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Educational Ecology: Examining the Interplay of Teaching Strategies, Resources, and Guidelines in Integrating EE/ESD into Life Science Curriculum

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Abstract

This study aims to examine the intricate dynamics of integrating Environmental Education and Education for Sustainable Development (EE/ESD) into the Life Science curriculum, emphasizing the interplay among diverse teaching strategies, resources, and guidelines in this integration process. The study utilized a qualitative interpretive design, comprising interviews with four Life Science teachers, observations of three teachers teaching EE/ESD-related topics and discussions with three Life Science subject advisors. The findings indicate a significant disparity between teachers' theoretical comprehension and the practical application of EE/ESD procedures, as well as deficiencies in resources and an absence of defined curriculum guidelines designed to accommodate varied teacher requirements. This study recommends for the formulation of tailored guidelines, specialized training programs, and cooperative platforms. These actions are essential for improving the educational ecosystem and guaranteeing the successful integration of EE/ESD. Addressing these problems is essential for achieving a more effective integration of EE/ESD within the Life Science curriculum. In doing so, we make a substantial contribution to the overarching dialogue on environmental education within the academic sphere.

Keywords: Educational ecology, teaching strategies, environmental education, education for sustainable development; life science curriculum

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1. Introduction

As the world faces unprecedented environmental challenges, the integration of Environmental Education and Education for Sustainable Development (EE/ESD) into the South African curriculum is not merely a constitutional mandate but a critical necessity for equipping future generations with the knowledge and skills needed for sustainable living. This commitment to holistic learning and environmental consciousness establishes the foundation for a comprehensive educational approach (South African Government, 1996). The evolution of this mandate is evident in the development of the National Curriculum Statement (NCS) and its pivotal revision into the Curriculum and Assessment Policy

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Statement (CAPS) in 2011, a policy document of paramount importance in shaping South Africa's educational landscape.

A Department of Basic Education (DBE) directive that promotes the integration of environmental themes into all topics in both the General Education and Training (GET) and Further Education and Training (FET) phases is included into CAPS (DBE, 2011). In order to embed environmental concepts within their respective topics without undermining the integrity of the primary subject, teachers are required to effortlessly integrate EE/ESD themes (Damoah and Adu, 2020). Achieving the goals of the curriculum and encouraging learners to be sustainable and environmentally conscious depend on this integration's success.

Globally, the integration of EE/ESD into education systems presents a range of challenges. In the United Kingdom, Parry and Metzger (2023) conducted a study on barriers to learning for sustainability, revealing that many teachers struggle with the multidisciplinary nature of sustainability. They feel unprepared in both content knowledge and the student-centered pedagogy required for ESD. Additionally, they lack adequate support in terms of resources, materials, time for collaboration, and ongoing professional development (Parry and Metzger, 2023). Aladejebi (2020) identified that inadequate teaching methodologies, and a lack of content expertise impede the successful instruction of EE in Nigeria. Abidin et al. (2023) observed that school administrators persistently encounter hurdles in executing Education for Sustainable Development (ESD), with these obstacles enduring from the inception of ESD programs to the enhancement of ESD activities.

While many challenges in integrating EE/ESD are shared globally, South African educators face context- hurdles in their efforts to incorporate these themes into their teaching practices. Tsotetsi's (2021) analysis of 'Assessing the Implementation of Environmental Education in Selected Vosloorus Township Schools' indicated that educators encounter difficulties in this integration owing to the substantial curriculum requirements mandated by the Curriculum and Assessment Policy Statement (CAPS). This provides minimal opportunity for investigating EE subjects outside the classroom. Additionally, Sikhosana (2019) discovered that time limitations considerably impede educators' capacity to integrate EE/ESD principles into their instruction. Furthermore, Masemene and Msezane (2021) emphasize the issue of insufficient environmental literacy among educators, which diminishes the self-efficacy required for the successful integration of environmental education. The deficiency of knowledge and abilities, along with inadequate teaching resources, time limitations, and substantial class numbers, intensifies the challenges of effectively incorporating EE/ESD into the school curriculum (Ntuli et al., 2022). Moreover, the exam-centric pedagogical approach common in South African schools, as observed by Damoah (2019),

frequently compels educators to emphasize examinable material, hence undermining the integration of EE/ESD themes and obstructing effective EE implementation.

To address these challenges and contribute meaningfully to the scholarly discourse, this paper investigates the nuanced interplay of teaching strategies, resources, and guidelines in integrating Environmental Education and Education for Sustainable Development (EE/ESD) into the Life Science curriculum. By adopting the conceptual framework of 'Educational Ecology,' the study considers the intricate relationships among the teaching strategies employed by educators, the availability of necessary resources, and the presence of clear guidelines for effective integration. Given the pivotal role of Life Science teachers in cultivating environmentally literate citizens, this investigation is crucial for identifying and addressing existing gaps in the literature. The primary aim of the study is to explore these dynamics, focusing on the following research questions:

- Which teaching strategies are presently employed by teachers to integrate 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?

2. Conceptualizing educational ecology

Educational ecology, as conceptualized by Ganderton (2021), represents a dynamic and adaptive learning system designed to address specific contextual needs. It draws from ecology, the branch of biology that studies the relationships between organisms and their environments, providing a foundational framework for understanding the complex dynamics of educational environments (Cushing Terrell, n.d.). By employing the "Ecology of Education" approach, multidisciplinary teams aim to comprehensively understand the needs of user groups and design optimal learning environments tailored to those requirements. Building upon this framework, Gu (2017) emphasizes the importance of educational ecology principles in guiding effective educational management measures. By aligning resource allocation with a people-oriented educational philosophy, fostering sustainable development within educational systems, and facilitating coordinated efforts among educational institutions, educational practices can be optimized to meet evolving societal needs. Thus, the adoption of educational ecology principles offers a systematic approach to enhancing educational practices and promoting holistic development within educational institutions.

In the context of this study, educational ecology refers to the intricate interplay of teaching strategies, resources, and guidelines that govern the integration of Environmental Education and Education for Sustainable

Development (EE/ESD) into the Life Science curriculum. The three fundamental components of this educational ecology are teaching strategies, teaching and learning resources, and guidelines. Teaching strategies encompass the methodologies employed by educators to effectively integrate EE/ESD into their instruction. Resources include the materials and tools necessary for successful implementation, while clear and effective guidelines provide a framework that supports teachers in incorporating EE/ESD principles into the Life Science curriculum.

Aligned with Education for Sustainable Development (ESD), teaching strategies provide opportunities for innovative, collaborative, and relevant instruction, as emphasized by Gonzalez (2021) and conceptualized by Freiburg (1996). Recognizing the importance of incorporating diverse methodologies—such as outdoor learning, fieldwork, group discussions, problem-solving, and interactive methods—this study acknowledges the necessity to cater to the varied learning styles of students (Senthamarai, 2018; Barrow, 1994). However, challenges persist in implementing these teaching strategies, as educators often lack guidance on integrating environmental issues and tend to rely on singular teaching approaches, as highlighted by Shumba and Kampamba (2013). This limitation undermines the potential benefits of employing a variety of methods and alternative assessment approaches, emphasizing the need for a more comprehensive approach to instructional design.

Transitioning to the realm of resources within educational ecology, Marpa (2020) and Laiphrakpam et al. (2019) highlight challenges stemming from resource constraints in Botswana and difficulties in India due to inflexible course structures and traditional teaching methods. Aladejebi (2020) observes that financial constraints in Nigeria hinder the effective integration of EE/ESD. Despite these challenges, the availability of resources—such as videos, educational apps, interactive online tools, books, posters, and teacher-generated materials—remains critical for the successful implementation of EE/ESD.

Bopape, Mudau, and Msezane (2021) identify the absence of integration guidelines in the Curriculum and Assessment Policy Statement (CAPS) document as a significant hindrance to the integration process within the South African school curriculum. Hebe (2019) and Damoah (2019) echo these concerns, noting that teachers struggle to make informed decisions regarding EE integration due to a prescriptive curriculum and the lack of environmental policies in schools. Additionally, Corpuz, San Andres, and Lagasca (2022) emphasize challenges stemming from unclear guidelines provided by management, which further impede teachers' ability to seamlessly integrate EE/ESD into their instruction. Kimaryo (2011) underscores the critical issue of an "unclear syllabus," leaving teachers without detailed descriptions of the environmental content necessary for incorporation into subject materials. These challenges highlight the urgent need

for comprehensive and clear guidelines within the educational ecology framework to facilitate effective integration of EE/ESD in the curriculum.

3. Theoretical framework

This paper combines two theoretical frameworks: Pedagogical Content Knowledge (PCK), developed by Lee Shulman in 1986, and Social Learning Theory, formulated by Albert Bandura. PCK emphasizes the intricate relationship between Content Knowledge (CK) and Pedagogical Knowledge (PK) in effective teaching. Shulman (1986) distinguishes between subject knowledge (CK) and the ability to convey it through teaching practices (PK). PCK encompasses teachers' understanding of a subject and their methods for conveying that information, serving as a foundational framework for effective pedagogy. The components of PCK—CK and PK—form a dynamic and context-dependent knowledge base influenced by various factors. Kimaryo (2011) characterizes PCK as crucial for empowering learners and shaping effective teaching practices.

In the context of Life Science, PCK becomes particularly relevant as it directly influences teachers' ability to integrate Environmental Education and Education for Sustainable Development (EE/ESD) into the curriculum. Teachers with strong PCK in Life Science can effectively bridge their content knowledge with pedagogical expertise, allowing for the seamless incorporation of EE/ESD principles into their lessons. This alignment ensures that environmental content is not only comprehensively understood but also effectively communicated to students, fostering a deeper understanding of environmental issues. Therefore, PCK plays a pivotal role in shaping the integration of EE/ESD within the Life Science curriculum.

Within the realm of educational ecology, PCK interacts with its various components, enhancing the integration of EE/ESD into Life Science. Firstly, within the teaching strategies component, teachers with robust PCK in Life Science can leverage their subject-specific knowledge to design and implement innovative and contextually relevant teaching methodologies. The ability to select and adapt strategies aligns with the dynamic nature of PCK, ensuring that content is effectively conveyed to students (Shulman, 1986). Moreover, regarding teaching and learning resources, teachers with strong PCK can critically evaluate and select materials that align with both subject content and the pedagogical needs of their students. The dynamic and context-dependent nature of PCK allows teachers to make informed decisions about the resources that best support the integration of EE/ESD, ensuring alignment with the Life Science curriculum.

Bandura's Social Learning Theory, formulated in 1986, serves as a significant framework for understanding how students learn through observation and

modeling (Bandura, 1986). Emphasizing the role of social context, Bandura posits that individuals learn by observing others and replicating observed behaviors (Navabi, 2012). The theory encompasses three interconnected themes—environmental, personal, and behavioral factors—and consists of four stages: attention, retention, reproduction, and motivation. Attention involves noticing and focusing on observed behaviors, while retention requires remembering and storing these behaviors in memory. Reproduction entails replicating observed behaviors, and motivation is crucial for successful behavior replication, influenced by reinforcement and punishment (Navabi, 2012).

In the context of teaching strategies, Social Learning Theory aligns with the collaborative and interactive nature of educational ecology. Bandura's theory suggests that learners acquire new behaviors by observing and imitating others, underscoring the importance of collaborative and relevant instructional settings (Bandura, 1977). Teachers, informed by Social Learning Theory, can design teaching strategies within educational ecology that encourage collaborative learning, group discussions, and interactive methods. This approach fosters a social environment that supports the integration of EE/ESD principles into the Life Science curriculum.

Within the teaching and learning resources component, Bandura's Social Learning Theory accentuates the role of modeling and observational learning. Teachers, as role models, can curate resources that not only provide information but also exemplify sustainable practices. Resources such as videos, educational apps, and interactive tools can effectively convey environmental principles through observational learning, aligning with the tenets of Social Learning Theory (Ganderton, 2021).

Furthermore, in the guidelines component of educational ecology, Social Learning Theory emphasizes the influence of social context on learning. Guidelines that promote social interaction, collaboration, and modeling of sustainable behaviors align with Bandura's theory, enhancing the effectiveness of EE/ESD integration. Clear and effective guidelines, coupled with social learning opportunities, create an environment where teachers can model behaviors and students can observe and imitate sustainable practices. The interaction between Bandura's Social Learning Theory and the components of educational ecology enriches the educational experience, highlighting the importance of collaborative and observational learning in teaching strategies, resource utilization, and guideline formulation within educational ecology (Bandura, 1977; Ganderton, 2021).

4. Methodology

4.1. Research design

This study employed a qualitative approach to explore the behaviours 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 behaviour and the reasoning that governs it. The study embraced an interpretivist paradigm to comprehend the universe of human experience. Nickerson (2022) posits that the interpretivist paradigm prioritizes qualitative methods, focusing on human perspectives, insights, and reasoning over quantitative approaches to comprehend social interactions. 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). In its exploration of the interplay of teaching strategies, resources, and guidelines in integrating Environmental Education and Education for Sustainable Development (EE/ESD) into the Life Science curriculum, this paper adhered to a case study design. Additionally, Yin (2017) mentions single, holistic, and multiple case studies. Therefore, this study specifically adopted an exploratory case study design.

4.2. Sampling

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. 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. Table 1 below provides the demographic details of the participants selected for the study.

Table 1: Demographic 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 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.

4.3 Data collection methods

This study followed Creswell's systematic data collection approach to thoroughly explore how Environmental Education and Education for Sustainable Development (EE/ESD) are integrated into Grade 11 Life Science lessons. Using a guided multi-method approach, which Creswell (2015:30) recommends, various qualitative methods like interviews and observations were chosen to gain a complete picture. Conducting semi-structured interviews with Grade 11 Life Science teachers and subject advisors revealed valuable information on teaching strategies and potential integration guidelines. Direct observations during lessons offered real-time insights into teaching strategies, contributing to a fuller understanding. By using a multi-method approach that combined document analysis, interviews, and observations, the research triangulated data, enhancing the exploration of how pedagogical content knowledge is developed for successful EE/ESD integration into the Grade 11 Life Science curriculum.

4.4 Data analysis

Thematic analysis, as expounded by Dawadi, Shrestha, and Giri (2021), is a qualitative research method that facilitates the systematic organization and analysis of extensive data. Maguire and Delahunt (2017) elaborate that thematic analysis involves identifying patterns or themes within qualitative data. In this study, the six-step framework outlined by Braun and Clarke (2006) was employed 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

5. Results

In this section we present the findings of the study. The findings are presented according to the themes that emerged from the analysis:

- The Teaching Strategies and Resources for Integrating EE/ESD into the Life Science Curriculum
- Guidelines for Effective Integration of EE/ESD into the Curriculum

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

The findings are presented through two sub-themes: theoretical vs. practical teaching and the utilization of teaching and learning resources.

5.1.1 Theoretical vs practical teaching

The exploration of theoretical versus practical teaching arose from insights gathered from Life Science teachers, the Life Science subject advisor, and classroom observations during the instruction of EE/ESD-related topics under the environmental studies strand in the grade 11 Life Science curriculum. Inquiring about the strategies employed to integrate EE/ESD into the Life Science curriculum revealed a diverse range of approaches among the participating teachers.

Mr. Sabawa, a Life Science teacher for instance, shared his practice of taking students into the field to observe and interact with different environmental features, stating:

> *" I have to go to the field, then point out some features of the environment, and even pick up some species from the environment so that learners can learn in a practical way."*

When asked about his classroom teaching methods for EE/ESD-related topics, Mr. Sabawa described employing a predominantly teacher-centered approach. However, he also noted instances of incorporating learner-centered methods by facilitating co-teaching among students. He said:

> *"Sometimes I use lecture method and sometimes I use learner centred methods. It depends on the topic."*

This flexibility in approach was consistent with the observed classroom dynamics. For example, during a lesson on interactions in the environment, Mr. Sabawa took an active, teacher-centered role, as evidenced by Picture A, where he is seen writing on the green board while explaining various environmental interactions to students.

Picture A: Mr Sabawa in front of the classroom

Source: Author

When asked about his approach to integrating EE/ESD into his lessons, Mr. Nkhumeleni who is a Life Science teacher shared that he heavily relies on the use of pictures as teaching aids to enhance understanding. Explaining his method, he said:

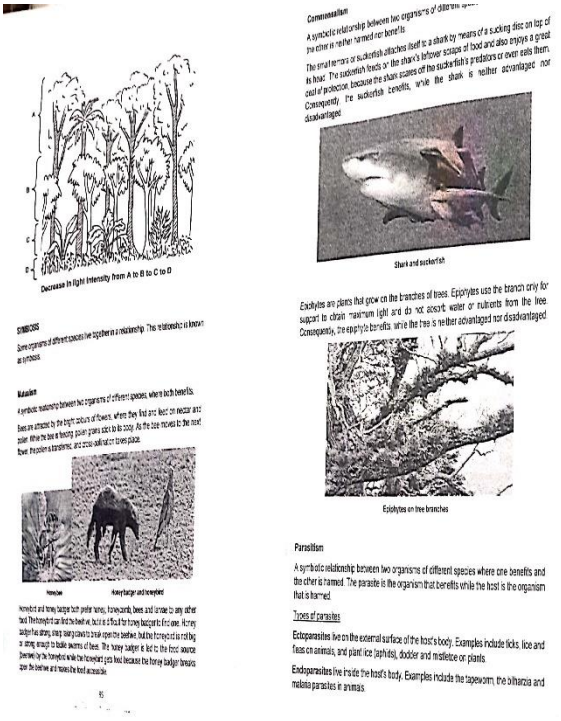
> *"I use a lot of pictures. I make copies for the learners so they can visually grasp the concepts I am discussing."*

This underscores the vital role visual aids play in fostering learners' comprehension of environmental topics. Regarding classroom teaching methods, Mr. Nkhumeleni stated:

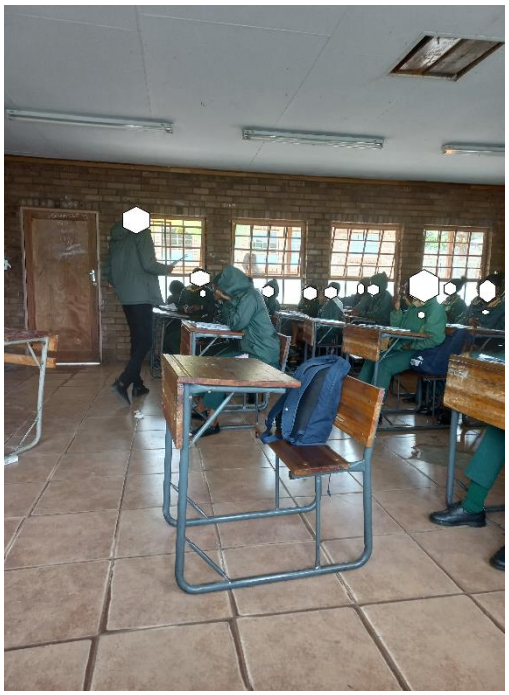
> *"I employ a learner-centered method when teaching EE/ESD-related topics. I begin by asking learners to share their understanding of the concepts."*

However, my observation of Mr. Nkhumeleni's lesson on ESD related topic revealed a variance from the teaching approach he mentioned during the interview. In practice, he predominantly used a lecture method, taking on the role of the primary speaker. Despite having prepared copies featuring relevant pictures for teaching EE/ESD-related subjects (refer to Picture B below), Mr. Nkhumeleni's instructional approach in the observed class leaned towards a lecture format (refer to Picture C below).

Picture B: copies given to leaners **Picture C: Mr Nkhumeleni teaching in class**



Source: Author



Source: Author

Mr. Makhokha, Life Science teacher discusses several teaching strategies, encompassing practical demonstrations, field trips, and the use of visual aids. He explains:

> *"I ensure that I prepare slides for my classroom, allowing students to visualize the concepts being taught. If necessary, we venture outside for practical sessions, but this depends on whether suitable teaching opportunities are available around the school premises."*

This revelation underscores Mr. Makhokha's adherence to curriculum guidelines and his reliance on the local environment for practical sessions. However, Mr. Makhokha acknowledges that the feasibility of taking learners outside the classroom is contingent on the availability of resources. For instance, he notes:

> *"The strategy I employ for teaching human impact to grade 11 learners involves taking them outdoors. This includes a theoretical aspect; for example, when discussing deforestation, we explore the school surroundings to observe tree cutting and overgrazing effects."*

Contrary to his stated teaching methods, the classroom observation of Mr. Makhokha's lesson on environmental interactions, revealed that he uses a combination of the lecture method and a teacher-centered approach (see picture D below).

Picture D: leaners raising hands and others not raising hand in Mr Makhokha's class

Source: Authors

The subject advisors in this study were asked about the teaching strategies and methods they recommend for effectively integrating EE/ESD into the Life Science curriculum. Mr. Shonisani advocated for a learner-centered approach as the ideal method for teaching EE/ESD topics. He acknowledged that this method could present challenges if teachers are not adequately prepared, stating:

> *"I think the right method is one that is learner-centered. Where learners themselves come up with something they know, and then teachers assist them in understanding what they do not know through their own knowledge. However, this method becomes problematic when the teacher is unprepared and does not anticipate the learners' knowledge, leading to potential disinterest among learners."*

Mr. Shonisani also critiqued the prevailing teacher-centered education system, asserting that it hinders learners from developing their perspectives and is resistant to new ideas from students. He expressed concern about the teacher-oriented nature of the education system, where learners bringing new perspectives to class are often regarded as distrusting and advised to follow the teacher's guidance to succeed. He said:

> *"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".*

Mr. Joseph, a subject advisor recommended that teachers align their teaching strategies with the specific aims related to EE/ESD. He emphasized the importance of setting clear objectives for each lesson and ensuring their achievement. He said that:

> *"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.*

Mrs Rose, a Life Science supervisor highlighted the need to shift from traditional, teacher-centred teaching methods to more learner-centered approaches. She recommends starting a lesson by presenting questions and engaging learners in active discussion before diving into the content. She gave an example of how she use to do it, starting that:

> *"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 ".*

She argued that this approach empowers learners to grasp and apply knowledge beyond the classroom, promoting a deeper comprehension of the subject matter.

5.1.2 The Use of teaching and learning resources

This section presents findings on the resources utilized by teachers to integrate EE/ESD topics into the Life Science curriculum. In this research, teachers were asked about the teaching and learning resources they employ when addressing EE/ESD-related topics in their lessons. Mr. Makhokha cited the use of a projector and taking learners outside to explore the environment. He expressed:

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

However, contrary to Mr. Makhokha's statement about using a projector and outdoor activities, neither of these resources was utilized during the observed lesson. Instead, my observation revealed that Mr. Makhokha relied on the textbook and the greenboard as instructional tools (see Picture E). It's worth noting that the classroom environment he used did not appear conducive for the implementation of a projector, as mentioned by him.

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

Source: Authors

When asked if the resources he currently have and is using are enough to enable him to teach ESD related topics well, 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.

Mrs. Mususumeli relies solely on textbooks and question papers as teaching resources for EE/ESD-related topics in Life Science. She said:

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

When asked about additional resources she believes would aid teaching and learning for these topics, she mentioned:

> *"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".*

Despite having a projector, she pointed out the lack of video content. When questioned about downloading videos from the internet, Mrs. Mususumeli explained that:

> *"the school lacks a computer and sufficient connectivity, making it challenging to access online content."*

Mrs. Mususumeli's teaching resources are currently limited to textbooks and question papers. She expresses a desire for diverse resources but faces challenges

due to the school's lack of a computer, insufficient connectivity, and the absence of a school laptop.

Mr. Sabawa outlined his use of various resources in teaching EE/ESD-related topics, including textbooks, charts, and outdoor experiences with learners. Acknowledging the resource limitations in his rural school, he mentioned improvising by bringing branches or leaves into the classroom for instructional purposes. He explained:

> *"Resources like books and textbooks, I will use them. There are times when I can use some charts. Also, as I've indicated before, I go out. There are all sorts of resources. 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."*

However, during the observation of Mr. Sabawa's lesson, it was noted that while he utilized textbooks, there were no charts on EE/ESD-related topics in the classroom, and he did not bring external resources for the lesson. The primary tools employed were the textbook, handouts, and the greenboard/chalkboard. Picture G illustrates Mr. Sabawa holding the copy used for teaching while explaining content on the board to students as they took notes.

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

Source: Authors

When asked if the available resources are enough to assit you integrate ESD into his lessons he said:

> *"They are not enough."*

Mr. Nkhumeleni exclusively relies on textbooks and study guides, stating:

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

This teaching approach, as described by Mr. Nkhumeleni in the interview, aligns seamlessly with what I observed during his lesson. He actively engages students by creating copies of the study guide, ensuring uniform distribution among the class. Subsequently, he elucidates on the content while students refer to the provided copies. Picture H vividly captures students in Mr. Nkhumeleni's class, attentively focusing on the distributed copies as he reads and explains the content on the paper.

Picture H: Mr Nkhumeleni teaching while leaners ready from the copy given to them.

Source: Authors

When asked about the adequacy of resources to support teaching and learning of EE/ESD-related topics, Mr. Nkhumeleni expressed:

> *"They are not enough. There ought to be a projector so that we can also play videos so that learners can see what we are teaching them."*

He underscores the need for additional resources, specifically emphasizing the necessity of a TV, DVD player, and projector to enhance the quality of teaching and learning in the context of EE/ESD. Mr. Nkhumeleni believes these resources can compensate for the inability to conduct field trips, ultimately leading to a better understanding of EE/ESD.

He further emphasizes the importance of having materials like TV, DVD, and a projector, statin:

> *"I believe better resources make teaching and learning better and enable learners to have better knowledge."*

5.2 Guidelines for Effective Integration of EE/ESD into the Curriculum

The findings of this section delve into a discussion on the perceptions of teachers and subject advisors regarding the guidelines crucial for supporting Life Science teachers' Pedagogical Content Knowledge (PCK) as they integrate EE/ESD into their lessons. Three distinct sub-themes emerged from the interviews with the teachers and subject advisors, and the subsequent discussion will be organized around these three themes: Utilization and Awareness of Existing Guidelines, Professional Development and Teacher Support, and Comprehensive Guidelines and Resource Allocation.

5.2.1 Utilization and Awareness of Existing Guidelines

Insights gathered from subject advisors and teachers suggest a perceived existence of guidelines for integrating EE/ESD into the Life Science curriculum. Mrs. Rose, a Life Science subject advisor confirms 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 emphasizes the importance of teachers acquiring a deeper understanding of seamlessly integrating EE/ESD into their instructional practices:

> *"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 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."*

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 emphasizes 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, like Mrs. Rose and Mr. Shonisani, recognize the existence of guidelines in diverse documents but voice apprehensions about their uniform implementation.

5.2.2 Professional Development and Teacher Support

The research findings emphasize a shared conviction among teachers regarding the critical importance of continuous professional development and workshops specifically designed for the seamless integration of EE/ESD into the Life Science curriculum. Mrs. Rose underscores the necessity for workshops, expressing the need for teachers to receive training on effectively teaching EE/ESD topics.

Mrs. Rose highlights the importance of providing teachers with ongoing professional development opportunities and workshops focused specifically on integrating EE/ESD into the Life Science curriculum. She asserts:

> *"They must conduct workshops. It is concerning so that they can teach. Teachers need to be trained on how to teach this topic".*

Echoing this sentiment, Mr. Shonisani emphasizes the pivotal role of support and training for teachers, stressing that teachers must be adequately supported to facilitate learners' success. 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".*

Contributing to the discussion, Mrs. Mususumeli underscores the importance of incorporating guidelines on how to teach EE/ESD directly into curriculum documents. 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."*

Mr. Sabawa concurs with the general perspective, emphasizing the need for guidelines and workshops to assist teachers in effectively teaching EE/ESD content. 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 emphasizes 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 stress the necessity for training and support to bolster their proficiency in effectively teaching EE/ESD topics. Furthermore, there is shared agreement on the importance of incorporating guidelines on teaching EE/ESD directly into curriculum documents, with advocates calling for regular workshops to deliberate on teaching methods for each topic and assist teachers in incorporating EE/ESD principles into their lessons.

5.2.3 Comprehensive Guidelines and Resource Allocation

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".*

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. 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 advocates for a balanced approach that respects teachers' individuality while providing a structured framework for effective teaching.

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. Discussion

The study reveals a marked discrepancy between the teachers' professed intentions to employ learner-centered approaches and the actual, predominantly teacher-centered practices observed in the classroom. For instance, Mr. Sabawa's acknowledgment of a transformative, hands-on approach aligns with theoretical ideals (Smith, 2013), yet in practice, his lessons remain teacher-led. The lack of learner engagement during classroom observations aligns with Nyanguza (2021), who highlights that many educators revert to traditional methods despite understanding the benefits of interactive approaches. This pattern suggests a gap in the integration of Content Knowledge (CK) and Pedagogical Knowledge (PK), a core component of Shulman's (1986) Pedagogical Content Knowledge (PCK) framework. As Shulman noted, effective teaching requires not only mastery of content but also the ability to convey that content in pedagogically sound ways. The observed reliance on teacher-centered methods, despite an understanding of learner-centered approaches, highlights a deficiency in PCK, where teachers' understanding of environmental content is not sufficiently aligned with pedagogical strategies to engage students actively. This is further reinforced by Dube's (2012) assertion that superficial knowledge of ESD contributes to reliance on teacher-centered methods.

Similarly, Mr. Nkhumeleni expressed support for learner-centered strategies but was observed relying on lecture-based teaching, which restricted student participation. The visibility issues caused by black-and-white images, along with the lack of multimedia resources, mirror the findings of Laiphrakpam et al. (2019), who highlight the challenges resource-constrained environments pose to

the effective teaching of environmental education. His reliance on outdated materials underscores a discrepancy between his intentions and the limitations imposed by the classroom environment, a reflection of a lack of contextual PCK—where the adaptation of teaching methods to fit the classroom context is insufficient. In this case, the lack of resources limits the opportunity to use innovative, interactive teaching methods that would better support the integration of EE/ESD. Teachers with stronger PCK could better adapt their strategies to the environmental and resource challenges, ensuring that content is communicated more effectively.

In Mr. Makhokha's case, while brief moments of peer discussions were encouraged, his overall reliance on traditional tools like the greenboard and textbooks, coupled with resource shortages, aligns with Okongo et al. (2015), who emphasize the difficulties rural schools face in diversifying teaching methods. The heavy dependence on past question papers for assessment further underscores these limitations, as teachers struggle to innovate with the resources available. This reliance on traditional tools highlights a deficiency in PCK's dynamic nature, where teachers are unable to bridge the gap between their content knowledge and the necessary pedagogical methods required to foster deeper learner engagement. According to Kimaryo (2011), robust PCK is crucial in empowering learners and shaping more effective teaching practices, yet in resource-constrained environments, teachers often lack the necessary support to apply their knowledge in practice.

Bandura's (1986) Social Learning Theory (SLT) adds further insight into these challenges. SLT emphasizes that students learn through observation and modeling, which aligns with the interactive, learner-centered strategies that teachers expressed intent to use. However, as seen in the study, the absence of multimedia resources, interactive tools, and the constraints of classroom environments inhibit teachers' ability to serve as effective role models for sustainable practices. Teachers like Mr. Nkhumeleni, who rely on outdated materials, cannot fully leverage SLT's principles of observational learning, where students could benefit from seeing environmental content modeled in engaging, practical ways. The limited use of group discussions and collaborative activities also limits opportunities for social learning, which SLT identifies as critical for student motivation and behavior replication (Bandura, 1977).

Across all classrooms, resource constraints emerged as a significant factor limiting the integration of Environmental Education (EE) and Education for Sustainable Development (ESD) into the Life Sciences curriculum. Teachers' reliance on basic tools like textbooks and greenboards reflects what Nyanguza (2021) describes as an outdated approach prevalent in resource-limited settings. From a PCK perspective, these constraints restrict teachers' ability to adapt their teaching strategies effectively. The disparity between teachers' expressed

preferences for interactive teaching tools like projectors and the actual tools used in practice highlights the critical need for improved access to multimedia resources, as also observed in Aladejebi's (2020) research in Nigerian schools. Bandura's SLT would suggest that providing such resources could enable teachers to model environmental practices more effectively, creating a more interactive and observational learning environment for students.

Additionally, the lack of explicit guidelines for integrating EE/ESD into the curriculum was a recurring theme. While Mrs. Rose pointed out the existence of guidelines in policy documents and ATPs, teachers frequently overlook or struggle to apply these resources effectively during lessons. The absence of actionable guidance within the CAPS documents, as noted by Bopape, Mudau, and Msezane (2021), leaves teachers relying on their discretion, which further complicates the integration process. This finding reinforces Damoah's (2019) observation that while the conceptual integration of EE/ESD across subjects is mandated, the operationalization of this mandate is hindered by the lack of explicit instructions in curriculum documents. From a PCK standpoint, this underscores the need for clearer guidelines that would better support teachers in combining their content and pedagogical knowledge to integrate EE/ESD into their lessons. Social Learning Theory also highlights the importance of a structured social context—clear guidelines would enable teachers to create environments where students can observe and practice sustainable behaviors effectively.

Resource constraints not only hinder teaching practices but also affect the professional development of teachers. The study highlights the importance of ongoing support and training in equipping educators with the necessary skills to teach EE/ESD effectively. Mrs. Rose and Mr. Shonisani both emphasize the need for workshops and consistent support for teachers, aligning with Siddiqui and Khan's (2015) findings that inadequate support can be detrimental to teaching EE/ESD. These professional development efforts would help teachers strengthen their PCK, ensuring they can integrate both content knowledge and pedagogical methods more effectively. Moreover, incorporating Bandura's SLT into professional development would further enhance teachers' capacity to design collaborative, social learning environments that support the integration of EE/ESD.

7. Conclusion

This study concludes that despite teachers' awareness of EE/ESD strategies, there is a notable gap between their theoretical knowledge and practical application, with traditional teaching methods dominating over learner-centered approaches. The limited integration of Pedagogical Content Knowledge (PCK), where teachers struggle to align content with pedagogical strategies suitable for

resource-constrained environments, exacerbates this issue. Furthermore, the principles of Social Learning Theory (SLT), which emphasize the importance of modeling and collaborative learning, are not fully utilized, limiting opportunities for learner engagement. The restricted use of diverse teaching resources and the inadequacy of existing materials, particularly in rural schools, further hinder the effective integration of EE/ESD into the Life Science curriculum.

Moreover, while teachers recognize the importance of professional development and express a need for clearer guidelines, the inconsistent use of available curriculum frameworks suggests that better support and explicit, adaptable guidelines are essential. Teachers require continuous support to develop PCK that is responsive to both environmental challenges and learner needs. Finally, this study underscores the need for comprehensive strategies to bridge these gaps, enhance resource accessibility, and foster professional development that equips teachers with both the content knowledge and pedagogical skills to improve EE/ESD integration.

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