between teaching EE/ESD subjects and real-life contexts to universities producing teachers with limited practical experience. He underscores that this lack of hands-on experience results in a disjointed teaching approach. Similarly, Mr. Joseph emphasizes teachers' inadequate knowledge and understanding of successful EE/ESD teaching, aligning with Tunce, Booner, Tuzun, and Oztekin's (2014) assertion that teachers' insufficient understanding of EE/ESD poses a significant obstacle. Nyunguza's (2021) study further emphasizes that a majority of Life Sciences teachers have limited or inadequate comprehension of knowledge integration, negatively impacting the information conveyed to learners. Mr. Joseph also highlights that teachers who lack a background in geography sometimes find it challenging to teach EE/ESD topics, aligning with Nyunguza's (2021) findings that teachers are often hesitant to learn other subject areas related to Life Sciences to alleviate the challenge of teaching what is available in the textbook.

Baxter and Jack (2008) advocate for the integrative teaching approach, emphasizing its ability to help teachers plan for the development of key skills and understanding, thereby enhancing learners' subject knowledge and accommodating their diverse prior knowledge and experiences. However, in this study, Mr. Sabawa notes that learners lack a fundamental understanding of EE/ESD. He observes that lower grades lack integrated education, resulting in learners having no prior knowledge of EE/ESD issues. This indicates that the absence of prior knowledge among learners poses a challenge for Mr. Sabawa in teaching EE/ESD-related topics. On a similar note, Mr. Nkhumeleni acknowledges guilt in teaching theory without practice and expresses caution against using real-life examples, fearing potential insults to learners. Mrs. Mususumeli shares a similar sentiment, avoiding real-life examples as she believes they might touch upon the lives of learners or parents. Both teachers' reluctance to use real-life examples contradicts Damoah and Adu (2019), who argue that environmental learning often involves practical activities and real-life examples. This discrepancy highlights the need for professional development for teachers on effectively incorporating real-life examples in their teaching of EE/ESD-related topics without causing discomfort to learners.

The challenges identified among teachers in this section, particularly the pedagogical-related obstacles, bear implications consistent with Michael Fullan's theory of educational change. The lack of comprehension and knowledge integration highlighted by Booi (2018) and echoed by Mr. Shonisani and Mr. Joseph aligns with Fullan's emphasis on the necessity of a thorough understanding of the innovation during the initiation phase (Fullan, 2007). The pedagogical challenges, characterized by insufficient practical experience and inadequate knowledge of EE/ESD content, pose obstacles to the successful implementation of educational change. Fullan's theory highlights the importance of clarity and understanding in the characteristics of educational change, suggesting that addressing these challenges requires targeted efforts in professional development and support.

Moreover, the problems raised, such as teachers resisting learning other subjects related to Life Sciences, align with Fullan's idea of institutionalization. This underscores the importance of truly understanding and committing to the change for successful and continuous addition of EE/ESD to the curriculum. Therefore, in accordance with Fullan's principles, addressing these pedagogical challenges necessitates focused initiatives to enhance teachers' knowledge, practical skills, and commitment to the integration of EE/ESD, ensuring a more effective and sustained educational change. The concerns expressed by Mr. Sabawa, Mr. Nkhumeleni, and Mrs. Mususumeli regarding teachers' challenges with using real-life examples and lacking integrative teaching methods highlight the necessity of training and supporting teachers comprehensively to resolve issues in both theory and practice. This approach will contribute to creating an ideal environment for the successful educational change in the integration of EE/ESD.

6.2.5.1.3 Exam-Oriented Teaching

Munasi and Madikizela-Madiya (2020) assert that a focus on exam-oriented teaching may lead to ignorance in specific sections of subject content and the teaching and learning process. Similarly, in this study, teachers and subject advisors identified exam-oriented teaching as one of the challenges faced by teachers in integrating EE/ESD into the Life Science curriculum. Mr. Nkhumeleni mentions that he primarily prioritizes helping learners achieve good results or pass exams rather than teaching them how to care for the environment. Likewise, Mrs. Mususumeli acknowledges that she teaches learners with a focus on passing exams, illustrating the challenge. This reveals that an exam-centric approach tends to overshadow the importance of teaching EE/ESD-related topics. However, Mrs. Mususumeli also recognizes that she teaches learners to apply their knowledge, emphasizing one of the objectives of teaching.

This finding suggests that the current emphasis on exams may not adequately promote the development of learners' ability to apply EE/ESD knowledge in their daily lives. Mrs. Rose emphasizes that EE/ESD is often taught in a theoretical manner, prioritizing exam preparation over fostering a deeper understanding and practical application of the concepts. Learners are encouraged to memorize information solely for exam purposes. Mr. Sabawa highlights a lack of concern for the environment, noting that both learners and the education department primarily focus on exam success, creating a need for EE/ESD knowledge and understanding. This underscores the challenge posed by an exam-oriented learning approach to the effective integration of EE/ESD into the Life Science curriculum.

The challenges identified align with Fullan's theory, particularly in the aspects of clarity in the characteristics of educational change and factors influencing institutionalization. The current exam-oriented approach may impede the development of a profound understanding and practical application of EE/ESD concepts, essential for the sustained success of educational change. Addressing these challenges requires a shift in institutional culture, emphasizing a more comprehensive approach that balances exam preparation with the broader objectives of environmental education, as recommended by Fullan's emphasis on clarity and ongoing commitment to change.

6.2.5.2 Support related Challenges

6.2.5.2.1 Lack of Financial Support for School Trips

Siddqui and Khan (2015) contend that insufficient support from an institution's administration can be detrimental to the teaching of EE/ESD, emphasizing the importance of support in terms of teaching and learning resources, PCK development, and financial assistance. However, this study reveals a lack of financial support specifically for school trips. In Australia, Gough's (2016) study found that field trips are a valuable method to utilize the outdoors in EE/ESD. In contrast, Mr. Makhokha cites a lack of financial support from the school, hindering his ability to organize school trips or excursions that could assist in elucidating EE/ESD-related concepts. Despite seeking assistance from the district office, he was referred back to the school, which was unable to finance such trips. Similarly, Mr. Nkhumeleni highlights a lack of financial support from the school for trips to the nearby National Park, emphasizing the perceived insignificance of school trips and the school's unwillingness to allocate funds for such endeavours, which could significantly benefit learners in understanding

EE/ESD-related concepts. This finding aligns with Aladejebi's (2020) observation of insufficient financial resources hindering EE and ESD integration in Nigeria.

In contrast to Mr. Makhokha and Mr. Nkhumeleni, Mr. Joseph attributes limited school travel to educational ignorance, asserting that schools prioritize financially lucrative sports trips over educational field trips and excursions. According to Mr. Joseph, more financial resources are allocated to sports and entertainment than to educational trips that focus on environmental issues and allow teachers to address EE/ESD concerns. Similarly, Mr. Shonisani notes that schools receive annual funds but often mismanage them, allocating a significant portion to academics and a smaller portion to other expenses. He suggests that schools are not utilizing this financial opportunity for teaching tours and excursions. This indicates a lack of financial education in schools, especially regarding environmental programs.

The challenges identified in financial support for school trips align with Fullan's theory, emphasizing the necessity of advocacy, support, and resources during the initiation and implementation phases. The mismanagement of funds and perceived misallocation to non-academic activities, as observed by Mr. Joseph and Mr. Shonisani, resonates with Fullan's notion of bureaucratic orientations affecting institutionalization. The findings underscore the importance of addressing bureaucratic challenges and advocating for financial support to ensure the successful integration and institutionalization of EE/ESD in the educational system.

6.2.5.2.2 Lack of Support from Subject Advisors and the DBE

The outcomes of this study reveal a consistent trend wherein subject advisors and the Department of Basic Education (DBE) consistently fall short in providing adequate support to teachers. The 2017 collective agreement of the Educational Labour Relations Council (ELRC) stipulates that subject advisors are expected to comprehend, monitor, and implement policies in schools, providing assistance and development to teachers (ELRC, 2017:9). However, Mr. Sabawa underscores insufficient support from subject advisors, emphasizing their predominant focus on assessment tasks rather than guiding teachers in teaching EE/ESD-related subjects. Despite Mrs. Rose's efforts in organizing workshops and training sessions, she indicates a primary focus on grade 12, potentially neglecting the needs of lower grades like 10 and 11. Additionally, Mr. Nkhumeleni echoes the sentiment that subject advisors offer minimal assistance, particularly for lower-grade levels, with their visits primarily centred on reviewing teacher files instead of providing teaching support. This finding aligns with a Namibian study by Haindoingo (2013), revealing subject advisors' lack of understanding regarding EE/ESD integration into the curriculum, leading to inadequate assistance and hindering teachers in integrating EE/ESD into their lessons.

Mrs. Musumeli, Mr. Joseph, and Mr. Makhokha accentuate the persistent issue of inadequate assistance for lower-grade levels. Mrs. Musumeli observes that subject advisors prioritize assistance to grade 12 learners while neglecting the needs of grade 11 learners. Mr. Joseph concurs, affirming that assistance for lower grades is limited, with subject advisors typically prioritizing grade 12 examinations. Mr. Makhokha, who has relied on independent research for teaching support, underscores the lack of assistance from subject advisors throughout his nine-year teaching tenure. This finding challenges the DBE and DHET (2011) description of subject advisors' role, which outlines their responsibility to offer guidance, training, and professional development for teachers through workshops and the establishment of Professional Learning Communities (PLCs). Mr. Makhokha asserts that he has never received any form of assistance from subject advisors.

In contrast, Mr. Shonisani stands out as an exception by actively endorsing teachers through workshops and individualized aid. This finding aligns with the role of subject advisors as defined by DBE (2020), emphasizing "facilitating curriculum implementation" and ensuring the provision of high-quality teaching and learning within schools. However, his perspective deviates from the predominant findings of the study, where teachers uniformly express a lack of assistance and guidance from subject advisors. This indicates a deficiency in the configuration of support systems for the integration of EE/ESD.

According to Fullan (2007), successful educational change necessitates comprehensive support structures, effective leadership, and a collective commitment to the change process. In the initiation phase of Fullan's model, Mr. Sabawa's dissatisfaction with subject advisors concentrating on assessment tasks rather than providing guidance on teaching EE/ESD-related subjects reflects a lack of clarity and understanding during the initiation of change (Fullan, 1991). Fullan emphasizes that initiation involves mobilizing resources around the idea of change, and Mr. Sabawa's experience highlights a deficiency in this crucial phase.

Mrs. Rose's primary focus on grade 12, as indicated by her workshops and training efforts, raises concerns about the effective implementation of educational change across all grade levels. Fullan's model underscores the importance of widespread implementation for successful change, and Mrs. Rose's focus on grade 12 may hinder the comprehensive integration of EE/ESD throughout the curriculum (Fullan, 2007).

The experiences of Mr. Nkhumeleni, Mrs. Mususumeli, Mr. Joseph, and Mr. Makhokha further highlight challenges during the implementation and institutionalization phases. Fullan argues that institutionalization involves making the change a permanent part of the system, and the lack of assistance reported by these teachers suggests a gap in institutionalizing EE/ESD within the curriculum (Fullan, 2007). Mr. Shonisani's proactive support for teachers, while commendable, is presented as an anomaly, indicating a deficiency in the overall configuration of support systems. Fullan emphasizes the need for collective responsibility and capacity building, and Mr. Shonisani's role stands out against the backdrop of widespread dissatisfaction among teachers (Fullan, 2007).

6.2.5.2.3 Lack of Support from School and colleagues

The findings in this section indicate that teachers have varied perspectives on the support they receive from their schools and colleagues. Mr. Nkhumeleni expresses a lack of support from both his colleagues and school management. He perceives a lack of trust from the school management, suggesting that they are reluctant to assist him with organizing trips or field activities, assuming he might engage in inappropriate behavior with the learners. Additionally, Mr. Nkhumeleni notes that his colleagues expect him to independently handle challenges associated with being responsible for the subject. This discovery resonates with Mwendwa's (2017) findings in Tanzania, highlighting a common challenge of insufficient support from colleagues and school administration, compounded by cultural myths and beliefs.

In contrast, Mrs. Mususmeli reports receiving support from her colleagues at school, particularly from an agricultural science teacher and a geography teacher who used to assist her in teaching EE/ESD-related topics. However, she expresses disappointment as one of the supporting teachers has retired. On the other hand, Mrs. Mususmeli indicates a lack of support from school management. Mr. Sabawa echoes a similar sentiment, stating that his colleagues merely observe his activities without providing active support. While he believes that the school management is willing to support him, the lack of available materials poses a challenge. This contrasts with Damoah and Adu's (2019) assertion that schools generally do not provide effective support to teachers in integrating EE.

The study presents a nuanced portrayal of teacher support within schools, showcasing both challenges and positive instances concerning EE/ESD integration. Mr. Nkhumeleni's struggles align with Fullan's initiation phase, underscoring the necessity for collaborative efforts during the early stages of educational change. This mirrors broader challenges outlined by Mwendwa (2017) in the implementation of EE/ESD. Conversely, Mrs. Mususmeli's positive interactions with certain colleagues suggest a collaborative culture, but the overall lack of support from school management, acknowledged by both Mrs. Mususmeli and Mr. Sabawa, indicates resource constraints impeding effective assistance during the implementation phase. These findings underscore the importance of addressing these challenges throughout Fullan's theory, from initiation to implementation, to foster sustained and comprehensive support for teachers navigating the complexities of EE/ESD integration.

6.2.5 Professional Development Mechanisms for Integrating EE/ESD into the Life Science Curriculum

This section delves into the theme that surfaced regarding mechanisms for professional development in integrating EE/ESD into the Life Science curriculum. The exploration of this theme is guided by the Social Learning Theory formulated by Albert Bandura (1986). Two sub-themes have emerged within this theme, focusing on the need for professional development and the available opportunities for professional growth.

6.2.5.1 Need for professional development

Antlely (2020) defined professional development (PD) as continuous education and career training once a person has entered the profession in order to assist them in developing new abilities. Teacher professional development is, however, defined as in-service teacher education that can enhance teachers' subject-matter knowledge and consequently their teaching practice (Mandikonza, 2020). This study identifies a need for professional development for Life Science teachers to integrate EE/ESD into their lessons. Teachers were questioned about their participation in professional development programs focused on integrating EE/ESD into their lessons.

The findings reveal that Mr. Sabawa has attended workshops for Life Sciences but is dissatisfied, stating that the workshops conducive to his needs lack EE/ESD-related topics. This emphasizes the necessity for professional development specifically tailored to EE/ESD. This aligns with Villegas-Reimers' (2003) critique of traditional PD models, emphasizing the shortcomings of one-time approaches and the need for more tailored and sustained initiatives. Mr. Sabawa emphasizes the dynamic nature of teachers' learning journeys, consistent with Antley's (2020) definition of PD as an ongoing and evolving process. He also stresses the need for training on incorporating technology into teaching EE/ESD topics, indicating a broader need for diverse professional development.

In contrast, Mr. Nkhumeleni states he has never attended any workshop on Life Science grade 11 topics. This raises concerns about his professional development and its potential impact on transforming his teaching skills, in line with Avalos' (2011) emphasis on ongoing TPD. Despite this, Mr. Nkhumeleni expresses a desire for workshops and training in EE/ESD-related topics, highlighting an opportunity for him to learn new strategies and approaches.

Mrs. Mususmeli notes a need for professional development, having attended workshops for grade 12 but not for grade 11. This contrasts with Guskey's (2002) perspective, suggesting that PD should enhance teachers' knowledge, abilities, and attitudes. It raises concerns about limiting Mrs. Mususmeli's knowledge and skills development for lower grades. Similarly, Mr. Makhokha reveals a lack of EE/ESD-related workshop attendance, emphasizing the need for professional development tailored to grades 10 and 11. This aligns with Guskey's (2002) argument against universally applicable PD models, emphasizing context-specific initiatives.

These findings underscore the importance of ongoing professional development for teachers, particularly tailored to the nuances of EE/ESD integration. Interpreted through Bandura's Social Learning Theory, these experiences highlight the significance of observational learning, modelling, and the impact of motivation on teachers' professional development journey. The study advocates for context-specific initiatives to address the diverse challenges faced by teachers at different stages of their careers.

6.2.5.2 Professional Development Opportunities

The subject advisors in this study were queried about the professional development opportunities provided by the Department of Basic Education (DBE) for Life Sciences teachers aiming to enhance their teaching of EE/ESD-related topics in the Life Science curriculum. The findings underscore a perceived necessity for professional development opportunities in EE/ESD. Mr. Joseph acknowledges the existence of professional development opportunities but notes their predominant focus on grade 12 teachers, leaving a noticeable gap for teachers in grades 10 and 11. His emphasis on the need for more accessible opportunities for lower grades, citing potential facilitator expertise issues and insufficient time for participation, underscores a demand for inclusive and well-tailored professional development initiatives for teachers in lower grades. This aligns with the call for a more equitable distribution of training resources (Guskey, 2002).

In contrast, Mr. Shonisani introduces a region-specific approach to workshops, incorporating the local context of medicinal plants. While recognizing the availability of workshops, he highlights a prevalent reluctance among teachers due to perceived inconvenience. This insight emphasizes the need for a shift in attitudes towards workshops, framing them as opportunities for professional growth rather than disruptions. This aligns with the literature, which underscores the importance of teachers perceiving professional development as valuable and relevant (Darling-Hammond et al., 2017).

Mrs. Rose, however, appears unaware of specific professional development opportunities provided by the DBE for Life Science teachers in the context of EE/ESD topics. She suggests that opportunities for professional development might exist through higher learning institutions, indicating a potential gap in structured departmental programs. Mrs. Rose also points out the limitation in the current approach, where subject advisors teach learners in the presence of teachers, advocating for a more sustainable solution—equipping teachers with the skills to teach specific topics independently. This aligns with the literature's emphasis on the need for sustained and self-directed professional development strategies (Harwell, 2002).

These findings underscore a compelling call for comprehensive and targeted professional development initiatives, ensuring inclusivity across grade levels and regions. The varied perspectives presented highlight the existing challenges and underscore the importance of re-evaluating and enhancing current professional development strategies to effectively support teachers in integrating EE/ESD into their curricula. This aligns with the literature's call for context-specific and sustainable professional development models (Darling-Hammond et al., 2017; Guskey, 2002).

The discussion among subject advisors in this study, framed through Bandura's Social Learning Theory, unveils insightful connections between teachers' experiences and the stages of observational learning. Mr. Joseph's acknowledgment of existing professional development opportunities, yet emphasis on the gap for grades 10 and 11, aligns with Bandura's concept of attention, indicating the need for teachers to notice and pay attention to the specific behaviours they aim to replicate. Mr. Shonisani's region-specific approach corresponds to Bandura's attention and retention stages, highlighting the importance of paying attention and remembering the information provided in workshops. Mrs. Rose's unawareness of opportunities and her advocacy for a sustainable solution resonate with Bandura (1986)'s attention, retention, and reproduction stages, emphasizing the necessity for teachers to be informed, remember, and independently replicate observed behaviours.

6.2.6 Guidelines for effective integration of EE/ESD into Life Science curriculum

This section delves into a discourse regarding the perceptions of teachers and subject advisors regarding the guidelines essential for supporting Life Science teachers' Pedagogical Content Knowledge (PCK) as they integrate EE/ESD into their lessons. Three distinct themes surfaced from the interviews with the teachers and subject advisors, and the subsequent discussion will be structured around these three sub-themes (refer to table 5.2 for details).

6.2.6.1 Utilization and awareness of existing guidelines

The insights gleaned from subject advisors and teachers point towards a perceived existence of guidelines for the integration of EE/ESD into the Life Science curriculum. Mrs. Rose affirms the presence of these guidelines within policy documents, Annual Teaching Plans (ATPs), the Curriculum and Assessment Policy Statement (CAPS), and exam guidelines. However, a crucial observation reveals that teachers often overlook these guidelines, exposing a notable gap in their application during lessons.

Mrs. Rose underscores the importance of teachers acquiring a deeper understanding of how to seamlessly integrate EE/ESD into their instructional practices.

In contrast to the perceived availability of guidelines, scholars such as Bopape, Mudau, and Msezane (2021), Hebe (2019), and Damoah (2019) contend that explicit guidelines to assist teachers in making informed decisions about integrating EE/ESD into their subjects are lacking. The study's examination indicates that ATPs lack specific guidelines for EE/ESD integration, presenting only thematic topics and concepts without clear teaching methodologies. Similarly, while the CAPS document provides thematic content and instructional resources, it lacks explicit guidelines for teaching EE/ESD-related topics, leaving teachers to exercise their discretion in implementation. Bandura's theory (1986) suggests that individuals learn through observation, and in this context, teachers observing others and replicating behaviours play a crucial role. Damoah (2019) notes a general conceptualization of integrating EE/ESD across subjects but underscores a lack of instructions or guidelines to operationalize. The discussion further nuances Damoah (2019)'s perspective by positing that the South African educational landscape has issued a directive for the integration of EE/ESD across all subjects from grade R-12.

Concerning the integration of Environmental Education and Sustainable Development (EE/ESD) guidelines, Mr. Shonisani's recommendation for teachers to utilize existing guidelines from policy documents contradicts the study's empirical findings, exposing deficiencies in ATPs, CAPS documents, and textbooks. Mr. Joseph's suggestion to align EE/ESD with subjects like Geography resonates with Bandura's social learning theory, emphasizing the importance of curricular coherence (Bandura, 1986). This alignment underscores the need for an integrated and harmonious educational approach. Moreover, Mr. Makhokha's acknowledgment of guidelines in CAPS documents, despite their absence in ATPs, contributes to the overall tension between perceived availability and actual utilization (Damoah, 2019). The findings underscore the necessity for clearer, more explicit guidelines, aligning with Bandura's emphasis on observational learning and the need for comprehensive instructional frameworks.

6.2.6.2 Professional Development and Teacher Support

The research findings underscore a shared conviction among teachers regarding the significance of continuous professional development and workshops specifically designed for the integration of EE/ESD into the Life Science curriculum. Mrs. Rose accentuates the necessity for workshops, expressing the need for teachers to undergo training on effectively teaching EE/ESD topics. This aligns with Antley's (2020) definition of professional development, which characterizes it as continuous education and career training once an individual enters a profession.

Similarly, Mr. Shonisani echoes this sentiment, emphasizing the pivotal role of support and training for teachers. He underscores the idea that teachers must be adequately supported to facilitate learners' success. Mr. Shonisani suggests that without sufficient support, learners may encounter challenges. This finding aligns with Siddqui and Khan (2015), who argued that inadequate support or motivation from school administration could be detrimental to the teaching of EE/ESD. Mr. Shonisani's emphasis on the essential role of support and training resonates with Bandura's motivation component, underscoring the importance of reinforcement for learning (Nabavi, 2012). His concern that the lack of support for teachers may lead to challenges for learners aligns with Bandura's notion that motivation impacts behaviour, particularly in the context of the effective teaching of EE/ESD.

Mrs. Mususumeli contributes to the discussion by stressing the importance of incorporating guidelines on how to teach EE/ESD directly into curriculum documents. However, the analysis of policy documents in this study revealed a lack of such guidelines. This finding from Mrs. Mususmeli and the analysis aligns with Hebe's (2019) observation that CAPS documents lack guidelines on how to teach. She further proposes organizing regular workshops to discuss teaching methods for each topic and to support teachers in integrating EE/ESD principles into their lessons. This aligns with Bandura's retention and reproduction components, emphasizing the need for teachers to remember and replicate effective teaching strategies (Navabi, 2012). The mention of guidelines in curriculum documents suggests a need for structured support consistently referred to by teachers.

Mr. Sabawa concurs with the general perspective, emphasizing the need for guidelines and workshops to assist teachers in effectively teaching EE/ESD content. This finding aligns with Bopape, Mudau, and Msezane (2021:167), who identified the "absence of integration guidelines from the CAPS document as one of the obstacles impeding the integration process". Mr. Sabawa also mentions that teachers need comprehensive tools and knowledge to successfully include EE/ESD in their teaching. This finding from Mr. Sabawa also aligns with Bandura (1986)'s motivation aspect, suggesting that providing resources and materials can positively impact the motivation of teachers to effectively teach EE/ESD content.

6.2.6.3 Comprehensive Guidelines and Resource Allocation

The research findings unveil divergent perspectives among teachers regarding the necessity of guidelines and workshops in teaching environmental education. Mr. Sabawa strongly endorses the idea of having specialized guidelines and workshops to enhance teachers' skills in this domain. He emphasizes that these guidelines should permit teachers to contextualize case studies from textbooks, encouraging them to adopt and create scenarios relevant to their local environment. This aligns with Hebe's (2021) recommendation that the South African public school curriculum policy framework should include explicit guidelines on integrating environmental education into teaching. Mr. Sabawa believes that guidelines are crucial in supporting teachers to effectively teach EE/ESD, aligning with Bandura's social learning theory, which underscores observational learning, retention, and reproduction (Navabi, 2012). His strong support for guidelines and workshops reflects attention to innovative strategies, corresponding with Bandura's concept of attention in the learning process.

In contrast, Mr. Makhokha proposes guidelines involving the allocation of funds for environmental studies in schools and the organization of schools into groups for field teaching. This practical perspective focuses on tangible aspects, such as funding and collaborative teaching approaches, to support the integration of environmental education. Mr. Makhokha's suggestion reflects Bandura's motivation component (Bandura, 1986), emphasizing the practical aspects and resources required for effective integration. This finding concurs with a study conducted by Aladejebi (2020), which also affirms that the lack of financial support and resources hinders learning important aspects of EE/ESD that require visiting sites to acquire first-hand knowledge. Mrs. Mususumeli proposes organizing workshops regularly, either each term or annually, to review content coverage and discuss teaching strategies for each topic. Her suggestion aims to provide ongoing support for teachers, emphasizing a consistent and structured approach to enhance their understanding and teaching skills. Bandura (1986)'s theory also emphasizes that there should be retention and reproduction of observed characteristics, which in this study can be achieved through regular workshops and ongoing support. Mrs. Mususumeli's findings share sentiments with Damoah and Adu (2019), who mentioned a lack of support for teachers on how to integrate EE/ESD, ranging from school level to the district office and other teachers.

On the other hand, Mr. Nkhumeleni expresses concerns about guidelines potentially restricting teachers' autonomy in choosing teaching strategies. He suggests that if guidelines are implemented, they should include both theoretical and practical components, similar to the approach in Life Orientation. Mr. Nkhumeleni advocates for a balanced approach that respects teachers' individuality while providing a structured framework for effective teaching. His concerns about guidelines restricting teachers' autonomy and his advocacy for a balanced approach align with Bandura's concept of motivation, emphasizing the need for a supportive framework without stifling individuality (Navabi, 2012).

These findings showcase diverse opinions on the role and form of guidelines and workshops for teaching environmental education. Some teachers emphasize the importance of targeted workshops and guidelines, while others focus on practical aspects and ongoing support. The varied viewpoints highlight the complexity of addressing teachers' needs in integrating environmental education into their teaching practices.

6.3 Chapter synthesis

The primary research question of this study focused on understanding how professional development supports Life Science teachers' pedagogical content knowledge to enhance the integration of EE/ESD into the Life Science curriculum. This overarching inquiry was further broken down into five sub-questions:

- What is the current coverage of EE/ESD in the Life Science curriculum?
- Which teaching strategies are currently employed by teachers to integrate EE/ESD into the Life Science curriculum?
- What challenges do teachers encounter when integrating EE/ESD into the Life Science curriculum?
- What professional development initiatives are in place to support teachers in integrating EE/ESD into the Life Science curriculum?
- What key elements should be included as guidelines for Life Science teachers to effectively integrate EE/ESD into their lessons?

Consequently, the synthesis of this chapter is organized in alignment with these five sub-questions.

6.3.1 What is the current coverage of EE/ESD in the Life Science curriculum?

This investigation concludes that the scrutinized documents adequately encompass EE/ESD in the Life Science curriculum. Consequently, teachers who regularly refer to these documents should be capable of identifying EE/ESD-related content to support the integration of EE/ESD into their lessons. Nevertheless, the teachers interviewed expressed the view that the coverage of EE/ESD in the analysed documents is insufficient. They highlighted omissions of certain concepts, such as climate change, flooding, and drought, which they believe should be treated as independent topics. In contrast, subject advisors held the opinion that the coverage of EE/ESD-related topics in the Life Science curriculum was sufficient.

6.3.2 Which teaching strategies are currently employed by teachers to integrate EE/ESD into the Life Science curriculum?

This investigation revealed that while teachers asserted their use of lecture methods to teach EE/ESD-related topics, the observed lessons demonstrated that most teachers predominantly employed lecture methods, resulting in a teacher-centred approach. Moreover, subject advisors were found to advocate for learner-centred methods and interactive teaching strategies for EE/ESD-related topics. Notably, these recommendations were exclusively provided to grade 12 teachers, despite the absence of coverage for EE/ESD topics in grade 12. This section on EE/ESD teaching strategies underscores a significant incongruity between teachers' stated methods and actual practices, highlighting a prevalent reliance on theoretical, teacher-centred approaches. Additionally, subject advisors recognized the challenges teachers encounter in implementing learner-centred methods.

6.3.3 What challenges do teachers encounter when integrating EE/ESD into the Life Science curriculum?

This investigation brings to light several challenges faced by teachers in integrating EE/ESD into the Life Science curriculum. These challenges encompass both curriculum-related and pedagogical issues. A consensus emerges among teachers and subject advisors that the limited time allocated to Life Science lessons hinders the effective incorporation of EE/ESD. Furthermore, the prevalent focus on exam-oriented teaching acts as a barrier to seamlessly integrating EE/ESD into Life Science classes, with teachers admitting to prioritizing exam preparation. Subject advisors acknowledge their concentration on grade 12 exams at the expense of lower grades, exacerbating the challenge.

Support-related issues also come to the forefront in this study. Teachers reveal that financial assistance for school trips is inadequate, as they prioritize conceptual teaching in the classroom over practical experiences outside. Additionally, a lack of support from subject advisors becomes evident, as teachers report insufficient guidance in integrating EE/ESD into their lessons. When subject advisors visit schools, their attention tends to focus on reviewing learners' books for completion rather than providing substantial teaching support. Subject advisors themselves concede to offering minimal assistance to teachers in lower grades, citing their limited numbers and busy schedules primarily centred on grade 12 rather than grades 10 and 11.

6.3.4 What professional development initiatives are in place to support teachers in integrating EE/ESD into the Life Science curriculum?

This investigation highlights a lack of professional development initiatives aimed at assisting teachers in integrating EE/ESD into their lessons. The study reveals that teachers, in general, have not participated in any workshops or training sessions specifically focused on EE/ESD teaching or topics. Even those who have attended workshops admitted that these were primarily oriented toward grade 12. Interestingly, the analysis of documents, particularly the Annual Teaching Plans (ATP), indicates that EE/ESD-related topics are limited in grade 12.

Contrary to teachers' limited exposure to EE/ESD professional development, the study finds that teachers express a willingness to attend such workshops and training sessions to enhance their skills and knowledge. Despite teachers' concerns, subject advisors participating in this study emphasize the necessity for teachers to undergo professional development in the realm of EE/ESD. However, they acknowledge that the current professional development opportunities predominantly cater to grade 12 teachers and often lack a specific focus on EE/ESD-related topics. Consequently, subject advisors advocate for extending EE/ESD-related professional development opportunities to teachers in lower grades, recognizing the importance of addressing their unique needs in this context.

6.3.5 What key elements should be included as guidelines for Life Science teachers to effectively integrate EE/ESD into their lessons?

This research underscores that well-crafted guidelines for integrating EE/ESD into Life Science lessons necessitate explicit and detailed instructions, aiming to bridge the gap between perceived availability and actual utilization. The identified need for continuous professional development and workshops underscores the crucial role of ongoing support and training for teachers, addressing the observed deficiencies in current guidelines. The allocation of resources, including funding for environmental studies and practical considerations such as field teaching, emerges as a pivotal element for the successful integration of EE/ESD. The diversity of opinions among teachers emphasizes the intricate nature of meeting their needs, highlighting the imperative of adopting a balanced approach that respects teachers' autonomy while providing a structured framework for effective teaching. This study contends that comprehensive guidelines should offer clarity, continuous development opportunities, resource support, and a balanced approach to ensure the successful integration of EE/ESD into the Life Science curriculum.

6.4 Chapter Summary

This chapter engages in a comprehensive discussion of the findings presented in Chapter 5. It covers the extent of EE/ESD in the analysed documents and explores the understanding of EE, sustainable development, and ESD among Life Science teachers and subject advisors. The teaching strategies employed by Life Science teachers to integrate EE/ESD into their lessons are examined, along with the challenges faced in this integration process. Additionally, the chapter delves into the available professional development strategies designed to support Life Science teachers in integrating EE into their lessons. The discussion reveals that while the analysed documents include EE/ESD-related topics, they lack clear guidelines on effective integration. Teachers demonstrate an understanding of EE/ESD concepts and integration strategies, yet encounter challenges in their practical application to address diverse needs. The study identifies challenges in integrating EE/ESD into lessons and notes a lack of professional development opportunities for teachers.

Furthermore, a perceived availability of guidelines for integrating EE/ESD in policy documents, ATPs, and CAPS is acknowledged, but teachers tend to neglect and underutilize them. Scholars highlight the absence of explicit guidelines, particularly in

ATPs, creating a gap in effective integration. Participants emphasize the importance of ongoing professional development, workshops, and explicit guidelines to enhance teacher support and facilitate the effective integration of EE/ESD into the curriculum. The tension between perceived availability and actual utilization underscores the need for clearer guidelines, aligning with the directive for EE/ESD integration across subjects. Diverse opinions emerge regarding the necessity for guidelines and workshops, emphasizing practical aspects and ongoing support, showcasing the complexity of addressing teachers' needs in integrating environmental education.

CHAPTER 7: SUMMARY OF THE STUDY, CONCLUSIONS AND RECOMMENDATIONS

7.1 Introduction

Chapter 6 of this study delves into the findings regarding the support for Life Science teachers' Pedagogical Content Knowledge (PCK) through professional development, specifically aimed at enhancing the integration of EE/ESD into the Life Science curriculum. The discussion within this chapter involves a comprehensive cross-reference with the content presented in chapters 2, 3, and 5.

Initiating with summaries of the preceding chapters, which include the literature review, empirical study, and conclusions pertaining to the integration of ESD into the Life Science curriculum, this chapter proceeds to outline the conclusions drawn from the study's findings. Moreover, it suggests recommendations for future investigations and improvements in the integration of EE/ESD into the Life Science curriculum. Additionally, the researcher provides specific recommendations derived from the empirical study, directed at the Department of Basic Education (DBE), subject advisors, teachers, and school management bodies, outlining strategies on how to effectively support teachers in integrating EE/ESD through professional development.

7.2 Summary of the study

This section serves as a synopsis of the preceding chapters in the study, which comprises a total of seven chapters, outlined as follows. The primary objective of this study was to explore how professional development supports Life Science teachers' Pedagogical Content Knowledge (PCK) to facilitate the integration of EE/ESD into the Life Science curriculum.

Chapter 1 initiates the study, providing an orientation by delving into the background, rationale, and context of the research. This chapter establishes the research questions, sub-questions, aims, and objectives, while also conducting a concise review of the literature, presenting theoretical frameworks, and outlining the research methodology. Additionally, it defines the study's limitations and key concepts, paving the way for the subsequent chapters.

Chapter 2 functions as the literature review, delving into Environmental Education (EE) and Education for Sustainable Development (ESD). It meticulously examines the historical development of these concepts, scrutinizing their impact on the South African curriculum. The chapter explores challenges faced by teachers, emphasizing the need for knowledge, skills, and technology. Furthermore, it investigates Pedagogical Content Knowledge (PCK) for Life Science teachers and the importance of teacher professional development, both domestically and internationally. The literature review also explores diverse teaching strategies employed by teachers for the integration of EE/ESD in schools, recognizing the crucial role of subject advisors. The chapter concludes by identifying the research gap framed by the reviewed literature.

Chapter 3 engages in an in-depth exploration of the theoretical frameworks that underpin the research, namely Pedagogical Content Knowledge (PCK) by Shulman, the Theory of Educational Change by Michael Fullan, and Social Learning Theory by Albert Bandura. The selection of these theories aims to enhance the understanding of integrating EE/ESD into the Life Sciences curriculum, elucidating the skills, knowledge, and teaching strategies essential for teachers. Fullan's Theory of Educational Change is employed to unveil the factors influencing the implementation of this educational change, while Bandura's Social Learning Theory addresses the identified support deficiencies faced by Life Science teachers.

In **Chapter 4**, the research methodology is expounded upon, embracing a qualitative interpretivist research design and employing an exploratory case study approach. The chapter details the purposive sampling of participants and sites, emphasizing document analysis, interviews, and participant observation as data collection methods. Thematic content analysis is employed for data analysis, structured to illuminate the support mechanisms for enhancing PCK among Life Science teachers through professional development initiatives.

Chapter 5 unfolds the study's findings, presenting participants' biographies and systematically coding data derived from document analysis, interviews, and participant observation. Six themes emerge, offering nuanced insights into the integration of EE/ESD into the Life Science curriculum. This chapter contributes to a deeper understanding of the complexities inherent in Life Science education by employing a rigorous combination of qualitative research methods.

Chapter 6 engages in a comprehensive discussion of the findings presented in Chapter 5. This analytical discourse connects the research findings with the literature review and theoretical frameworks, offering a nuanced interpretation of the intricate interplay between themes and existing knowledge. The discussion informs insightful recommendations, emphasizing a critical gap in the support provided to teachers for the effective integration of EE/ESD into their curriculum.

Chapter 7 concludes the study, summarizing the research and providing conclusions and recommendations based on the findings. It suggests further studies and introduces a proposed model of Integrated Professional Development, incorporating guidelines for teachers and subject advisors to enhance the integration of EE/ESD into the Life Science curriculum.

7.3 Conclusion from the study

The conclusions drawn from this study can be summarized as follows.

7.3.1 Coverage of EE/ESD in the Life Science curriculum

This study concludes that while the analysed documents do encompass EE/ESD-related topics, the inclusion of comprehensive guidelines is imperative to augment the coverage. Recognizing the significance of Pedagogical Content Knowledge (PCK), the absence of thorough guidelines for integrating EE/ESD-related topics underscores the necessity for continuous training to enhance the efficacy of EE/ESD education in Grade 11.

The study further concludes that the perceptions of teachers and subject advisors regarding the coverage of EE/ESD-related topics in the CAPS document, ATPs, and textbooks reveal a nuanced landscape navigable by PCK. Subject advisors exhibit awareness and contentment with the existing material, yet a discernible gap exists in the coverage of EE/ESD, as underscored by teachers advocating for the elevation of climate change from a concept to a dedicated topic. The insights from Grade 11 Life Sciences teachers and subject advisors accentuate the complexity of incorporating EE/ESD-related topics into the curriculum, emphasizing the need for a robust PCK framework. While overall positive evaluations are noted, reservations are expressed, particularly regarding the insufficient integration of key topics like climate change. This underscores the imperative for ongoing scrutiny, potential adjustments, and additions to enhance the depth and breadth of EE/ESD coverage.

7.3.2 Teachers' and subject advisors’ Understanding of EE/ESD

This study concludes that teachers involved in this investigation demonstrated a commendable level of Pedagogical Content Knowledge (PCK) regarding their understanding of Environmental Education (EE) and Education for Sustainable Development (ESD). This is evident as, when prompted to define EE, sustainable development, and ESD, teachers were generally able to provide definitions for these concepts, indicating a certain level of comprehension. However, it's worth noting that one teacher encountered challenges in defining sustainable development and ESD, indicating a potential gap in teachers' PCK, particularly concerning these aspects of EE/ESD.

As a result, the study further concludes that there is a need for teachers to possess a comprehensive understanding of all concepts related to EE/ESD. The examination of teachers' and subject advisors' perspectives on EE/ESD in this study reveals a commendable consensus among teachers, showcasing their ability to integrate PCK into their understanding of the multifaceted nature of EE. Teachers align with the Environmental Protection Agency's (EPA) definition, emphasizing diverse aspects of environmental understanding. Subject advisors exhibit a parallel understanding, emphasizing the continuous process of equipping individuals with knowledge related to socio-ecological issues.

According to UNESCO and the Department of Global Communications, teaching about sustainable development aligns with teachers' priorities of addressing immediate needs without compromising the future. Nevertheless, this study concludes that discrepancies, such as a teacher's lack of understanding of ESD, highlight the need for focused attention in observational learning and targeted professional development to enhance PCK. The varied perspectives offered by teachers underscore the ongoing need for comprehensive education to ensure a unified understanding of ESD concepts.

In summary, this study further concludes that a deep understanding and acceptance of EE/ESD ideas are essential for implementing them successfully in schools, making a significant difference in achieving broader sustainability and environmental responsibility goals.

7.3.3 Teaching Strategies and Resources for Integrating EE/ESD into the Life Science Curriculum

This study concludes that teachers demonstrate a knowledge gap between their professed understanding of EE/ESD strategies and the teaching practices observed, aligning with the principles of social learning theory. While teachers express awareness of recommended methodologies for teaching EE/ESD topics, the prevalent use of traditional, teacher-centred methods suggests a reluctance to implement learner-centred approaches. Social learning theory posits that individuals learn through observation and imitation, and the observed disparities between teachers' theoretical knowledge and practical application highlight the necessity for targeted efforts to enhance pedagogical approaches within a social learning context. Ongoing professional development, framed within the social learning framework, is essential, coupled with the creation of an enabling environment that encourages effective EE/ESD integration through shared experiences and collaborative learning.

Furthermore, this study concludes that variations in practices among participating teachers concerning teaching resources unveil challenges in resource utilization for EE/ESD integration. While some teachers recognize the potential benefits of diverse materials, resource limitations, such as the lack of a school laptop and poor connectivity, pose challenges. The emphasis on additional resources underscores the perceived inadequacy of current materials, emphasizing the need for multimedia resources. The overall inadequacy of teaching and learning resources in rural schools hampers the effective integration of EE/ESD topics into the Life Science curriculum. Policymakers and school administrators should consider these findings to develop strategies that address resource gaps and support teachers in delivering quality environmental education in resource-constrained environments. This study emphasizes the imperative to enhance both theoretical knowledge and practical implementation for effective EE/ESD teaching, providing valuable insights for policymakers and teachers working towards sustainable educational practices.

7.3.4 Challenges Faced by Teachers in Integrating EE/ESD into the Life Science Curriculum

This study concludes that challenges in integrating EE/ESD into the Life Science curriculum are in line with Michael Fullan's educational change theory, encompassing curriculum-related, pedagogical, and support-related obstacles. The struggles teachers face with time allocation and curriculum constraints reflect the external and internal pressures described by Fullan, emphasizing the need for comprehensive strategies to address these challenges for the effective integration of EE/ESD.

Furthermore, the study concludes that pedagogical challenges, exemplified by teachers' insufficient understanding of knowledge integration and the theory-practice gap, resonate with Fullan's emphasis on building educators' capacity for change. The reluctance to incorporate real-life examples and the absence of prior knowledge among students underscore the necessity for targeted professional development initiatives, aligning with Fullan's focus on enhancing both the knowledge and skills of teachers for successful educational change.

Moreover, the study concludes that exam-oriented teaching practices, identified as a hindrance to deep understanding, correspond with Fullan's idea of the need for a shared vision promoting holistic learning experiences. The findings underscore the significance of transforming educational practices to align with a broader understanding and practical application of EE/ESD concepts, reflecting Fullan's emphasis on fundamental shifts in pedagogical approaches.

Additionally, the study concludes that support-related challenges, such as a lack of financial support for school trips and insufficient assistance from various stakeholders, align with Fullan's notion of the importance of support structures. Policymakers and education stakeholders should consider Fullan's framework when devising comprehensive support structures and strategies to facilitate the effective and sustained integration of EE/ESD into the Life Science curriculum.

7.3.5 Professional Development Mechanisms for Integrating EE/ESD into the Life Science Curriculum

This study concludes that a significant demand exists for professional development mechanisms tailored specifically to the integration of EE/ESD into the Life Science curriculum. Teachers express a clear need for professional development opportunities focused on EE/ESD topics. Traditional professional development models may not adequately address the specific needs of teachers aiming to integrate EE/ESD into their lessons, emphasizing the dynamic and evolving nature of teachers' learning journeys, in alignment with Bandura's Social Learning Theory.

The lack of professional development opportunities, especially for teachers in grades 10 and 11, presents a significant challenge. Varied experiences of teachers underscore the need for ongoing, accessible, and grade-specific professional development. The absence of EE/ESD-related workshops for lower grades may impede teachers' ability to effectively integrate these concepts, emphasizing the critical need for targeted initiatives that consider the specific challenges faced by teachers at different stages of their careers.

Additionally, there is a pronounced demand for inclusive and well-tailored professional development opportunities. Teachers highlight the existing gap in professional development initiatives, particularly for teachers in grades 10 and 11. The study suggests that a more equitable distribution of training resources is imperative to address this gap and effectively support teachers. Varied perspectives of teachers, including emphasis on region-specific approaches and advocacy for sustainable solutions, underscore the necessity for a comprehensive and flexible professional development framework.

This study emphasizes the importance of ongoing, targeted, and inclusive professional development mechanisms to empower Life Science teachers with the knowledge and skills necessary for integrating EE/ESD into their curriculum effectively. Teachers' perspectives point towards the need for a paradigm shift in professional development strategies to facilitate observational learning, retention, and reproduction of effective teaching practices, aligning with the principles of Bandura's Social Learning Theory.

7.3.6 Guidelines for effective integration of EE/ESD into Life Science curriculum

This study concludes that, although guidelines for integrating EE/ESD into the Life Science curriculum are perceived to be available, subject advisors and teachers encounter a significant gap in their utilization during instruction. Despite the existence of these guidelines in policy documents, Annual Teaching Plans (ATPs), Curriculum and Assessment Policy Statement (CAPS), and exam guidelines, teachers often overlook them. This finding underscores the necessity for clearer and more explicit guidelines to effectively support teachers in integrating EE/ESD into their lessons. The absence of comprehensive guidelines within existing educational materials, as highlighted by scholars, further emphasizes the challenges teachers encounter in incorporating EE/ESD into their subjects.

Furthermore, this study concludes that teachers share a common understanding of the importance of ongoing professional development and workshops for integrating EE/ESD into the Life Science curriculum. Teachers express the need for continuous support and training to enhance their ability to teach EE/ESD topics effectively. The study reveals a connection between teacher support and learner success, emphasizing the significance of attention, retention, reproduction, and motivation, as outlined in Bandura's Social Learning Theory.

Additionally, this study concludes that there are diverse opinions among teachers about the need for guidelines and workshops in teaching environmental education. Some teachers strongly support the idea of explicit guidelines and workshops to enhance their skills, while others propose practical aspects, such as allocating funds for environmental studies and organizing collaborative field teaching. The varied viewpoints highlight the complexity of addressing teachers' needs and underscore the importance of considering different perspectives in developing comprehensive guidelines for teaching environmental education.

This study highlights the imperative need for clearer and more explicit guidelines to support teachers in integrating EE/ESD into the Life Science curriculum effectively. The findings also emphasize the crucial role of ongoing professional development, workshops, and a balanced approach to guidelines in addressing the challenges faced by teachers. A comprehensive and flexible framework is deemed essential, as this study concludes, to cater to the diverse needs of teachers and facilitate the successful integration of EE/ESD principles into their teaching practices.

7.4 The study’s recommendations

This study delved into the integration of EE/ESD into the Life Science curriculum in selected schools in Limpopo province, South Africa. Based on the findings from interviews, document analysis, and participant observations, the following recommendations are proposed for teachers, subject advisors, school management, and the Department of Education:

Continuous Training Programs for Teachers:

- Identify and address gaps in the coverage of EE/ESD-related topics in the curriculum.
- Advocate for continuous training programs to equip teachers with the knowledge and skills required for effective integration.
- Push for the extension of guidelines to provide a roadmap for curriculum planning and implementation.

Collaboration between Subject Advisors and Policymakers:

- Subject advisors should collaborate with policymakers to enhance the curriculum.
- Address the need for comprehensive guidelines and ensure the inclusion of essential EE/ESD concepts.
- Play a pivotal role in providing ongoing support to teachers, especially in navigating challenges related to climate change.

Unified Understanding among Teachers:

- Implement observational learning strategies to ensure a unified understanding among teachers.
- Encourage teachers to participate in targeted professional development opportunities to address the multifaceted nature of EE and overcome identified challenges.

Enhanced Understanding for Subject Advisors:

- Conduct workshops for subject advisors focusing on EE/ESD concepts to equip them with the knowledge needed for meaningful support.
- Advocate for ongoing, accessible, and grade-specific professional development for teachers based on their varied experiences.

Bridging the Gap between Knowledge and Implementation:

- Adopt learner-centred approaches and interactive teaching methods to bridge the gap between theoretical knowledge and practical implementation.
- Encourage teachers facing resource limitations to advocate for increased access to multimedia resources.

Collaboration on Resource Gaps:

- Subject advisors should collaborate with policymakers to address resource gaps and ensure the provision of multimedia resources.
- Provide support and resources for teachers to implement learner-centred approaches, addressing knowledge gaps and promoting effective teaching strategies.

Addressing Exam-Oriented Challenges:

- Encourage teachers to collaborate with colleagues to share best practices, fostering a supportive teaching environment.
- Advocate for financial support for school trips and increased assistance from subject advisors, schools, and the Department of Basic Education to overcome support-related challenges.

Development of Comprehensive Support Structures:

- Subject advisors can collaborate with policymakers to develop comprehensive support structures to address time and curriculum challenges.
- Provide ongoing support to teachers, overcoming challenges related to time constraints and curriculum issues.

Grade-Specific Professional Development Opportunities:

- Teachers are recommended to advocate for ongoing, accessible, and grade-specific professional development opportunities.
- Actively participate in workshops designed based on the Integrated Professional Development model, aligning with the dynamic nature of their learning journeys.

Subject-Specific Professional Development Initiatives:

- Subject advisors are recommended to develop grade-specific professional development initiatives to cater to the diverse needs of teachers at different career stages.
- Advocate for an equitable distribution of training resources, ensuring fair access for all teachers.

Effective Utilization of Existing Guidelines:

- Teachers are recommended to actively utilize existing guidelines during instruction to ensure effective integration.
- Advocate for clearer and more explicit guidelines, responding to the study's finding that, despite perceived availability, guidelines are not effectively used.

Collaborative Enhancement of Guidelines:

- Subject advisors can collaborate with policymakers to enhance existing guidelines, providing clearer and more explicit guidance that caters to the diverse needs of teachers.
- Consider different perspectives among teachers when developing guidelines, ensuring a balanced approach that addresses various teaching styles and preferences.

7.5 Recommendations for further study

Based on the findings of this study, the following recommendations for further research are proposed:

Expansion of Educational Contexts:

- While this study focused on the FET band within the domain of Life Sciences, future research endeavours should extend into diverse educational contexts, including the GET band.
- Recommendations include exploring various circuits, districts, provinces, and even different countries worldwide to provide a broader understanding and refinement of the Integrated Professional Development model.

Incorporating Rural Perspectives:

- Given that the current study was conducted in rural schools of Limpopo province, South Africa, it is crucial to expand the scope of studies to incorporate various rural perspectives.
- Future research should consider and integrate rural viewpoints into investigations conducted in different geographical locations, enhancing the overall comprehension of EE/ESD in diverse settings.

Specific Areas for Further Studies:

- Research can be conducted to examine the impact of observational learning on professional development, evaluating its contribution to cultivating a cohesive comprehension of EE/ESD among teachers.
- Another area of focus could be the creation and execution of extensive support systems, exploring collaborative strategies employed by subject

advisors to overcome time and curriculum obstacles in the integration of EE/ESD.

- Additionally, an examination of teachers' support and practical use of multimedia resources in education can be undertaken, aiming to enhance teaching practices for improved EE/ESD integration.
- These recommended further studies aim to contribute valuable insights to the existing body of knowledge, addressing specific aspects related to educational contexts, rural perspectives, and targeted areas within the integration of EE/ESD.

7.6 The contributions of the findings to the body of knowledge

The findings of this study contribute significantly to the body of knowledge in the field of EE/ESD in the following ways:

Illumination of EE/ESD Coverage:

- The study sheds light on the current coverage of EE/ESD-related topics within the Life Science curriculum. Recognizing existing content and identifying gaps emphasizes the intricate landscape teachers navigate. The absence of comprehensive integration guidelines underscores the need for an explicit roadmap, deepening discussions on the practical challenges of curriculum planning and implementation in environmental education.

Understanding of EE/ESD Concepts:

- The study explores the understanding of EE/ESD concepts among teachers and subject advisors. While consensus exists, identified discrepancies underscore the necessity for observational learning strategies and comprehensive professional development. This finding contributes to the ongoing discourse on the dynamic nature of teachers' learning journeys, emphasizing the need for tailored initiatives to bridge knowledge gaps.

Teaching Strategies and Resources:

- Examination of teaching strategies and resources reveals a knowledge gap between theoretical understanding and practical application. Emphasizing the need for pedagogical enhancements and resource access provides valuable insights for teachers and policymakers. The findings draw attention to challenges in resource utilization, contributing to discussions on implementing learner-centred approaches and the role of resources in effective EE/ESD integration.

Challenges in Integration:

- Challenges faced by teachers in integrating EE/ESD into the Life Science curriculum constitute a significant contribution. Identification of intricate obstacles enriches understanding of multifaceted barriers hindering effective environmental education. Practical recommendations add actionable insights for policymakers, school administrators, and teachers striving for sustainable educational practices.

Professional Development Mechanisms:

- Professional development mechanisms emerge as a critical theme, recognizing a significant need for targeted initiatives. The findings highlight the demand for ongoing, accessible, and grade-specific professional development, contributing to scholarly discussions on the evolving nature of teachers' professional development needs.

Guidelines for Integration:

- The study addresses guidelines for the effective integration of EE/ESD into the Life Science curriculum. Recognition of a perceived availability of guidelines but underutilization underscores the practical challenges teachers encounter. Recommendations for clearer and more explicit guidelines contribute to the ongoing dialogue on essential components needed to support effective integration.

Introduction of Integrated Professional Development (IPD) Model:

- Based on document analysis, interviews, and participant observation, the study proposes a novel Integrated Professional Development (IPD) model. Illustrated in Figure 7.1, this versatile model can be applied across various contexts, strategically addressing gaps in coverage, enhancing teachers' understanding, and bridging the theoretical-practical gap. Its application extends to teacher training programs, professional development workshops, curriculum enhancement initiatives, support structures, advocacy efforts, resource allocation, guideline development, community engagement, and continuous evaluation. The introduction of this model adds a transformative dimension to educational practices.

7.6.1 Proposed Integrated Professional Development Model for Effective EE/ESD Teaching

Figure 7.1 below depicts the suggested integrated professional model designed for the effective teaching of EE/ESD.

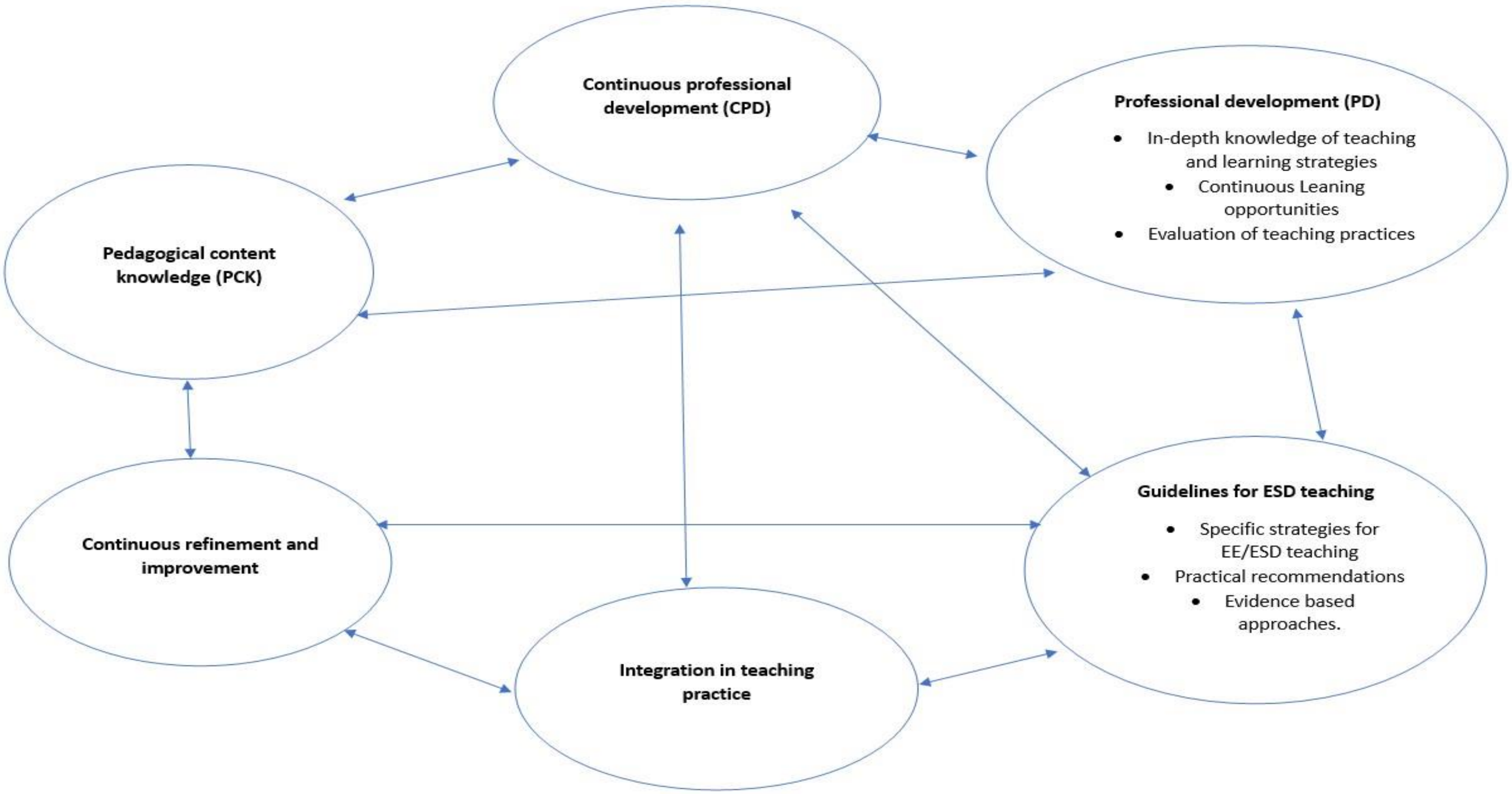


Figure 7.1 Integrated Professional Development (IPD) model (source: Author)

The proposed model functions as a unified system designed to enhance the incorporation of Education for Sustainable Development (ESD) into the Life Sciences curriculum, promoting continuous growth among teachers. At the core of this model is Continuous Professional Development (CPD), a foundational element that not only shapes but is also shaped by various crucial components. The arrows within the model symbolize the reciprocal relationships among its components, detailed below.

Continuous Professional Development (CPD):

Continuous Professional Development (CPD) serves as the cornerstone of this model, offering continuous learning opportunities for teachers to adeptly integrate EE/ESD into their lessons. Support through ongoing professional development is vital, refining teaching skills and guiding the formulation of specific guidelines for teaching EE/ESD. CPD maintains a reciprocal relationship with all elements of this model. It influences the broader spectrum of Professional Development (PD) by providing continuous learning opportunities, while the overall direction and content of PD programs can shape specific CPD initiatives tailored to teachers' continual advancement.

CPD also shares a reciprocal connection with guidelines for EE/ESD teaching. CPD programs expose teachers to these guidelines, offering insights and practical applications. Concurrently, feedback and experiences from teachers adhering to the guidelines contribute to refining and updating CPD content. CPD initiatives guide and inform teachers about effective strategies for Integration in Teaching Practices. The content and insights derived from CPD initiatives provide guidance on best practices for incorporating EE/ESD principles into the curriculum.

The relationship between CPD and Continuous Refinement is reciprocal. CPD programs expose teachers to new ideas and approaches, and the feedback and experiences gained through continuous refinement contribute to the ongoing improvement of CPD content. CPD programs aim to enhance teachers' overall pedagogical skills, including their Pedagogical Content Knowledge (PCK). CPD initiatives expose teachers to new insights, teaching strategies, and content-related developments, contributing to the continuous development and enrichment of their PCK.

Professional Development (PD):

Professional Development (PD) initiatives play a guiding role in shaping specific guidelines for EE/ESD teaching. The insights and content derived from broader PD endeavours influence the principles and recommendations articulated in the guidelines for effective EE/ESD teaching. PD and Pedagogical Content Knowledge (PCK) maintain a reciprocal relationship, with PD endeavours seeking to enhance teachers' PCK, while evolving PCK insights from practical experiences contribute to continuous improvements in professional development strategies. The ongoing process of Continuous Refinement, driven by teachers' experiences and challenges, exerts influence on the content and structure of broader PD initiatives. As teachers refine their practices, the insights from these refinements contribute to the evolution of PD.

Guidelines for EE/ESD Teaching:

This study has developed three guidelines to support teachers in integrating EE/ESD into their lessons, tailored for both teachers and subject advisors:

Specific strategies for EE/ESD teaching:

Guideline for Teachers: Integrate specific teaching strategies such as project-based learning, field trips, case studies, and interactive activities tailored to EE/ESD. Engage students in real-world environmental issues to enhance their understanding and application of EE/ESD concepts in the Life Science curriculum.

Guideline for Subject Advisors: Provide teachers with specific strategies for integrating EE/ESD into the Life Science curriculum. Offer guidance on incorporating project-based learning, recommending relevant field trips, and suggesting interactive teaching methods. Support teachers in adapting these strategies to suit the unique needs of their students.

Practical recommendations:

Guideline for Teachers: Implement practical recommendations to effectively integrate EE/ESD into Life Science lessons, including creating thematic units, integrating sustainability practices into laboratory work, and collaborating with local environmental organizations. These actionable suggestions aim to address practical challenges in curriculum integration.

Guideline for Subject Advisors: Assist teachers with practical recommendations to facilitate the seamless integration of EE/ESD into their lessons. Encourage the creation of thematic units, advise on incorporating sustainability practices into laboratory work, and collaborate on community-based projects. Address practical challenges through targeted support and guidance.

Evidence-based approaches:

Guideline for Teachers: Adopt evidence-based approaches by incorporating current research findings, utilizing data to illustrate environmental trends, and integrating evidence-driven content into lessons. Base teaching practices on reliable evidence to ensure the accuracy and relevance of EE/ESD concepts in the Life Science curriculum.

Guideline for Subject Advisors: Advocate for evidence-based approaches in EE/ESD integration. Support teachers in incorporating the latest research findings, utilizing relevant data to illustrate environmental concepts, and aligning lessons with evidence-driven content. Provide resources and training to enhance subject advisors' ability to guide teachers effectively.

The Guidelines for EE/ESD Teaching serve as a framework guiding the integration of principles into daily teaching practices. Teachers follow these guidelines to incorporate EE/ESD concepts into their lessons, and experiences from practical implementation inform the ongoing refinement of the guidelines. The relationship between Integration in Teaching Practices and Guidelines is reciprocal: teachers follow the guidelines to integrate EE/ESD principles into their teaching, and practical experiences and challenges encountered during integration contribute to refining and updating the guidelines.

Integration in Teaching Practice:

The continuous refinement of teaching practices is influenced by the real-world application of guidelines in Integration in Teaching Practices. As teachers apply EE/ESD principles, they identify areas for improvement, leading to an ongoing cycle of refinement and enhancement. When teachers apply PCK in the integration of EE/ESD, practical experience further enhances their PCK.

Continuous Refinement and Improvement:

Continuous Refinement and Integration in Teaching Practices share a reciprocal relationship. The practical experiences of teachers during integration contribute to continuous refinement, while evolving guidelines from continuous refinement inform teachers' ongoing integration efforts. The continuous refinement of teaching practices influences the development and enhancement of Pedagogical Content Knowledge (PCK). As teachers continually refine their approaches, they deepen their understanding of effective strategies for integrating EE/ESD concepts into the Life Sciences curriculum.

Pedagogical Content Knowledge (PCK):

Pedagogical Content Knowledge (PCK) and Guidelines for EE/ESD Teaching maintain a reciprocal relationship. PCK development is guided by the principles outlined in the guidelines, and the practical application of PCK in teaching informs updates and refinements to the guidelines. PCK and PD share a reciprocal relationship, with Professional Development efforts aiming to enhance teachers' PCK, while the evolving PCK insights from practical experience contribute to ongoing improvements in Professional Development strategies.

7.7 Limitations of the study

This study aimed to investigate the extent to which EE/ESD is integrated into the Life Science curriculum within selected schools. However, a limitation of the study is its focus solely on Life Sciences, thereby not providing insights into the integration across all school subjects, despite the overarching goal of incorporating EE/ESD throughout the curriculum. The examination was restricted to secondary schools, as Life Sciences are typically taught at this level. To manage constraints related to time, resources, and funding, the researcher opted to assess three secondary schools within the Vhembe East District. Consequently, the study specifically centred on Grade 11 Life Sciences, leading to the inclusion of Grade 11 Life Sciences teachers from the four selected schools.

7.8 Chapter summary

This chapter provides a comprehensive overview, concluding remarks, and recommendations derived from the inquiry into the integration of EE/ESD into the Life Science curriculum in Limpopo province, South Africa. It encompasses a synthesis of the literature, the empirical discoveries of the study, and an exposition of the suggested framework designed to enhance guidelines for embedding EE/ESD into the Life Science curriculum. The chapter further delves into the study's recommendations and suggests potential avenues for future research related to the integration of EE/ESD into the Life Science curriculum. Moreover, it acknowledges and deliberates on the study's limitations, considering their implications for the general applicability of the findings.

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APPENDICES

Appendix A: Proof of registration

UNISA university of south africa

2315

MUNASI K R MR
P O BOX 3120
MUTALE
0956

STUDENT NUMBER : 57162522

ENQUIRIES TEL : 0861670411
FAX : (012)429-4150
eMAIL : mandd@unisa.ac.za

2023-03-14

Dear Student

I hereby confirm that you have been registered for the current academic year as follows:

Proposed Qualification: PHD (EDUCATION) (90019)

CODE	PAPER	S	NAME OF STUDY UNIT	NQF crdts	LANG.	PROVISIONAL EXAM.DATE	EXAMINATION CENTRE(PLACE)
Study units registered without formal exams:							
TFENE01			PhD - Education (Environmental Education)	**	E		

You are referred to the "MyRegistration" brochure regarding fees that are forfeited on cancellation of any study units.

\# Your attention is drawn to University rules and regulations (www.unisa.ac.za/register).
Please note the new requirements for reregistration and the number of credits per year which state that students registered for the first time from 2013, must complete 36 NQF credits in the first year of study, and thereafter must complete 48 NQF credits per year.
Students registered for the MBA, MBL and DBL degrees must visit the SBL's ESOnLine for study material and other important information.
Readmission rules for Honours: Note that in terms of the Unisa Admission Policy academic activity must be demonstrated to the satisfaction of the University during each year of study. If you fail to meet this requirement in the first year of study, you will be admitted to another year of study. After a second year of not demonstrating academic activity to the satisfaction of the University, you will not be re-admitted, except with the express approval of the Executive Dean of the College in which you are registered. Note too, that this study programme must be completed within three years. Non-compliance will result in your academic exclusion, and you will therefore not be allowed to re-register for a qualification at the same level on the National Qualifications Framework in the same College for a period of five years after such exclusion, after which you will have to re-apply for admission to any such qualification.
Readmission rules for M&D: Note that in terms of the Unisa Admission Policy, a candidate must complete a Master's qualification within three years. Under exceptional circumstances and on recommendation of the Executive Dean, a candidate may be allowed an extra (fourth) year to complete the qualification. For a Doctoral degree, a candidate must complete the study programme within six years. Under exceptional circumstances, and on recommendation by the Executive Dean, a candidate may be allowed an extra (seventh) year to complete the qualification.

\# Your study material is available on www.my.unisa.ac.za, as no printed matter will be made available for the research proposal module.
Study material can be accessed on the Unisa website. You must register on MyUnisa (https://my.unisa.ac.za/portal/) for this purpose. You are also reminded to activate your myLife email address since all electronic correspondence will be sent to this email address.

CREDIT BALANCE ON STUDY ACCOUNT: 75.00-

Yours faithfully,

Prof M S Mothata
Registrar

0108 O 00 0

UNIVERSITEIT VAN SUID-AFRIKA
PRETORIA
UNIVERSITY OF SOUTH AFRICA

University of South Africa
Preller Street, Muckleneuk Ridge, City of Tshwane
PO Box 392 UNISA 0003 South Africa
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www.unisa.ac.za

Appendix B: Ethical clearance certificate

UNISA university of south africa

UNISA COLLEGE OF EDUCATION ETHICS REVIEW COMMITTEE

Date: 2023/06/07

Ref: **2023/06/07/57162522/11/AM**
Name: Mr KR Munasi
Student No.:57162522

Dear Mr KR Munasi

Decision: Ethics Approval from 2023/06/07 to 2028/06/07

Researcher(s): Name: Mr KR Munasi
E-mail address: 57162522@mylife.unisa.ac.za
Telephone: 0790354981

Supervisor(s): Name: Prof SB Msezane
E-mail address: msezasb@unisa.ac.za
Telephone: 0124812888

Title of research:

Integration of Education for Sustainable Development into the Life Sciences curriculum: teachers' pedagogical content knowledge and professional development

Qualification: PhD Environmental Education

Thank you for the application for research ethics clearance by the UNISA College of Education Ethics Review Committee for the above mentioned research. Ethics approval is granted for the period 2023/06/07 to 2028/06/07.

*The **low risk** application was reviewed by the Ethics Review Committee on 2023/06/07 in compliance with the UNISA Policy on Research Ethics and the Standard Operating Procedure on Research Ethics Risk Assessment.*

The proposed research may now commence with the provisions that:

1. The researcher will ensure that the research project adheres to the relevant guidelines set out in the Unisa Covid-19 position statement on research ethics attached.
2. The researcher(s) will ensure that the research project adheres to the values and principles expressed in the UNISA Policy on Research Ethics.

University of South Africa
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3. Any adverse circumstance arising in the undertaking of the research project that is relevant to the ethicality of the study should be communicated in writing to the UNISA College of Education Ethics Review Committee.
4. The researcher(s) will conduct the study according to the methods and procedures set out in the approved application.
5. Any changes that can affect the study-related risks for the research participants, particularly in terms of assurances made with regards to the protection of participants' privacy and the confidentiality of the data, should be reported to the Committee in writing.
6. The researcher will ensure that the research project adheres to any applicable national legislation, professional codes of conduct, institutional guidelines and scientific standards relevant to the specific field of study. Adherence to the following South African legislation is important, if applicable: Protection of Personal Information Act, no 4 of 2013; Children's act no 38 of 2005 and the National Health Act, no 61 of 2003.
7. Only de-identified research data may be used for secondary research purposes in future on condition that the research objectives are similar to those of the original research. Secondary use of identifiable human research data requires additional ethics clearance.
8. No field work activities may continue after the expiry date **2028/06/07**. Submission of a completed research ethics progress report will constitute an application for renewal of Ethics Research Committee approval.

Note:

The reference number **2023/06/07/57162522/11/AM** *should be clearly indicated on all forms of communication with the intended research participants, as well as with the Committee.*

Kind regards,

Prof AT Motlhabane
CHAIRPERSON: CEDU RERC
motlhat@unisa.ac.za

Prof Mpine Makoe
ACTING EXECUTIVE DEAN
qakisme@unisa.ac.za

Appendix C: Letter to Request Permission from Limpopo Department of Education (Vhembe east District)

UNISA university of south africa

Enq. KR Munasi
Cell: 079 035 4981
E-Mail: emunask@unisa.ac.za

P.O. Box 3120
Mutale
0956

08 June 2023

The District Director
Department of Basic Education
Vhembe East District
Private Bag X 2250
Sibasa, 0970

Dear sir/madam

Request for permission to conduct research

I, Munasi Khathutshelo Ronald am doing research under supervision of _Prof SB Msezane, a Professor in the Department of Adult Community and Continuing Education towards a D Ed (Environmental Education) at the University of South Africa. We are asking permission to conduct research at your district. The study is entitled *Integration of Education for Sustainable Development into the Life Sciences curriculum: teachers' pedagogical content knowledge and professional development*. This research will be conducted in three secondary schools from three different circuits at Vhembe East district. One school from Vhumbedzi Circuit, one school from Mutshindudi Circuit, and one school from Sambandou Circuit.

It is envisaged that this research will be beneficial to teachers and subject advisors because the findings of this study will contribute towards developing guidelines on how to use teacher professional development initiatives, to facilitate the integration of EE/ESD in the teaching of Life Sciences

Yours sincerely

______________________ (signature of researcher)

_____Munasi KR____(079 035 4981)______ (name of the above signatory)

____Researcher______________________ (signatory's position)

Appendix D: Limpopo Department of Education (Vhembe east District) Approval Letter

LIMPOPO
PROVINCIAL GOVERNMENT
REPUBLIC OF SOUTH AFRICA

DEPARTMENT OF
EDUCATION

CONFIDENTIAL

Ref: 2/2/2 Enq: Makola MC Tel No: 015 290 9448 E-mail:MakolaMC@edu.limpopo.gov.za

Munasi KR
P.O BOX 3120
0956

RE: REQUEST FOR PERMISSION TO CONDUCT RESEARCH

1. The above bears reference.

2. The Department wishes to inform you that your request to conduct research has been approved. Topic of the research proposal: **"INTEGRATION OF EDUCATION FOR SUSTAINABLE DEVEMENT INTO THE LIFE SCIENCES CURRICULUM: TEACHERS' PEDAGOGICAL CONTENT KNOWLEDGE AND PROFESSIONAL DEVELOPMENT."**

3. The following conditions should be considered:

3.1 The research should not have any financial implications for Limpopo Department of Education.

3.2 Arrangements should be made with the Circuit Office and the School concerned.

3.3 The conduct of research should not in anyhow disrupt the academic programs at the schools.

3.4 The research should not be conducted during the time of Examinations especially the fourth term.

3.5 During the study, applicable research ethics should be adhered to; in particular the principle of voluntary participation (the people involved should be respected).

3.6 Upon completion of research study, the researcher shall share the final product of the research with the Department.

REQUEST FOR PERMISSION TO CONDUCT RESEARCH : MUNASI KR Page 1

Cnr 113 Biccard & 24 Excelsior Street, POLOKWANE, 0700, Private Bag X 9489, Polokwane, 0700
Tel:015 290 7600/ 7702 Fax 086 218 0560

The heartland of Southern Africa-development is about people

4 Furthermore, you are expected to produce this letter at Schools/ Offices where you intend conducting your research as an evidence that you are permitted to conduct the research.

5 The department appreciates the contribution that you wish to make and wishes you success in your investigation.

Best wishes.

05/07/2023

Mashaba KM
DDG: CORPORATE SERVICES

Date

Cnr 113 Biccard & 24 Excelsior Street, POLOKWANE, 0700, Private Bag X 9489, Polokwane, 0700
Tel:015 290 7600/ 7702 Fax 086 218 0560

The heartland of Southern Africa-development is about people

Appendix E: Letters to Request Permission from the three circuit managers

Enq. KR Munasi
Cell: 079 035 4981
E-mail: emunask@unisa.ac.za

P.O. Box 3120
Mutale
0956
13 June 2023

The Circuit Manager
Department of Basic Education
Mutshindudi Circuit
Private Bag X 4000
Sibasa, 0970

Dear sir/madam

Request for permission to conduct research

I, Munasi Khathutshelo Ronald am doing research under supervision of Prof SB Msezane, a Professor in the Department of Adult Community and Continuing Education towards a D Ed (Environmental Education) at the University of South Africa. We are asking permission to conduct research at your circuit. The study is entitled *Integration of Education for Sustainable Development into the Life Sciences curriculum: teachers' pedagogical content knowledge and professional development.* This research will be conducted in one secondary school from Mutshindudi circuit.

It is envisaged that this research will be beneficial to teachers and subject advisors because the findings of this study will contribute towards developing guidelines on how to use teacher professional development initiatives, to facilitate the integration of EE/ESD in the teaching of Life Sciences

Yours sincerely

________________________ (signature of researcher)

Munasi KR (079 035 4981) (name of the above signatory)

Researcher (signatory's position)

Enq: KR Munasi

Cell no: 079 035 4981

E-mail: emunask@unisa.ac.za

P.O. Box 3120

Mutale

0956

13 June 2023

The Circuit Manager

Department of Basic Education

Sambandou Circuit

Private Bag X 1195

Mutale, 0956

Dear circuit manager

Request for permission to conduct research

I, Munasi Khathutshelo Ronald am doing research under supervision of Prof SB Msezane, a Professor in the Department of Adult Community and Continuing Education towards a D Ed (Environmental Education) at the University of South Africa. We are asking permission to conduct research at your circuit. The study is entitled *Integration of Education for Sustainable Development into the Life Sciences curriculum: teachers' pedagogical content knowledge and professional development*. This research will be conducted in one secondary school from Sambandou circuit.

It is envisaged that this research will be beneficial to teachers and subject advisors because the findings of this study will contribute towards developing guidelines on how to use teacher professional development initiatives, to facilitate the integration of EE/ESD in the teaching of Life Sciences

Yours sincerely

________________________ (signature of researcher)

Munasi KR (079 035 4981) (name of the above signatory)

Researcher (signatory's position)

UNISA

Eng: KR Munasi
Cell no: 079 035 4981
E-mail: emunask@unisa.ac.za

P.O. Box 3120
Mutale
0956
13 June 2023

The Circuit Manager
Department of Basic Education
Vhumbedzi Circuit
Private Bag X 1120
Tshaulu, 0987

Dear sir/madam

Request for permission to conduct research

I, Munasi Khathutshelo Ronald am doing research under supervision of Prof SB Msezane, a Professor in the Department of Adult Community and Continuing Education towards a D Ed (Environmental Education) at the University of South Africa. We are asking permission to conduct research at your circuit. The study is entitled *Integration of Education for Sustainable Development into the Life Sciences curriculum: teachers' pedagogical content knowledge and professional development.* This research will be conducted in one secondary school from Vhumbedzi circuit.

It is envisaged that this research will be beneficial to teachers and subject advisors because the findings of this study will contribute towards developing guidelines on how to use teacher professional development initiatives, to facilitate the integration of EE/ESD in the teaching of Life Sciences

Yours sincerely

_______________ (signature of researcher)

Munasi KR (079 035 4981) (name of the above signatory)

Researcher (signatory's position)

Appendix F: Approval Letters from The Three circuit managers

LIMPOPO
PROVINCIAL GOVERNMENT
REPUBLIC OF SOUTH AFRICA

DEPARTMENT OF
EDUCATION
VHEMBE DISTRICT

MUTSHINDUDI CIRCUIT
P/BAG X 4000
TSHIDIMBINI
0972
19 JULY 2023

Ref:2/2/2
Enq: MUVHALI M.R
Cell: 082-424-9173

TO: MUNASI K.R

REQUEST FOR PERMISSION TO CONDUCT RESEARCH FOR SUSTAINABLE DEVELOPMENT INTO THE LIFE SCIENCES CURRICULUM TEACHERS PEDAGOGICAL KNOWLEDGE AND PROFESSIONAL DEVELOPMENT: MUNASI K.R

1. The above matter refers.
2. Approval has been granted to do research to the chosen school.
3. The conduct of research should not disrupt the academic programs at the school.

R. Muvhali ....
CIRCUIT MANAGER: MUTSHINDUDI

19/07/2023
DATE

DEPARTMENT OF EDUCATION
MUTSHUNDUDI CIRCUIT
VHEMBE EAST DISTRICT
DEPARTMENTAL DATE STAMP
19 JUL 2023
PRIVATE BAG X 4000 TSHIDIMBINI 0972
LIMPOPO PROVINCE

LIMPOPO
PROVINCIAL GOVERNMENT
REPUBLIC OF SOUTH AFRICA

Department of Education

Ref: 2/2/2 Enq: Maliavusa M.L Tel: 082 953 3684 Date 21 June 2023

CONFIDENTIAL

DEPARTMENT OF EDUCATION
VHUMBEDZI CIRCUIT OFFICE
2023 -06- 21
PRIVATE BAG X 1120
TSHAULU 0987
LIMPOPO PROVINCE

TO: Munasi K.R
P.O BOX 3120
Mutale
0956

REQUEST FOR PERMISSION TO CONDUCT RESEARCH: MUNASI K.R

1. The above matter refers.
2. Vhumbedzi Circuit office hereby acknowledges receipt of your letter dated 13 June 2023 in which your requested permission to conduct research at our schools.
3. Permission is hereby granted on conditions.

3.1 That teaching and learning is not disrupted.
3.2 That arrangements should be made with affected schools.

4. The office wishes you all the best on your research journey.

Hoping you will find everything in order.

....
DR MUEDI F.P. (CIRCUIT MANAGER)

21/06/2023
DATE

VHEMBE EAST DISTRICT, VHUMBEDZI CIRCUIT
Mutshetshe Presidential School Private Bag X1120, Tshaulu, 0987 Tel: 015 978 3364
e - mail: muedifp@gmail .com

The heartland of southern Africa – development is about people!

Appendix G: Example of Letter to Request permission from the four school principals.

Enq: KR Munasi

Cell no: 079 035 4981

E-mail: emunask@unisa.ac.za

P.O. Box 3120

Mutale

0956

11 September 2023

The Principal

Department of Basic Education

[redacted] school

[redacted]

Dear sir/madam

Request for permission to conduct research

I, Munasi Khathutshelo Ronald am doing research under supervision of Prof SB Msezane, a Professor in the Department of Adult Community and Continuing Education towards a D Ed (Environmental Education) at the University of South Africa. We are asking permission to conduct research at your school. The study is entitled Integration of Education for Sustainable Development into the Life Sciences curriculum: teachers' pedagogical content knowledge and professional development.

The aim of the study is to investigate how Life Science teachers' pedagogical content knowledge is supported through professional development to enhance the integration of EE/ESD into Life Science curriculum.

Your school has been chosen for this study because it falls under the Mutshundudi circuit, which is one of the circuits included in the research.

The study will involve observing and conducting interviews with three grade 11 Life Science teachers from the Vhembe East district, as well as interviewing three Life Science subject advisors. In the case of your school, the study will solely focus on observing and interviewing the grade 11 Life Science teacher. The participants will be requested to participate, and with their consent, the teachers will be observed during a lesson and subsequently interviewed.

gain a better understanding based on the study's findings and recommendations. It is also hoped that the findings of this study will contribute towards developing guidelines on how to use teacher professional development initiatives, to facilitate the integration of EE/ESD in the teaching of Life Sciences.

There are no potential risks for participating in this study. Participants will take part in the study voluntarily and will be ensured of confidentiality. They have a right to withdraw from the study at any point without any form of penalty. Their names will not be mentioned during and beyond the research process and they will have a right to withdraw from participating without any penalty or threat.

There will be no reimbursement or any incentives for participation in the research.
Feedback procedure will entail giving feedback to all participants upon request.

Yours sincerely

Munasi KR

________________________________ (signature of researcher)

_____Munasi KR______________________ (name of the above signatory)

____Researcher_________________________ (signatory's position)

Appendix H: Example of Letter for approved permission from the four school principals.

[redacted]

REF: [redacted]

27 July [redacted]

To: Munasi KR

REQUEST FOR PERMISSION TO CONDUCT RESEARCH

1. The above matter refers.
2. Makuya Secondary School has acknowledged receipt of your letter dated 27-07-2023, in which you requested permission to conduct research at our school.
3. Permission is hereby granted, on conditions.

3.1. That teaching and learning is not disrupted.

3.2. Arrangement should be made with the relevant teachers.

Hoping you find everything in good order.

[redacted] ....

[Deputy Principal's Full Name] Signature

Date: 28/07/2023

DEPARTMENT OF EDUCATION
[redacted]
2023 -07- 28
[redacted]
LIMPOPO PROVINCE

Appendix I: Participant Information sheet for teachers

UNISA

APPENDIX I: PARTICIPANT INFORMATION SHEET FOR TEACHERS

Title: **Integration of Education for Sustainable Development into the Life Sciences curriculum: teachers' pedagogical content knowledge and professional development**

DEAR PROSPECTIVE PARTICIPANT

My name is Khathutshelo Ronald Munasi and I am doing research under the supervision of Pro SB Msezane, a Professor in the Department of Adult Community and Continuing Education towards a D Ed (Environmental Education) at the University of South Africa. We are inviting you to participate in a study entitled Integration of Education for Sustainable Development into the Life Sciences curriculum: teachers' pedagogical content knowledge and professional development.

WHAT IS THE PURPOSE OF THE STUDY?

This study is expected to collect important information that could contribute towards developing guidelines on how to use teacher professional development initiatives, to facilitate the integration of EE/ESD in the teaching of Life Sciences.

WHY AM I BEING INVITED TO PARTICIPATE?

You are invited because your currently teaching Life Sciences in grade 11.

I obtained your contact details from your school principal. This study will include three Life Sciences teachers from different schools in Vhembe East district, with you included. Three subject advisors will also form part of the participants in this study.

WHAT IS THE NATURE OF MY PARTICIPATION IN THIS STUDY?

The study involves observation and semi-structured one-on-one interviews. three Life Science teachers from Vhembe East District will be requested to participate in this study. I will conduct an observation from the Life science class where you will be teaching environmental studies topic for a full period (45 minutes to an hour depending on your school timetable) the observation will be to find out the teaching method you use to teach environmental studies topic in your class. I will also conduct semi-structured interview with you. The interview will be to explore the challenges you face when integrating Education for sustainable development into your lesson. The questions about how you are supported to integrate Education for Sustainable Development in your subject curricula will also be asked. This interview will take about 45 minutes to an hour of your time, at a time most convenient for you.

CAN I WITHDRAW FROM THIS STUDY EVEN AFTER HAVING AGREED TO PARTICIPATE?

Participating in this study is voluntary and you are under no obligation to consent to participation. If you do decide to take part, you will be given this information sheet to keep and be asked to sign a written consent form. You are free to withdraw at any time and without giving a reason.

WHAT ARE THE POTENTIAL BENEFITS OF TAKING PART IN THIS STUDY?

There are no direct possible benefits for participants. The information you provide will assist me in fulfilling the aim set out in my study and also provide some insights into teaching strategies that Life Sciences teachers use to integrate Education for Sustainable Development and also the challenges that they face when they integrate Education for Sustainable Development into their subject curriculum.

ARE THERE ANY NEGATIVE CONSEQUENCES FOR ME IF I PARTICIPATE IN THE RESEARCH PROJECT?

There are no foreseeable consequences for participating in this study. This study also does don't have any potential risk.

WILL THE INFORMATION THAT I CONVEY TO THE RESEARCHER AND MY IDENTITY BE KEPT CONFIDENTIAL?

All the information provided by you in this research will be treated as highly confidential. You have the right to insist that your name will not be recorded anywhere and that no one, apart from me and my supervisor, will know about your involvement in this research. Your name will not be recorded anywhere and no one will be able to connect you to the answers you give. Your answers will be given a code number or a pseudonym with which you will be referred to in the report or any publications. Members of the Research Ethics Review Committee may review your answers. Otherwise, records that identify you will be available only to my supervisor and me, unless you give permission for other people to see the records. Your anonymous data may be used for other purposes, such as journal articles and/or conference proceedings. In whatever form your supplied data may be used, your name and identity will always be kept confidential and private.

HOW WILL THE RESEARCHER(S) PROTECT THE SECURITY OF DATA?

Hard copies of your answers will be stored by the researcher for a period of five years in a locked cupboard/filing cabinet at my home for future research or academic purposes; electronic information will be stored on a password protected computer. Future use of the stored data will be subject to further Research Ethics Review and approval if applicable. After that particular time, if the data needs to be destroyed, the electronic copy will be deleted permanently, and the hard copies will be shred.

WILL I RECEIVE PAYMENT OR ANY INCENTIVES FOR PARTICIPATING IN THIS STUDY?

There is no reward for participating in this study and participation is voluntary. Furthermore, there are no costs that will be incurred by participating in this research study.

HAS THE STUDY RECEIVED ETHICS APPROVAL

This study has received written approval from the Research Ethics Review Committee of the college of education (CEDU), Unisa. A copy of the approval letter can be obtained from the researcher if you so wish.

HOW WILL I BE INFORMED OF THE FINDINGS/RESULTS OF THE RESEARCH?

If you would like to be informed of the final research findings, please contact **Khathutshelo Ronald Munasi** on 079 0354981 or email emunask@unisa.ac.za /munasikr@gmail.com. The findings are accessible for five years.

Should you require any further information or want to contact the researcher about any aspect of this study, please contact 0790354981/ emunask@unisa.ac.za /munasikr@gmail.com .

Should you have concerns about the way in which the research has been conducted, you may contact_0124812888/ msezasb@unisa.ac.za.

Thank you for taking time to read this information sheet and for participating in this study.

Thank you.

____

(insert signature)

KR Munasi

(type your name)

Appendix J: CONSENT/ASSENT TO PARTICIPATE IN THIS STUDY (Return slip)

APPENDIX K: CONSENT/ASSENT TO PARTICIPATE IN THIS STUDY (Return slip)

I, _________________ (participant name), confirm that the person asking my consent to take part in this research has told me about the nature, procedure, potential benefits and anticipated inconvenience of participation.

I have read (or had explained to me) and understood the study as explained in the information sheet.

I have had sufficient opportunity to ask questions and am prepared to participate in the study.

I understand that my participation is voluntary and that I am free to withdraw at any time without penalty (if applicable).

I am aware that the findings of this study will be processed into a research report, journal publications and/or conference proceedings, but that my participation will be kept confidential unless otherwise specified.

I agree to the recording of the observation and the interviews ________________

I have received a signed copy of the informed consent agreement.

Participant Name & Surname (please print) ___________________________________

___________________________ ___________________________________

Participant Signature Date

Researcher's Name & Surname (please print)__ ___Khathutshelo Ronald Munasi______

___________________________ __________27-07-2023__________________

Researcher's signature Date

Appendix K: Participant information sheet for subject advisors

UNISA

PARTICIPANT INFORMATION SHEET FOR SUBJECT ADVISOR

Title: **Integration of Education for Sustainable Development into the Life Sciences curriculum: teachers' pedagogical content knowledge and professional development**

DEAR PROSPECTIVE PARTICIPANT

My name is **Khathutshelo Ronald Munasi** and I am doing research under the supervision of **Pro SB Msezane**, a Professor in the Department of **Adult Community and Continuing Education** towards a ____ **D Ed (Environmental Education)** at the University of South Africa. We are inviting you to participate in a study entitled **Integration of Education for Sustainable Development into the Life Sciences curriculum: teachers' pedagogical content knowledge and professional development.**

WHAT IS THE PURPOSE OF THE STUDY?

This study is expected to collect important information that could contribute towards developing guidelines on how to use teacher professional development initiatives, to facilitate the integration of EE/ESD in the teaching of Life Sciences.

WHY AM I BEING INVITED TO PARTICIPATE?

You are invited because you're currently a subject advisor for Life Sciences.

I obtained your contact details from your district manager/director. This study will include three Life Sciences subject advisors from Vhembe East district, with you included. Three Life Science teachers will also form part of the participants in this study.

WHAT IS THE NATURE OF MY PARTICIPATION IN THIS STUDY?

The study involves semi-structured one-on-one interviews. I will conduct a semi-structured interview with you and with the other two subject advisors. The interview will be to determine any supportive mechanisms, available for supporting teacher in integrating Education for Sustainable Development into Life Science curriculum. The questions about how you support teachers to integrate Education for Sustainable Development in their subject curricula will also be asked. This interview will take about 45 minutes to an hour of your time, at a time most convenient for you.

CAN I WITHDRAW FROM THIS STUDY EVEN AFTER HAVING AGREED TO PARTICIPATE?

Participating in this study is voluntary and you are under no obligation to consent to participation. If you do decide to take part, you will be given this information sheet to keep and be asked to sign a written consent form. You are free to withdraw at any time and without giving a reason.

WHAT ARE THE POTENTIAL BENEFITS OF TAKING PART IN THIS STUDY?

There are no direct possible benefits for participants. The information you provide will assist me in fulfilling the aim set out in my study and also provide some insights into supportive mechanisms, available for supporting teacher in integrating Education for Sustainable Development into Life Science curriculum and also provide insight into the challenges you have observed Life Science teachers facing when integrating Education for Sustainable Development into their curriculum.

ARE THERE ANY NEGATIVE CONSEQUENCES FOR ME IF I PARTICIPATE IN THE RESEARCH PROJECT?

There are no foreseeable consequences for participating in this study. This study also does don't have any potential risk.

WILL THE INFORMATION THAT I CONVEY TO THE RESEARCHER AND MY IDENTITY BE KEPT CONFIDENTIAL?

All the information provided by you in this research will be treated as highly confidential. You have the right to insist that your name will not be recorded anywhere and that no one, apart from me and my supervisor, will know about your involvement in this research. Your name will not be recorded anywhere and no one will be able to connect you to the answers you give. Your answers will be given a code number or a pseudonym with which you will be referred to in the report or any publications. Members of the Research Ethics Review Committee may review your answers. Otherwise, records that identify you will be available only to my supervisor and me, unless you give permission for other people to see the records. Your anonymous data may be used for other purposes, such as journal articles and/or conference proceedings. In whatever form your supplied data may be used, your name and identity will always be kept confidential and private.

HOW WILL THE RESEARCHER(S) PROTECT THE SECURITY OF DATA?

Hard copies of your answers will be stored by the researcher for a period of five years in a locked cupboard/filing cabinet at my home for future research or academic purposes; electronic information will be stored on a password protected computer. Future use of the stored data will be subject to further Research Ethics Review and approval if applicable. After that particular time, if the data needs to be destroyed, the electronic copy will be deleted permanently, and the hard copies will be shred.

WILL I RECEIVE PAYMENT OR ANY INCENTIVES FOR PARTICIPATING IN THIS STUDY?

There is no reward for participating in this study and participation is voluntary. Furthermore, there are no costs that will be incurred by participating in this research study.

HAS THE STUDY RECEIVED ETHICS APPROVAL

This study has received written approval from the Research Ethics Review Committee of the college of education (CEDU), Unisa. A copy of the approval letter can be obtained from the researcher if you so wish.

UNISA

HOW WILL I BE INFORMED OF THE FINDINGS/RESULTS OF THE RESEARCH?

If you would like to be informed of the final research findings, please contact **Khathutshelo Ronald Munasi** on 079 0354981 or email ___emunask@unisa.ac.za /munasikr@gmail.com. The findings are accessible for five years. Should you require any further information or want to contact the researcher about any aspect of this study, please contact 0790354981/ emunask@unisa.ac.za /munasikr@gmail.com .

Should you have concerns about the way in which the research has been conducted, you may contact_0124812888/ msezasb@unisa.ac.za .

Thank you for taking time to read this information sheet and for participating in this study.

Thank you.

____

(insert signature)

___KR Munasi____________________

(type your name)

Appendix L: Subject advisor consent/assent to participate in this study (Return slip)

UNISA university of south africa

APPENDIX K: CONSENT/ASSENT TO PARTICIPATE IN THIS STUDY (Return slip)

I, ________________ (participant name), confirm that the person asking my consent to take part in this research has told me about the nature, procedure, potential benefits and anticipated inconvenience of participation.

I have read (or had explained to me) and understood the study as explained in the information sheet.

I have had sufficient opportunity to ask questions and am prepared to participate in the study.

I understand that my participation is voluntary and that I am free to withdraw at any time without penalty (if applicable).

I am aware that the findings of this study will be processed into a research report, journal publications and/or conference proceedings, but that my participation will be kept confidential unless otherwise specified.

I agree to the recording of the interviews ______________

I have received a signed copy of the informed consent agreement.

Participant Name & Surname (please print) ________________________________

__________________________ ________________________________

Participant Signature Date

Researcher's Name & Surname (please print)___ ___Khathutshelo Ronald Munasi______

__________________________ __________04-08-2023_________________

Researcher's signature Date

Appendix M: Interview Schedule for teachers

Interview Schedule for teachers:

Gender________________________________ Age:_________________________

Teaching experience___________________ _ Educational Level_____________________

1. What do you understand by environmental education (EE)
2. What is sustainable development?
3. What do you understand by the concept of education for sustainable development?
4. What is the current level of coverage of EE/ESD in the Life Science curriculum, and do you feel that it is adequate?
5. Do you integrate EE/ESD in your lessons when you teach life science? If yes in which topics, do you do that and which documents do you use to assist to integrate EE/ESD into your lesson?
6. What teaching strategies/ methods have you used/ do you use to integrate EE/ESD into your Life Science lessons, and how effective have these strategies been?
7. Which teaching and learning resources do you use when you teach EE/ESD-related topics in life sciences?
8. What challenges have you faced in integrating EE/ESD into your Life Science curriculum, and how have you addressed these challenges?
9. Have you received any support to integrating EE/ESD into your Life Science curriculum, and if so, how has this support impacted your teaching?
10. Have you participated in any professional development programs that specifically aimed to improve your capacity to teach EE/ESD topics within the life science curriculum? If so, in what ways has the program influenced your teaching practice?
11. As a teacher, what do you consider to be the key elements that should be incorporated as guidelines to support Life Science teachers in effectively integrating EE/ESD principles into their lessons?

Appendix N: Interview Schedule for subject advisors

UNISA

interview Schedule for subject advisors

Gender_________________________________ Age:_________________________

Teaching experience___________________ _ Educational Level_____________________

1. What do you understand by environmental education (EE)
2. What is sustainable development?
3. What do you understand by the concept of education for sustainable development?
4. Is EE/ESD integrated in the life science curriculum, if yes in which grade(s) is it covered?
5. In your opinion, do you think it is important to integrate EE/ESD into the Life Science curriculum, if so why?
6. What are the main challenges that you have observed Life Science teachers facing when integrating EE/ESD into their curriculum, and how do you recommend addressing these challenges?
7. What role do you play in supporting Life Science teachers in integrating EE/ESD into their curriculum, and how do you go about providing this support?
8. Which teaching resources do you use to support life science teachers to integrate EE/ESD into their lesson?
9. What teaching strategies/methods do you recommend to Life Science teachers for effectively integrating EE/ESD into their curriculum?
10. Are there any professional development opportunities that the DBE provides for life sciences teachers tc improve their teaching of EE/ESD-related topics in the life science curriculum?
11. Are there any available guidelines to support life science teachers in integrating EE/ESD into their lessons? I so, do you believe these guidelines are effective in providing sufficient support to teachers for the integratior of EE/ESD into their lessons?

Appendix O: Observation Schedule/Guide

Observation guide/tool

A. Teacher personal information

Gender_______________________________ Age:_______________________
Teaching experience__________________ Educational Level____________________
Subject_______________________________ Grade____________________________
Previous training/workshops in teaching ESD related content:_________________________

B. Lesson observation details

1. Was the topic related to ESD? Yes/No
   If No, how were ESD aspect addressed in the topic?

2. Did the teacher start the lesson by discussing the relevance of the topic to ESD concepts? Yes/No
   If No, how was the lesson started and how was ESD incorporate into the lesson?

3. Which teaching strategy did the teacher use to deliver the lesson in their class?
   a) Outdoor learning and field work
   b) Group discussion and debates
   c) Textbook methods
   d) Problem-solving method
   e) Lecture method
   f) Interactive teaching strategy
   g) Others
   If, other please mention and describe the teaching strategy.
4. How did the used teaching strategy influence the involvement of learners in the classroom?

5. Which teaching materials did the teacher use to teach the topic?
   a) Posters
   b) Diagrams
   c) Visual aids
   d) Videos
   e) Prepared slides
   f) Others
   If, other mention the teaching material used.

6. Does the teacher encourage student discussion and participation in the lesson? Yes/No
   If, No explain how learners were involved in the lesson.

7. Does the teacher use any form of assessment to evaluate student understanding of the topic in relation to ESD?
   If Yes, which form of assessment did the teacher use?

8. How knowledgeable was the teacher about the ESD content which he/she taught?

Appendix P: Document analysis Checklist

Document analysis checklist

Document analysis checklist Subject: Life Sciences Document Type: official documents Documents to be analysed: CAPS document (Grade 10-12) : Life sciences grade 11 textbook		
Category	**Checklist item**	**Results Y/N**
CAPS document (Grade 10-12, focussing on grade 11)	Does the CAPS document cover topics related to EE/ESD?	
	Is the depth of coverage of EE/ESD-related topics in the CAPS document evaluated?	
	Are examples and case studies related to EE/ESD-related topics in the CAPS document checked?	
	Are the assessment methods used to evaluate student learning in EE/ESD-related topics evaluated?	
	Are gaps or omissions related to EE/ESD in the CAPS document identified?	
	Are the strategies recommended for implementing EE/ESD-related topics in the curriculum analysed?	
Textbook (Grade 11 Life Sciences textbook)	Do the textbooks identify topics related to EE/ESD?	
	Is the depth of coverage of EE/ESD-related topics in the textbooks evaluated?	
	Are examples and case studies related to EE/ESD-related topics looked for in the textbooks?	
	Does the textbooks integrate EE/ESD with other disciplines, such as social sciences, economics, or politics?	

	Is the use of visual aids, such as diagrams, illustrations, and pictures, in the textbooks evaluated to check whether they enhance understanding or are misleading or confusing when discussing EE/ESD-related topics?	
	Are any gaps or omissions related to EE/ESD in the textbooks identified?	
Annual teaching plan (ATPS)	Do the ATPs identify topics related to EE/ESD?	
	Is the depth of coverage of EE/ESD-related topics in the ATPs evaluated?	
	Are examples and case studies related to EE/ESD-related topics looked for in the ATPs?	
	Does the ATPs integrate EE/ESD with other disciplines, such as social sciences, economics, or politics?	
	Is the use of visual aids, such as diagrams, illustrations, and pictures, in the ATPs evaluated to check whether they enhance understanding or are misleading or confusing when discussing EE/ESD-related topics?	
	Are any gaps or omissions related to EE/ESD in the ATPs identified?	

Appendix Q : Editors confirmation letter

Shiraz 16

50 Quail Avenue

Thatchfield Close

Centurion, Pretoria

0157

Date: 12 January 2024

To whom it may concern

This letter confirms that the research proposal entitled: **INTEGRATION OF EDUCATION FOR SUSTAINABLE DEVELOPMENT INTO THE LIFE SCIENCES CURRICULUM: TEACHERS' PEDAGOGICAL CONTENT KNOWLEDGE AND PROFESSIONAL DEVELOPMENT** written by **KHATHUTSHELO RONALD MUNASI** has been edited by Sam Ramaila.

Sincerely,

Sam Ramaila (PhD)

Cell: 0646566387

Appendix Q : Turnitin Report

Document Viewer

Turnitin Originality Report

Processed on: 30-Jan-2024 14:25 SAST

ID: 2282015505

Word Count: 71308

Submitted: 1

INTEGRATION OF EDUCATION FOR SUSTAINABLE DEVE... By Khathutshelo Ronald Munasi

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Kimaryo, Lydia. "Integrating environmental education in primary school education in Tanzania : teachers' perceptions and teaching practices", Åbo Akademis förlag - Åbo Akademi University Press, 2011

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