DEVELOPING AND IMPLEMENTING A STRATEGIC FRAMEWORK TO ENHANCE THE TEACHING AND LEARNING OF SCIENCE IN SCIENCE CENTRES: A CASE STUDY OF THE NATIONAL ZOOLOGICAL GARDEN IN PRETORIA

BY

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August 2023

DECLARATION

I, Hasani Justice Bilankulu, hereby declare that the thesis entitled

Developing and implementing a strategic framework to enhance the teaching and learning of science in science centres: A case study of the National Zoological Garden

is my own work and that all resources that I have used or quoted have been indicated and acknowledged by means of complete references. It is being submitted for the degree of Doctor of Philosophy at the University of South Africa. It has not been submitted before for any degree or examination at any other university

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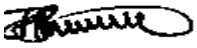

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SIGNATURE DATE

DEDICATION

This study is dedicated to:

- My parents Samuel Bilankulu and Florah Maluleke
- My wife Ruth and my two sons, Matimba Bilankulu and Mahlori Bilankulu

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ABSTRACT

This study investigates the development and implementation of a strategic framework aimed at enhancing the teaching and learning of science within the context of a unique educational setting, specifically the National Zoological Garden in Pretoria, South Africa. With the growing emphasis on hands-on and experiential learning approaches, science centres, zoos and botanical gardens have gained recognition as valuable platforms for science education. This qualitative multiple case study design located within an interpretive paradigm focuses on the National Zoological Garden's endeavour to optimize its potential as an educational institution, examining the challenges faced and innovative strategies employed. Drawing on a qualitative approach, this research delves into the various aspects of the strategic framework's development and execution. The study involved teachers and learners from six schools as well as education officers working for the National Zoological Garden. Qualitative data were collected through observations, semi-structured interviews and dairies and analysed using a typology approach.

The findings highlight the multifaceted nature of the strategic framework, encompassing curriculum design, teacher training, resource allocation, and community engagement. In addition, the study reveals the challenges faced in integrating formal education goals with the zoo's recreational aspects, and how these challenges were addressed through innovative instructional strategies. Furthermore, it explores the impact of the strategic framework on visitor experiences, learning outcomes, and the overall perception of the zoo as an educational institution. The case study of the National Zoological Garden in Pretoria provides valuable insights into the complexities of developing and implementing an effective science education framework within a non-traditional educational environment. The research contributes to the broader discourse on enhancing science education through experiential learning settings and offers practical implications for educators, administrators, and policymakers seeking to maximize the educational potential of zoos, botanical gardens, and similar institutions. Ultimately, this study underscores the significance of strategic planning and collaboration in bridging the gap between conservation, recreation, and science education.

Keywords: Science Centre; Education Officers; Exhibits; National Zoological Garden, teachers, learners, interacting & discourse and knowledge construction.

Description of Keywords

Science centre

A place where science activities are taught/explored by visiting teachers and learners.

Education officers

Employees of the science centre who are responsible for teaching and interacting with the visiting teachers and learners at the centre.

Exhibits

Resources on display at the science centre used that are to teach and learn science.

National Zoological Garden

A garden in Pretoria that houses animals and other science exhibits

Teachers

Educators from school that accompany learners to the science centre

Learners

A group of organised school-going children visiting the science centre

Mabonelo ka buripa (Setswana)

Patlisiso eno e batlisisa go dirwa le go tsenngwa tirisong ga thulaganyo ya togamaano e e ikaeletseng go tokafatsa go ruta le go ithuta saense mo tikologong e e kgethegileng ya thuto, segolobogolo Serapa sa Bosetshaba sa Diphologolo kwa Pretoria, Afrika Borwa. Ka go gatelelwa thata mekgwa ya go ithuta ka diatla le, Serapa sa Diphologolo le Botanical Garden di ile tsa simolola go tsewa jaaka mafelo a a botlhokwa a go ruta batho saense. Thulaganyo eno ya go ithuta ka maemo a a farologaneng e e leng mo thulaganyong ya go tlhalosa dilo e bua thata ka maiteko a Serapa sa Bosetshaba sa Diphologolo a go tokafatsa bokgoni jwa yone jaaka setheo sa thuto, e sekaseka dikgwetlho tse e lebaneng le tsone. Ka go dirisa mokgwa wa boleng, patlisiso eno e sekaseka dintlha tse di farologaneng tsa go dirwa le go diragadiwa ga thulaganyo eno ya maano. Mo patlisisong eno go ne go na le barutabana le baithuti go tswa kwa dikolong tse tharo mmogo le batlhankedi ba thuto ba ba berekang kwa Serapeng sa Bosetshaba sa Diphologolo. Tshedimosetso ya boleng e ne ya kokoanngwa ka go ela tlhoko, go botsolodiwa ka tsela e e rulagantsweng le tiriso ya dibukana mme ene ya sekasekwa ka go dirisa mokgwa wa typology approach.

Se se fitlheletsweng se bontsha gore thulaganyo eno, ena le dikarolo di le ditsi tse di akaretsang go tlhama kharikhulamo, tlhatlhobo ya barutabana, go neela batho dilo tse ba di tlhokang le go dira gore banne le seabe. Mo godimo ga moo, patlisisio e no e senola dikgwetlho tse di neng di le teng fa gone go kopanngwa thuto ya semmuso le dikarolo tsa boitapoloso tsa serapa sa diphologolo, le kafa dikgwetlho tseno di neng tsa rarabololwa ka teng ka go dirisa mekgwa e mesha ya go ruta. Mo godimo ga moo, esekaseka kafa thulagano eno e amang maitemogelo a baeti ka teng, dipoelo tsa go ithuta le kakaretso yotlhe ya separa sa diphologolo e tsewang ka teng jaaka setheo sa thuto. Patlisiso ya Serapa sa Diphologolo kwa Pretoria e re naya tshedimosetso e e maleba ka go tlhama le tsennya tirisong thulaganyo e e nonofileng ya thuto ya saense mo tikologong e e seng ya tlwaelo ya thuto., Botonical Garden le tse dingwe tse di tshwanang le tsone. Kgabagare, patlisiso e no e gatelela botlhokwa jwa go rulaganya dilo ka tsela e e tshwanetseng le go dirisana mmogo mo go direng gore gonne le pharologano fa gare ga go sireletso dilo tsa tlholego, boitapoloso le go ruta batho saense.

Mantso a botlhokwa : Barutisi bako Serapeng; di tisiso ta thuto; le felo la go e thuta saense; Serapa sa Bosetshaba sa Diphologolo; boledisano le go dira mmogo; bogone ba bo tsibi.

Ntshaho (Xitsonga)

Ndavisiso lowu, wu komba dyondyo na maendlelo ka ku tumbuluxa ndlela yo antswisa tidyondzo ta sayense ka tidhawu to dyodya sayense ku fana na ntanga wa swihari wale Pretoria. Swi kolo swo tala swi vhakela ntanga wa swihari ku yak u hungaseni, a swi swi tivi kuri ntanga lowu wuna vutshila bya sayense. Vadyonndzisi vale xikolweni a va ngheneleli ka swi ave swa dyondzo loko va vhakele ntanga lowu, na vona van ava xikolo va tsakisiwa hi ku vona swi harhi ntsena a va ti nyiketeli ku twisisa sayense ley inga kona ka ntanga lowu. Hambi vari vadyondzisi vale ntangeni a va endli leswaku vana va titwa vari na ku navela ku dyondza sayense.

Xikongomelo xa vulavisisi-dyondzo leyi i ku tumbuluxa maedlelo lawa ma nga tirhisiwaka ku hlohlotela vudyondzisi na ku dyondza sayense ka ntanga lowu. Mulavisisi u tirhisi qualitative case study hi ku tirhisa constructivism ku tumbuluxa maedlelo lawa. Interpretative paradigm yi tirhisiwile ka vulavisisi lebyi. Swikolo swinhanru swa ku hambana ku huma ka tiprovinsi to hambana leswi nga vhakela ntanga swi tirhisiwile ka xiphemu xo sungula. Va nghenelerí a kuri vana va xikilo, vadyondzi va von vana na vadyondzisi vale ntangeni. Swi nwana swikolo swi nharhu swi nghenelele ka xiphemu xa vumbirhi.

Marungula ya kumeke hi ku langutisa matirhele, ku vutisa swi vutisa na ku tsala hansi hi masiku leswi endlekaka entangeni. Marungula ku suka ka swiphemu leswi nharhu ya hleriwe hi ku tirhisa mahlelelo ya typology. Marungula lawa ya kote ku tumbuluxa madyondziselo na ku dyondza ka sayense a ntangeni lama vuriwaka TLSSC. Vuxokoxoko byi kombile leswaku ntanga lowu a wu tirhisiwi hi ku hetiseka ku dyondzisa no dyondza siyense. Maritiselo ya TLSSC ya kombe leswaku ku laveka ku tirha kunwe ka vadyonzisi lava vhakaku na vana ntangeni, vana va xikolo na vadyondzisi vale ntangeni. Vulavisisi-dyondzo byi hlohlotela leswaku kuva na timiting xikari ka ndzawulo ya dyondzo, va dyondzisi vale xikiloni, va dyondzisi vale ntangeni ku vulavula hi ma dyondziselo na ku dyondza ka sayeni e ntangeni wa swihari. Ti dyondzo ti nwana ti nga ha endliwa ku antswisa TLSSC leyi nga tumbuluxiwa.

Maritonkulu : Vadyondzisi wale ntangeni; swikomnisiwa; ndhawu ya sayense; ntanga wa swiharhi; kutirha kunwe na mbulavurisano; mavumbelo ya vutivi.

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ACRONYMS

CBD	Central Business District
DBE	Department of Basic Education
DFFE	Department of Forestry Fishery and Environment
DSC	Discovery Science Centre
DST	Department of Science and Technology
EO	Education Officer
GEM	Grand Egyptian Museum
MOU	Memorandum of Understanding
NRF	National Research Foundation
NSW	National Science Week
NZG	National Zoological Garden
PSC	Planetarium Science Centre
SAASTA	South African Agency for Science and Technology Advancement
SANBI	South African National Biodiversity Institute
SCKC	Science centre Knowledge Construction
STEM	Science Technology Engineering and Mathematics
SWOT	Strength, Weakness, Opportunities and Threats
TIMSS	Trends in International Mathematics and Science Study
TLSSC	Teaching and Learning Science in a Science Centre
WESC	Wadi Environnemental Science Centre

CHAPTER 1: INTRODUCTION

1.1 Introduction

In an era marked by rapid advancements in science and technology, the cultivation of a scientifically literate populace has emerged as a critical imperative. The traditional paradigms of science education, often confined to classroom settings and textbooks, are proving insufficient in capturing the imagination and fostering a deep understanding of scientific concepts among learners. As society becomes increasingly interconnected with the natural world and its intricate systems, there is an amplified need for innovative educational approaches that can engage and inspire learners on a profound level. The National Zoological Garden (NZG), with its diverse collection of animal species, ecosystems, and interactive exhibits, stands as a beacon of experiential learning. It has the inherent capacity to kindle curiosity, incite wonder, and facilitate a tangible connection between learners and the natural world. This study seeks to harness this inherent potential and unravel how a well-structured strategic framework can magnify the educational impact of such a dynamic setting.

Global development in science and technology happens rapidly. According to Talib (2020), one of the major goals of science education is the improvement of scientific literacy among learners. Scientific literacy entails a multitude of intellectual resources which include, but not limited to, the ability to conceptualize phenomena and reasoning from scientific epistemology (DeBoer, 2016). The relationship that exists between learners and science and technology (S&T) subjects is central to the maximisation of participation and development of scientists in the country (Potvin & Hasni, 2014). As societies make a transition from industry-based economy to knowledge-based economy, science engagement through interaction and discourse is fundamental in building a competent society (Falk & Dierking, 2017). There is a growing awareness by researchers that science education should not just be centre around passing exams and promoting learners from one grade to the other in a formal schooling system, but it must foster lifelong learning for economic change (Vedder-Weiss & Fortus, 2010).

The formal classroom setting is not the only educational setting in which scientific literacy can be improved. According to Gerber (2011), the majority of learners

experience science outside of formal classroom settings. Outdoor settings such as the National Zoological Garden, science centres and museums play an important role in developing learners' attitudes and understanding of science through learning and teaching of scientific principles and concepts. These outdoor settings are referred to as informal settings (Cullen, 2005). Researchers such as Parcher (2018), Parker and Ballentyne (2012) and Cullen (2005) argue that science centres and museums such as the National Zoological Garden play an important role in developing learners' attitudes and understanding of scientific concepts. They further argue that, due to their nature and what they are able to offer, these institutions have the potential to inspire and excite learners to study science. Science centres and museums are excellent places to learn about science because they give learners a special setting outside of the confines of the traditional classroom (Boileau, 2017). Hence, they can be integrated into the school curriculum to assist in the facilitation of learning and develop learners' attitudes and understanding of science and technology concepts (Cullen, 2005). It is for this reason that this study sought to develop and implement a framework for enhancing science teaching and learning at centres such as the National Zoological Garden.

1.2 Background of the study

The education system plays an increasingly important role in the production of a skilled labour force in science and technology (Kholmirzayev *at el,* 2022) The enhancement of the understanding of science and technology in the learning process remains the main agenda for the global education system (Talib, 2020). The need to cultivate learners' attitudes and understanding of science through dialogue and motivation through interaction to learn science is the key drive for the development of a knowledge-based society (Falk & Dierking, 2017). According to Jevons (2022) Natural science teachings must help learners to develop a better understanding of science holistically.

Achievement in science and technology is one of the key indicators to assess the impact of the education system in a country towards the acceleration of a knowledge-based economy (Falk & Dierking, 2017). However, there is a serious concern about the quality of science education in South Africa. It has been found that South African learners continue to underperform in science and mathematics education (Reddy,

2021). South Africa was ranked last out of 38 countries that participated in the Trends in International Mathematics and Science Study (TIMSS) (Reddy, 2005). In 2011, forty countries including South Africa and Botswana participated in the Trends in International Mathematics and Science study. In the 2011 TIMSS study, South Africa scored below Botswana in Mathematics and scored the lowest of all countries in science (Schulze & Heerden, 2015). In the 2015 TIMSS study, South Africa showed marginal improvement as compared to its performance in the 2011 TIMSS study (Reddy et al., 2016). It is important to point out that South Africa was still one of the five lowest-performing countries in science and mathematics in the 2015 TIMSS study.

Schulze and Heerden (2015) argue that in light of the poor performance by South African learners in science and mathematics, science teaching and learning must be enhanced. A better understanding of how learners interact and discuss science concepts could influence teaching and enhance scientific literacy and academic achievement of South African learners. Science centres and museums have an important role to play in motivating learners to study science and their leisurely setting provides a medium through which learners can acquire scientific information and develop ideas for themselves and their societies (Parker & Ballantyne, 2012). These centres have positioned themselves well in societies' collective knowledge and as sites for the promotion of public understanding of science. They complement formal education by promoting the development of scientific literacy (Bencze & Lemelin, 2001). Therefore, it is vital for learners to visit these centres to be motivated and acquire a better understanding of science.

Science centres and museums that focus on interactive activities and exhibits which are simulative and have touch-feel experience are being celebrated for being able to engage learners in science concepts and principles (Watermeyer, 2012). In addition, Interactive lessons and exhibits are commended for being more pedagogically effective than more traditional means of knowledge transfer due to their hands-on aspect (Watermeyer, 2012). A direct interaction with the phenomenon, as opposed to merely thinking about it, is the focus of the experiential learning paradigm that science centres and museums provide (Jevons, 2022). This experiential learning style offers a distinctive platform for engaging with science (Addison, 2002). According to Watermeyer (2012), the operating philosophy of science centres and museums promotes social contact that inspires scientific conversation.

Researchers such as Eshach (2016), Addison (2002) and Watermayer (2012) argue that educational settings in science centres and museums can lead to improvement in learners' attitudes and understanding of scientific concepts. However, little is known about educational settings in science centres and museums within the South African context. Mosabala (2014) observed that most schools visit science centres and museums as part of school tradition within a South African context. Hence, the study sought to develop and implement a framework for the enhancement of science teaching and learning at the National Zoological Garden.

1.3 Problem statement

The number of learners doing science at the school level in South Africa is declining (Department of Science and Technology, 2016). According to Maluleke (2019), some high school learners perceive science to be a difficult and demanding subject. Mushaikwa (2014) argues that learners leave science subjects and mathematics to choose other subjects that are perceived to be less demanding with the belief that they will do better in those subjects. Learners view science and mathematics as abstract subjects which do not have any link to their everyday life. There is a lack of science and mathematics activities that can arouse learners' interest in science (Mushaikwa, 2014). Science education in South Africa is in a state of crisis (Fish, 2017). According to Schulze and Heerden (2015), science education in South Africa needs serious attention.

Science centres are created to mitigate negative perceptions about science. In brief, the purpose of science centres is to popularise science by making it more interesting and to encourage learners to study science and choose science careers (DST, 2016). Science centres seek to achieve this objective through the deployment of science exhibits and lessons that are linked to the school curriculum (DST, 2014). As a researcher, I have observed that some of the schools visiting the National Zoological Garden had no idea about how the institution can help learners learn and understand science on a practical level. Schools visit the centres just to relax and be out of the formal educational setting (Mosabala, 2014). In addition, the visiting schools do not explore learning opportunities provided by the National Zoological Garden. For example, learners do not fully interact with science displays and exhibits at these centres. Some schools view these centres as places for relaxation and not learning

institutions. Employees (education officers) at the centre do not pay much attention to the interaction between learners and the environment. The teachers who accompany learners at the centre do not interact with their learners or the education officers at the centre. According to Ellis (2020), learners are left alone to figure out exhibits and linkage to the curriculum. There is a need for teachers and learners to embrace and fully harness learning opportunities provided by the National Zoological Garden in particular.

1.4 Aim of the study

The study aims to develop and implement a framework for enhancing science teaching and learning at a National Zoological Garden.

1.5 Research Questions

The following research questions guided the study.

1.5.1 What are the opportunities and challenges associated with science teaching and learning at a National Zoological Garden?

1.5.2 How can a framework for enhancing science teaching and learning at a National Zoological Garden be developed and implemented?

1.5.3 How does the developed framework for enhancing science teaching and learning at a National Zoological Garden influence learner interaction and discourse?

1.6 Objectives of the study

1.6.1 To explore opportunities and challenges associated with science teaching and learning at a National Zoological Garden.

1.6.2 To develop and implement a framework for enhancing science teaching and learning at a National Zoological Garden.

1.6.3 To explore the influence of the framework for enhancing science teaching and learning at a National Zoological Garden on learner interaction and discourse.

1.7 Rationale

According to Schulze and Heerden (2015), many changes have been made in the South African curriculum in an attempt to improve the teaching and learning of science in the classroom. The Department of Science and Technology (DST) reviews its science engagement strategy every five years to improve how science centres can engage with learners to enhance the quality of science education in South Africa (DST, 2016). The performance of South African learners in science and mathematics in international assessments such as the TIMMS study is not satisfactory (Reddy, 2021). One of the strategic aims of science centres is to popularise science to make it more relevant and attractive to encourage learners to pursue science careers. It is envisaged that science centres should stimulate learners' interest in science through the provision of new learning experiences and the promotion of lifelong learning (DST, 2016). Science centres have science exhibits that are used to teach learners about science concepts and principles. This study is relevant as it provides valuable insights into how the National Zoological Garden can make a meaningful contribution to the improvement of science teaching and learning within the broader South African context. The study provides plausible mechanisms on how pervasive gaps in learners' interaction and discourse highlighted by Falk and Dierking (2017) and Packer (2018) can be adequately addressed.

The study addresses a significant need for innovative and effective science education methods that can engage learners and foster a deeper understanding of scientific concepts. This study is particularly relevant in the context of the National Zoological Garden in Pretoria, a renowned educational institution that has the potential to play a pivotal role in enhancing science education. Traditional classroom settings often struggle to engage learners in the complexities of science. By focusing on a case study involving a zoological garden, this research acknowledges the potential of informal learning environments in promoting science education. The National Zoological Garden in Pretoria, with its diverse collection of animal species and natural habitats, presents a unique opportunity to create an immersive and interactive learning experience. Across the globe, there is a growing concern about the declining interest and proficiency in science-related subjects. This study aims to bridge this gap by exploring how the National Zoological Garden can be strategically transformed into an effective science education platform. By leveraging the inherent fascination that

animals and ecosystems evoke, the study seeks to inspire and captivate learners' curiosity about the natural world. Science education is not limited to textbook knowledge; it encompasses observation, critical thinking, and hands-on experiences. The National Zoological Garden, as an experiential learning space, offers the potential for learners to engage with scientific concepts holistically.

This study intends to design a strategic framework that integrates various elements, such as guided tours, interactive exhibits, workshops, and educational technology, to foster a comprehensive learning experience. In an era where STEM (Science, Technology, Engineering, and Mathematics) careers drive innovation and progress, fostering an early interest in science is crucial. By enhancing the educational offerings of the National Zoological Garden, this study seeks to contribute to nurturing the next generation of scientists, researchers, and science enthusiasts. The outcomes of this study hold the potential for broader implications in science education. The strategic framework developed for the National Zoological Garden can serve as a model for other educational institutions, science centres, museums, and zoos worldwide, aiming to improve their science education programs. It will provide insights into effective methodologies, curriculum integration, and engagement strategies that can be adapted to diverse learning environments. The effectiveness of the proposed strategic framework can be measured through various quantitative and qualitative methods. Assessment of changes in learners' knowledge retention, attitude towards science, and engagement levels can provide valuable insights into the success of the initiative. Additionally, feedback from teachers, visitors, and stakeholders will contribute to refining the framework over time. In conclusion, the study addresses a pressing need for innovative approaches to science education. By leveraging the potential of informal learning environments and strategically enhancing the educational offerings of the National Zoological Garden, this research aims to foster a generation of scientifically literate individuals who are passionate about the natural world and equipped to tackle future challenges.

1.8 Delimitations of the study

The National Zoological Gardens, one of Pretoria's science centres, was the subject of this study since more than 200,000 teachers and learners visit there each year. The researcher had easy access to the centre. The three education officers who agreed to engage in the study, along with learners and teachers from the six schools, were the main subjects of the study. Education officers are the facilitators who interact with schools at the science centre daily. The study sought to develop and implement a strategic framework for enhancing science teaching and learning in science centres. Each education officer had an interview as well as a lesson observation. This was carried out to guarantee the comfort of all study participants. Teachers and learners were also interviewed and observed on the engagement.

1.9 Structure of the thesis

The breakdown in terms of the structure of the thesis is provided below.

Chapter 1: This chapter provides an orientated introduction, background, problem statement, aims, research questions, objectives, rationale and delimitation of the study.

Chapter 2: This chapter provides a review of relevant literature related to the study.

Chapter 3: This chapter provides a reflection on the theoretical and conceptual frameworks underpinning the study.

Chapter 4: This chapter provides a description of the research design and the justification of the research methods employed in this study.

Chapter 5: This chapter provides the results emanating from phase one of the study.

Chapter 6: This chapter outlines the development of the strategic framework for enhancing science teaching and learning at the National Zoological Garden.

Chapter 7 This chapter provides the results emanating from phase two of the study.

Chapter 8: This chapter reflects on key findings, conclusion and recommendations arising from the study.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

This chapter provides the theoretical underpinnings and a review of the literature relevant to the study. The literature review provides a reflection on out-of-school science learning as well as the role of science centres and museums in the development of scientific literacy and the promotion of public understanding of science. The role of education officers working at science centres and museums and learner interaction and discourse are unpacked.

2.2 Out-of-school science learning

According to Geveke *et al* (2017), non-formal and informal learning are part of out-of-school learning that occurs outside the formal classroom. Out-of-school learning is characterized by the amount of learning that learners experience when they are not in the formal science classroom. Yapicis (2018) defines out-of-school learning settings as trips and activities that are conducted beyond the school walls which are planned for a specific objective. Although out-of-school learning is an informal education, it involves planned education activities. Laanements (2018) differentiates two types of learning as informal and formal learning. Laanements (2018) contends that a person acquires knowledge, skills, and attitudes through everyday encounters, which is referred to as informal learning. These daily experiences include any organised and systematic education activities carried outside the formal education system such as in museums and science centres (Parker, 2012). Formal learning is characterized by an institutionalised and chronologically graded system which is evaluative in nature. These forms of education can contribute to the humanisation, socialisation and enculturation of young people within societies (Laanements, 2018).

According to Ellis (2020), all learning experiences that happen outside the formal school system form part of out-of-school learning. Ellis (2020) further argues that learning that happens out-of-school is labelled as free-choice learning because of the emphasis on self-directed activities as opposed to the facilitated and evaluative structure of learning that takes place in formal schooling. Gerber *et al* (2017) contend that proper science learning institutions such as schools are characterised by their all-around organized educational program and are evaluative in nature. Non-formal and

out-of-school learning establishments such as science centres and museums are not rigid and less organized. Cox (2019) argues that there is a contrast between informal learning and non-formal learning. According to Eshach (2007) informal learning happens intuitively and happens in places that are inside our daily schedules such as our homes or roads while non-formal learning is semi-organized. School groups frequently visit non-formal establishments such as science centres and museums to learn science, culture and history (Islek & Danju, 2019).

Fortner (1997) noticed that formal classroom includes arranged illustrations while visits to non-formal institutions are typically short and once off. At science centres and museums, learners visit for a more limited period and once off to investigate science concepts and principles. In a formal school, learners return to a similar classroom throughout the school calendar year. Yapicis (2018) posits that out-of-school learning has the ability to motivate and increase learners' desire to learn in a free and non-evaluative manner. Pfeiffer (2011) argues that out-of-school learning settings have a positive impact on learners' cognitive development as they encourage learners to learn freely and develop knowledge at their own pace. Out-of-school science learning settings are illustrated in Figure 2.1 below.

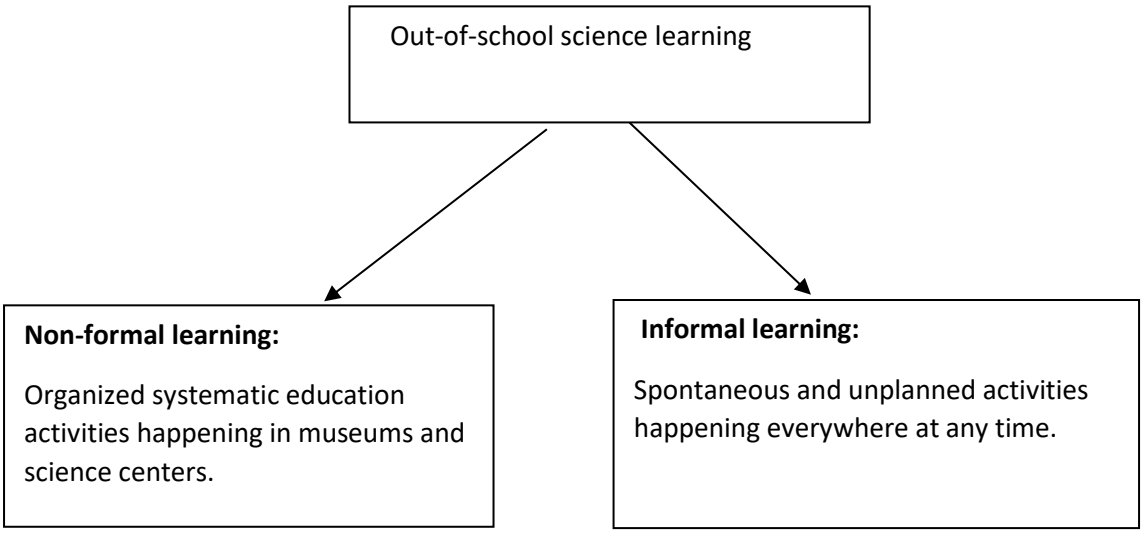


Figure 2.1: Out-of-school science learning settings (Pfeiffer, 2011).

2.3 The role played by science centres and Museums in science education

Science centres and museums expose learners to interesting science activities and exhibits. Science centres and museums are viewed as non-formal organizations that promote active involvement in self-directed science learning activities (Islek & Danju, 2019). According to Ellis (2020), self-directed learning of science is a cornerstone for contemporary Science, Technology, Engineering and Mathematics (STEM) education. This approach enables learners to acquire critical thinking skills which help them to be creative problem solvers and make them marketable in a workplace. Science centres and museums can offer an astonishing encounter with science learning outside the formal classroom (Hourdakis & Ieronimakis, 2020). Encounter with science learning outside the formal classroom provides a casual connection and non-evaluative opportunity for growth and affords learners opportunities to effectively investigate science knowledge and ideas (Harington, 2001). Ramey-Gassert (2016) contends that out-of-school science learning settings such as science centres are suitable for teaching learners to notice and explore regular items and live specimens in a manner that textbooks and other teaching materials cannot do. Out-of-school science learning settings complement science school learning (Reiss, 2018). According to Reiss (2018), symbiotic and complementary relationships between formal and out-of-school science learning settings can revolutionise the way societies view science.

Science centres and museums can serve as sources of society's aggregate science and technology information as they can supplement the learning that takes place in the formal classroom by advancing science education (Eshach, 2016). Bencze and Lemelin (2011) contend that it is critical to empower learners who are in formal classrooms by organising visits to science centres and museums to foster deep learning. Visits to science centres and museums can also serve to develop learners' appreciation of science learning in the formal classroom environment (Hourdakis & Ieronimakis, 2020). Science centres and museums have the potential to provide opportunities for active involvement in hands-on activities (Ramey-Gassert, 2016). In particular, science centres and museums afford learners opportunities to interact with exhibits to develop their reasoning skills (Bencze & Lemelin, 2011).

Science centres can serve as productive forums for conversations and debates that let citizens learn about and take part in the democratic advancement of science (Bandelli & Konijin, 2011). Science centres and museums can enable learners to learn science effectively in harmless and non-evaluative environments (Anderson, et al, 2002). These centres can generally motivate young girls to do science subjects (Ramey-Gassert, 2016). There is a solid relationship between perspectives towards science and learners' performance in the science formal classroom. It was found, for example, that learners who are exposed to science outside the formal classroom are spurred towards science projects (Cox, 2019).

Science centres and museums that put particular emphasis on interactive activities and displays which are simulative and have contact feel experience are recommended in light of their capacity to connect with learners through the provision of logical information (Watermeyer, 2012). Interactive activities and displays at science centres and museums are credited for stimulating learners' interest in science (Watermeyer, 2012). Science centres, museums, zoological and botanical gardens have repositories of unique specimen, and artefacts which are exhibited to form a reference point for the accumulation and enhancement of scientific knowledge (Reiss, 2018). In addition, collections at these institutions provide learners with the opportunity to see and touch the exhibits and ask questions to develop their scientific and technological understanding (Reiss, 2018). Science centres and museums can offer a model of experiential discovery (Eshack, 2016). Science centres and museums are novel platforms for learning science outside the typical classroom settings (Cox, 2019). According to Gerber, et al (2001), the way science is communicated in science centres, museums, botanical gardens and zoological gardens is mostly seen as exciting, challenging and uplifting. Watermeyer (2012) argues that the usual methodology of science centres and museums supports social collaboration and lived experiences which can inspire logical talk.

Visits to science centres and museums have turned into a lifestyle (Griffin, 2009). Teachers and learners generally visit these centres for various reasons. Griffin (2009) outlined six reasons why schools visit these centres: 1. Exploration of science and advancements related to the formal classroom teachings; 2. Exploration of new opportunities for growth which affects learners' turn of events and future learning of science; 3. Embrace growth opportunities; 4. Stimulate learners' interest in science; 5.

Learn science outside the normal school setting; and 6. Foster lifelong science learning.

Visiting a science centre or museum provides an enduring impression to learners (Hourdakis & Ieronomakis, 2020). Science centres and museums can give a connection between the hypothetical part of science and its items of common sense and issues which influence us at our homes, networks and any remaining issues all over the planet. Hourdakis and Ieronomakis (2020) further contend that science centres can assist with creating perspectives, qualities and better comprehension of scientific phenomena such as environmental change. Science centres and museums can play a critical role in the enhancement of the quality of science education (Ash, 2003). In addition, Science centres can promote curiosity, enhance attitudes and motivation, and engage learners via involvement and teamwork (Franco, et al, 2018). According to Reiss (2018), science teaching and learning enhance collaborative practices when learners are involved in interactive activities. Cooperation and collaboration require effective communication to take place (Ellis, 2020). Education officers and teachers accompanying learners have a responsibility to keep learners interested by using puzzles or object phenomena (Schep, *et al,* 2018).

Science centres and museums can supplement the school curriculum and help learners comprehend logical ideas (Cullen, 2005). Science centres and museums help learners to understand “Big” science (Yapicis, 2018). The concept of “Big” science refers to the science that requires large and sophisticated instruments or machinery such as a telescope, electron microscope or DNA sequencing (Reiss, 2018; Yapicis, 2018). Learners can find “Big” science to be inspirational and it can motivate them to study science at the school level (Reiss, 2018). “Big” science is instrumental in encouraging learners to follow science and technology careers (Reiss, 2018. It also helps learners to appreciate the nature of science and its enterprise.

Many countries have witnessed a decline in the number of learners studying science (Hourdakis & Ieronomakis, 2020). Reiss (2018) argues that science centres and museums can play an important role in encouraging learners to study science as these institutions can provide a connection between school science and industrial science and technology and stimulate learners to think deeper about the relationship between science and communities. Visits to science centres and museums can develop

learners' intuitive understanding of science (Cox, 2019). The interactive activities, illustrations and techniques used in science centres and museums can benefit teachers as well (Ramey-Gassert, 1997).

Visiting a science centre can develop learners' logical reasoning skills (Mosabala, 2014). Reasons for visiting science centres include edutainment, support of the educational program, access to intuitive exercises, and access to career information (Mosabala, 2014).

On the other hand, science centres and museums are seen as edutainment institutions where entertainment is more emphasized than authentic science learning (Brooks, 2009). Museums have been criticized for being playgrounds where learners are being entertained as opposed to learning science (Mkhize, 2020). Reiss (2018) argues that if engagement through enjoyment of the interaction that takes place in science centres and museums is far more important than educational gain, then science centres and museums cannot claim to be authentic science learning institutions. Reiss (2018) further argues that if science learning is rarely substantial, misconceptions are initiated or fostered in science centres and museums.

2.4 A brief overview of science centres and museums in the world

Globally there are more than 3 000 science centres and museums in developed and developing countries. Most of these centres are in Europe, America, and parts of Asia (Persson, 2018). In an international workshop held in Vietnam in 2004 on "The changing role played by science centres and museums in developing countries", the participants of the workshop resolved that The interactive character of science centres and museums can be seen as a unique opportunity to advance scientific literacy, non-formal science education and possibilities for science professionals to continue learning throughout their careers (DST, 2015).

One of the well-known science centres in the world is the "American Museum of Natural History" situated in New York, USA (https://www.amnh.org**).** The museum has more than 45 exhibition halls and is visited by more than 5 million people every year. Its science education programme is rich in exciting activities and is developed to address the needs of the American K-12 education system. The museum covers

biological science, physics, chemistry, geology, mathematics and technology programmes (**https://www.amnh.org/learn-teach/resources-for-learning).**

In Latin America, it was confirmed that science centres and museums are key institutions for science engagement. Both adults and school-going children use these institutions to learn more about science. Science communication is highly promoted by the governments and private sectors (Gouveia & Kurtenbarch, 2013). In Brazil, for example, about 65% of the science centres and museums are located in the South East region. This area has about 40% of the Brazilian population (Carletti & Massarani, 2015). There are more interactive science centres and museums in the Southern region of Brazil, of which 8 have a planetarium, three science museums, four natural history museums, 5 planetariums, 6 zoos, 8 botanical gardens and two history museums (Carletti & Massarani, 2015).

One of the well-known science centres in Rio de Janeiro, Brazil, is the Planetarium Foundation which was established in 1970. The aim of this science centre is to popularise astronomy and related sciences and develop cultural projects. The scientific centre supports initiatives including "Music in the Stars" and "Sleeping with the Stars," as well as interactive experiments, telescopic observations, courses, talks, exhibitions, and summer camps. Teachers and learners visit this centre to learn about practical concepts of astronomy which are incorporated in the school curriculum (Carletti & Massarani, 2015). The Planetarium Foundation is also a research tool and disseminates information about astronomical sciences and other related sciences. Visitors' courses, temporary exhibitions, a permanent exhibit with 56 interactive experiments, dome sessions, escorted tours of the museum with exhibits, and monthly astronomical observations are among the activities organized by the Planetarium Foundation.

It is interesting to learn that the Planetarium Foundation prioritises the school curriculum in its engagement with learners. It shows that teachers and learners visit the centre not only to learn about science in general, but also to reinforce what is learned in formal classrooms. Interactive experiments and telescope observations should be very interesting to the learners because they are hands-on and fun. Activities such as summer camps could be used to encourage discussion of science concepts amongst learners outside their formal classrooms. The use of the Planetarium Foundation as a research tool and dissemination of information about

astronomical sciences is encouraging because learners can have the opportunity to meet scientists and learn about scientific observations and data collection techniques.

Scientific development is well advanced in Europe. Two of the largest museums, namely, the Science Museum and the Natural History Museum, both located in London, are well known for their interactive exhibits. According to Bandelli and Konijin (2018), One of London's top museums is the Science Museum, located on Exhibition Road in South Kensington. It was established in 1857 and now draws 3.3 million tourists a year, making it one of the city's top tourist destinations. One of the well-known exhibits in the Science Museum in London is the Apollo 11 Lunar Module Eagle, the first crewed vehicle to land on the moon in 1969 (Murphy, 2016). The display of the Apollo 11 is a replica of the original Apollo 11. Bandelli and Konijin (2018) argue that visitors are fascinated by this exhibit and learners are enthused and encouraged to study science further by these types of exhibits. At the Science Museum in London, for example, The Dana Center was specifically constructed with the intention of fostering interactions between learners who are visiting and scientists, researchers, museum employees, and other actors in the science fields. (Bandelli & Konijin, 2018). This centre is a place where visitors can debate scientific issues with the library providing a better understanding of science concepts (Murphy, 2016)

The Science Museum in London has exhibition halls for different fields of science where visiting teachers and learners get to visit an exhibition hall that covers topics of their interest. Lessons are designed according to the needs of the school curriculum. Visitors are able to interact with the exhibits and the officers at the centre. The education programme is edutainment inclined. Teachers and learners can also access the materials online. Specific lessons are offered according to publicised time slots. Entrance to the Science Museum is free (https://www.sciencemuseum.org.uk).

A characteristic feature of the Science Museum and Natural History Museum is interactive exhibits. It clearly shows that visiting learners are hands-on at these science centres, which is one of the best ways of learning science through touch and feel concepts through involvement in practical activities. The Apollo 11 replica at the Science Museum provides the “wow” experience to the learners because the science of landing on the moon in 1969 captured the whole world and revolutionised science. Getting to see and interact with the Apollo 11 exhibit is an experience never to be

missed. This kind of experience can encourage learners to pursue science careers. It is also interesting to learn that lessons at the Science Museum are designed to address the needs of the curriculum. Learners have the opportunity to see and interact with practical exhibits related to the theory learned in the formal classroom.

The National Science Centre in Delhi, India, is one of the largest and well-known science centres in Asia. It is popularly known as “A Dream of Castle for one and all” amongst its visitors. This centre is a unit of the National Council of Science Museum (NCSM). The council has 27 science centres and science cities under its umbrella and is funded by the Ministry of Culture of the government of India. The National Science Centre was established in 1992. The centre is visited by more than half a million people annually. Its visitors include families, school groups, scientists, and tourists (*https://nscd.gov.in)*. The primary objective of the National Science Museum in Delhi, is to popularise science amongst the general public through engagement, education and entertainment of the visitors by using thematic exhibitions, interactive educational activities and outreach programmes (Sardana, 2020). The major attraction of the National Science Museum is the “Water Gallery”, which is about the Earth being the only planet in the Universe that consists of water which enables life in its diversity to thrive. The second attraction is the “Emerging Technologies Gallery”, which is about the scope of innovations which guarantee to change human life in the future. The third attraction is the “Energy Ball Gallery”, which is about the lifting of the ball to 15 kilometres and rolling back to the ground to explain the transformation of potential energy into other forms of energy. The fourth attraction is the “Human Biology Gallery”, which explains the miracles of human life and many other attractions in the centre (Sardana, 2020). According to Huerta and Cohen-Pantaja (2018), the gallery has a significant impact on the development of visitors’ knowledge and understanding of science concepts.

There are many lessons to be learned about science centres and museums in India. It is interesting to note that there is a National body which coordinates science centres and museums in India and this body is funded by the government of India. This coordination creates a coherent way of running science activities and also creates a particular standard for all science centres and museums in the country. The National

Science Museum in Delhi has galleries focusing on different themes. Visiting learners are able to learn about a particular theme in the gallery without any disturbance from other exhibits which are not linked to the theme. For example, they can learn about Human Biology in one specific gallery.

There are more than twenty-five science centres in South Africa, nine in Egypt, four in Tunisia, two in Mauritius and two in Kenya (DST, 2019). According to Persson (2018), Africa appears to be the prime territory for the establishment of the network of interactive science centres. There is no doubt that a strong collaborative network of science centres in Africa would unlock the potential of millions of young people and promote science awareness in the continent (DST, 2019). Two well-known science centres in Egypt are the Planetarium Science Centre (PSC) and the WADI Environmental Science Centre (WESC). The PSC was founded in 2006 in Cairo, Egypt. The PSC fulfils its strategic mandate by encouraging curiosity, imagination and creativity through a number of diverse activities presented in three sections. Namely: (1) The Planetarium which is aimed at establishing scientific culture in Egypt by offering scientific shows to the visitors, (2) The History of Natural Museum which is the permanent exhibition that highlights the historical aspects of science in Egypt and is aimed at reviving the ancient discoveries of scientific scholars of Egypt, and (3) The ALEXploratorium which is a hands-on facility targeted at school children to encourage them to study science **(**https://www.bibalex.org).

The WADI Environmental Science Centre (WESC) is an Egyptian non-governmental organisation (NGO) founded in 1998. The centre is situated in Cairo. It is dedicated to progressive outdoor environmental education (*wesc***-**egypt***.****com).* According to Mallenson (2021), the goal of WESC is to complement and build on what is currently taught to Egyptian learners in the science field. Pedagogical approaches in the WESC include cooperative learning, collaboration, hands-on activities and inquiry-based discovery. Mallenson (2021) argues that learners are taught about their environment and cultural heritage through science using topics such as water, renewable energy, waste management, pollution issues, biodiversity and climate change. This centre is visited by more than 14 000 learners annually. The biggest project undertaken by the Egyptian government lately is the construction of the Grand Egyptian Museum (GEM). The GEM is the largest archaeological museum in the world (EL-Sheikh, 2020). It

houses artefacts from ancient Egypt. The museum is located on a plot of 480 000 square metres. The museum open its doors during 2022.

The Planetarium Science Centre in Egypt has a specific gallery dedicated to historical science. The interesting part of the Planetarium Science Centre that addresses science education is the ALEX-Ploratorium section which is specifically designed for school groups that visit the centre. This section of the centre has interactive and hands-on activities that encourage learners to study science. The WADI Environmental Centre coordinates outdoor environmental activities for learners which are linked to the school curriculum. Environmental sciences are mostly neglected by other science centres. WADI Environmental Centre plays an important role in addressing other environmental issues such as waste management which remains a fundamental challenge in many developing countries.

Kenya has two registered and recognised science centres, namely, the Discovery Centre and the Trinity Science Centre, both based in Nairobi. Little is known about the Trinity Science Centre (**https://sciencecentrekenya.wixsite.com**). The Discovery Science Centre is known as Science Centre Kenya. The Discovery Science Centre aims to simplify the communication of science by making it exciting and interesting to ensure that children understand scientific concepts and are inspired to develop an interest in science. The Discovery Science Centre runs programmes such as exhibitions, science shows, school laboratory experiments, science clubs at schools, field trips and educational toys for young children (https://www.thediscoverycentre.co.ke). The Discovery Science Centre is operational and is targeting learners at an early age. The Discovery Science Centre simplifies science for young children and makes it exciting through shows and experiments. The use of shows, experiments and exhibits assist learners to love science from a young age.

The Department of Science and Technology (DST) in South Africa identified a network of science centres as important infrastructures required to promote public understanding of science and technology (DST, 2019). Th A science centre is a "permanently established educational facility that provides an interactive educational experience through the use of interactive exhibits, displays, and programs in science, technology, engineering, and mathematics," according to the National Norms and

Standard. The are currently more than 25 established science centres in South Africa (DST, 2019). According to DST (2019), science centres in South Africa are coordinated by South African Agency for Science and Technology Advancement (SAASTA), which is a business unit of the National Research Foundation (NRF). DST assists science centres with funding through grants and other special programmes that promote science within the country. Some of the well-known South African science centres are summarised on Table 2.1 below. The table indicates the geographic location, name of the science centre, strength and weakness as observed by the researcher and the lesson learned.

Table 2.1: South African Science Centres (Bilankulu, 2023)

No.	Province	Organization	Strength	Weakness	Lessons Learned
1	Mpumalanga	Anglo-American Science Centre	Have good relationships with surrounding communities.	Lack of exhibits and infrastructure.	Is important for the centres to build a good relationship with visitors.
2	KZN	ArcelorMittal Newcastle Science Centre	Well organised and lessons aligned with the curriculum.	Not enough room for exploration. Using old methodology.	Aligning lessons to the curriculum is important.
3	Western Cape	ArcelorMittal Saldanha Bay Science Centre	Well organised and lessons aligned with the curriculum.	Not enough room for exploration. Using old methodology	Aligning lessons to the curriculum is important.

4	Gauteng	ArcelorMittal Science Centre Sebokeng	Well organised and lessons aligned with the curriculum.	Not enough room for exploration. Using old methodology.	Aligning lessons to the curriculum is important.
5	Western Cape	Cape Town Science Centre	Interactive exhibits and activities	Limited space for the exhibits	Interactive exhibits makes science fun
6	Limpopo	Giyani Science Centre	Good infrastructure	Exhibits not in good condition	Looking after exhibits and resources makes interaction easy
7	Western Cape	iThemba Labs	Well-resourced Labs and good relationship with schools	Not easily accessible by the public	Resources makes teaching easy and interesting.
8	Gauteng	Johannesburg City Parks and Zoo	Outdoor exhibits and relaxed environment	Using show and tell method of teaching	Outdoor learning makes science fun and relevant.
9	Mpumalanga	Mondi Science Centre	Good relationship with surrounding schools	Lack resources and interactive exhibits	Building partnership with surrounding schools for science advancement.
10	Northern Cape	Mothibistad Science Centre	Stationed in the township closed to previously	Lack resources and interactive exhibits	Without resource and exhibits is difficult for a science centre to operate optimally.

			disadvantaged schools		
11	Gauteng	National Zoological Gardenlogical Gardens	Outdoor exhibits, relaxed environment and interactive activities	Less interaction with visitors and method of teaching outdated.	Outdoor learning makes science fun. Connecting with nature makes science interesting.
12	Eastern Cape	Nelson Mandela Bay Science Centre	Good Relationship with surrounding schools	Lack resources and have small space	The importance of building a good relationship with visiting schools
13	North West	NWU Mafikeng Science Centre	Well position in the university with enough human resource	Lack of interactive exhibits	Good management attract human resource
14	North West	NWU Potchefstroom Science Centre	Well position in the university with enough human resource	Lack of interactive exhibits and interactive activities	Good management attract human resource
15	Mpumalanga	Osizweni Education Development Centre			
16	Gauteng	Sci-Bono Discovery Centre	Well-resourced with exhibits and Labs for experiments	Old teaching method	Resources and exhibits attract visitors

			and outreach activities		
17	Gauteng	Sci-Enza Science Centre	Well-resourced with exhibits, activities and outreach activities	Limited space	Activities make science interesting
18	Western Cape	South African Astronomical Observatory	Well-resourced with telescopes	Old teaching method not effective	Relevant resources attract visitors
20	KZN	The KZN Science Centre	Enough scape with exhibits	Old teaching method not effective	Enough space and exhibits create a good learning environment
21	Gauteng	University of JHB Soweto Science Centre	Well positioned in the township	Lack exhibits and interactive exhibits	The area makes it easy accessible by visitors.
22	Limpopo	University of Limpopo Science Centre	Well managed with strong outreach activities	Lack exhibits and interactive activities	Strong outreach activities assist to reach out to communities
23	KZN	Unizulu Science Centre	Well positioned in the university with human resource	Old teaching method and lack of exhibit	Human resource are important to advance science awareness
24	Limpopo	Vuwani Science Centre	Well positioned in the rural area	Lack of exhibits and still using old	They reach many schools with their outreach activities

			of Limpopo. Strong outreach activities	method of teaching	and they are good at improvising
26	Free State	Kopanang Science Centre	Good relationship with schools in the area	Lack of exhibits and activities	Partnership with other stakeholders assist in science advancement.

Science encompasses natural sciences, biological sciences, life sciences, technology, engineering, and mathematical sciences in the setting of a network of science centres. The goal of South African Science Centres is to advance science utilizing outcomes-based education, which is the cornerstone of the country's curricula. This curriculum adopts a learner-centred and activity-based approach to teaching in an effort to help all learners realize their full learning potential. (DST, 2005). A structured school-based science engagement strategy has been established in collaboration with the Department of Basic Education (DBE). The DST and DBE have signed a Memorandum of Understanding (MoU) that allows the two departments to work together in promoting science education in South Africa (DST, 2015). The engagement strategy encourages science centres to focus on four pillars when promoting science to school learners, namely: Nurturing learners' problem-solving skills, stimulating learners' scientific curiosity, training learners in science communication and exposing learners to science projects (DST, 2015).

2.5 The role of teachers and education officers in science education

A successful visit to a science centre or museum involves the participation of learners, teachers and science centre staff (Graffin, 2014). According to Graffin (2014), the success of a visit to a science centre or museum is influenced by aspects such as planning of learning during the visit, consideration of the unique learning opportunities for teachers and learners and the careful use of the learning worksheets. Tal, *et al* (2005) argue that meaningful learning in science centres and museums happen when teachers get involved in the preparations for the visit. Many science centres' and museums' programs are developed to support and reinforce the school curriculum (Rennie & McClaffety, 1995).

According to Rennie and McClaffey (2002), teachers believe that a visit to a science centre or museum can stimulate and motivate learners to study science and develop scientific and social skills. Tal *et al* (2005) argue that other reasons for teachers to visit science centres and museums include social experience and having fun. This makes teachers to be valuable visitors to science centres and museums. McClaffey (2014) argues that most science centres neglect teachers and focus on learners. McClaffey (2014) further argues that in a meaningful visit to a science centre or museum, learners should be encouraged to investigate the exhibits on their own and also in small groups. Learners should engage in social interaction with their peers, teachers and guides and they must be encouraged to ask questions and interact with the exhibits.

Schep *et al* (2018) found that very little is done in the preparation for the visit to museums. Most teachers hardly understand the objective of the visit to the museum. Some teachers only focus on issues such as clothing and food for the excursion. Teachers hardly perceive museum activities as engaging sociocultural learning experiences. Teachers are never engaged in the learning activities coordinated by museums (McClaffey, 2014). Falk and Dierking (2000) also found that some teachers only visit museums to have fun and leave the responsibility of the learners to the museum guides. Science centre and museum staff, guides, science communicators and education officers represent the science centre or museum and should act accordingly in order to advance science engagement (Schep, *et al*, 2018). According to Tran and King (2007), education officers at science centres and museums should be able to connect and build on the experiences and wishes of different visiting school groups and be flexible with the programme. Schep *et al* (2018) argue that the physical context which is the shape and the size, the number of visiting learners and the different exhibits influence opportunities for science learning in the centre. Education officers should be able to take advantage of their institution to enhance science learning.

According to Schep *et al* (2018), the exhibits in science centres and museums make these institutions a special place for science learning. Therefore, education officers must be competent to utilize these resources for science teaching. Tran and King (2007) argue that for education officers to do their job successfully, they must have

sufficient knowledge. Tran and King (2007) clarifies the type of knowledge required by the education officers as knowledge of the exhibits, knowledge of the curriculum, pedagogic knowledge and knowledge of current affairs. Flexibility in the use of knowledge is very important for education officers. Education officers must be able to strike a balance between sharing knowledge and allowing learners to interpret the exhibits. Figure 2.2 provides an illustration of education officer knowledge.

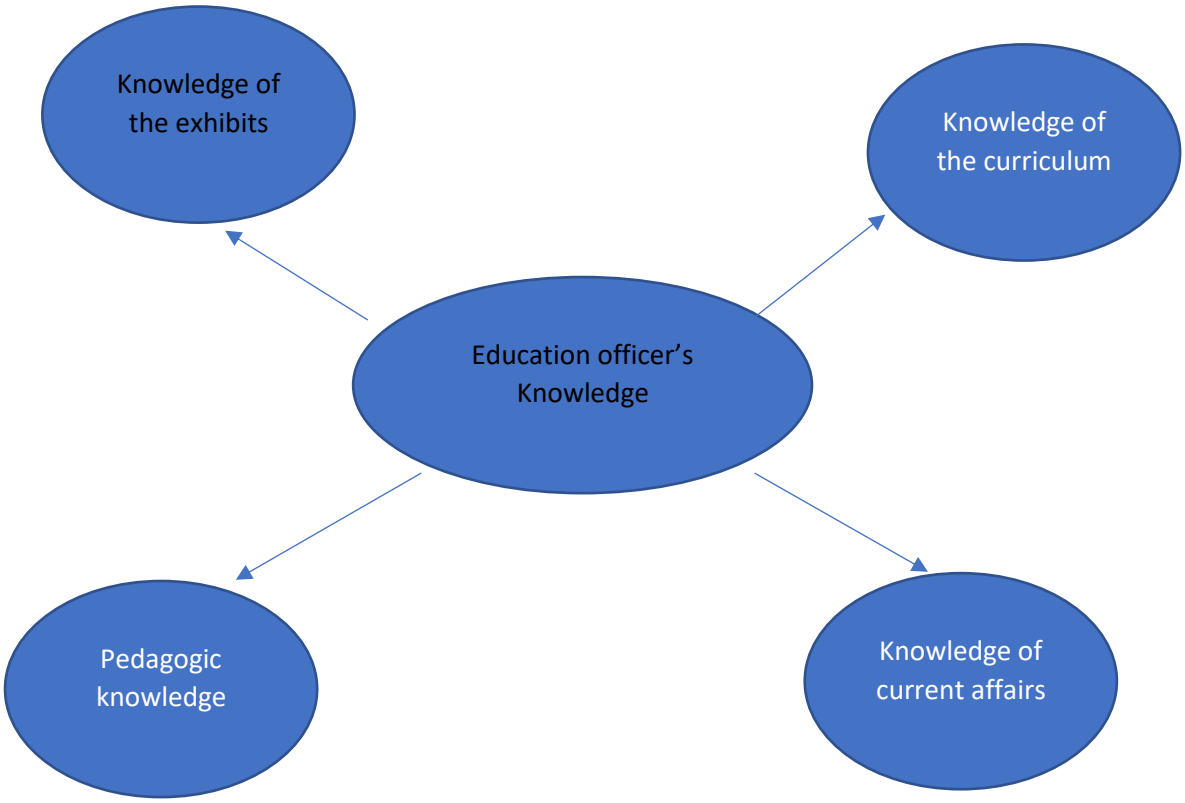


Figure 2.2: Illustration of education officer knowledge (Tran & King, 2007)

The teaching methods and materials used should be adapted to the learners' aptitudes and capacities (Schep *et al*, 2018). In addition, Learning institutions should design learning spaces that enable learners to engage with exhibits physically and cognitively through practical experimentation and reflection (Schep *et al*, 2018). Education officers at science centres and museums should make an effort to provide materials and instructions that demystify scientific concepts (Tran & King, 2007). Education officers are in charge of utilizing the necessary skills and resources to improve the impact and

efficacy of their interaction (Laanemets *et al,* 2018). For example, Independent projects used as one of the teaching methods can encourage learners to learn science (Tran & King, 2007). Using independent projects as educational tools might encourage learners to study science on their own (Tran & King, 2007).

Schep *et al* (2018) argue that apart from the knowledge required, education officers require excellent verbal and non-verbal communication skills. They should be able to speak clearly, be able to listen to the learners and be able to initiate a dialogue. According to Tran (2006), As a result of their awareness of and attention to the learners' prior knowledge, skills, and interests, education officers at science centres and museums are able to customize their pre-planned lessons for the specific school groups who are visiting their facilities. Their lessons' main objective is to increase interest in science education so that learners and teachers would be inspired to continue science by engaging in learning in a relaxed and judgmental-free environment. Education officers can make sure that their education activities, confidence and decision-making are of higher calibre consistently (Tran & King, 2007). Tran and King (2007) identified six components of knowledge which distinguish science centre education officers from normal science school teachers as illustrated in Figure 2.3. These six components are choice, context and objects, motivation, content, theories of learning and talk. The concept of diversity inspires each of these components.

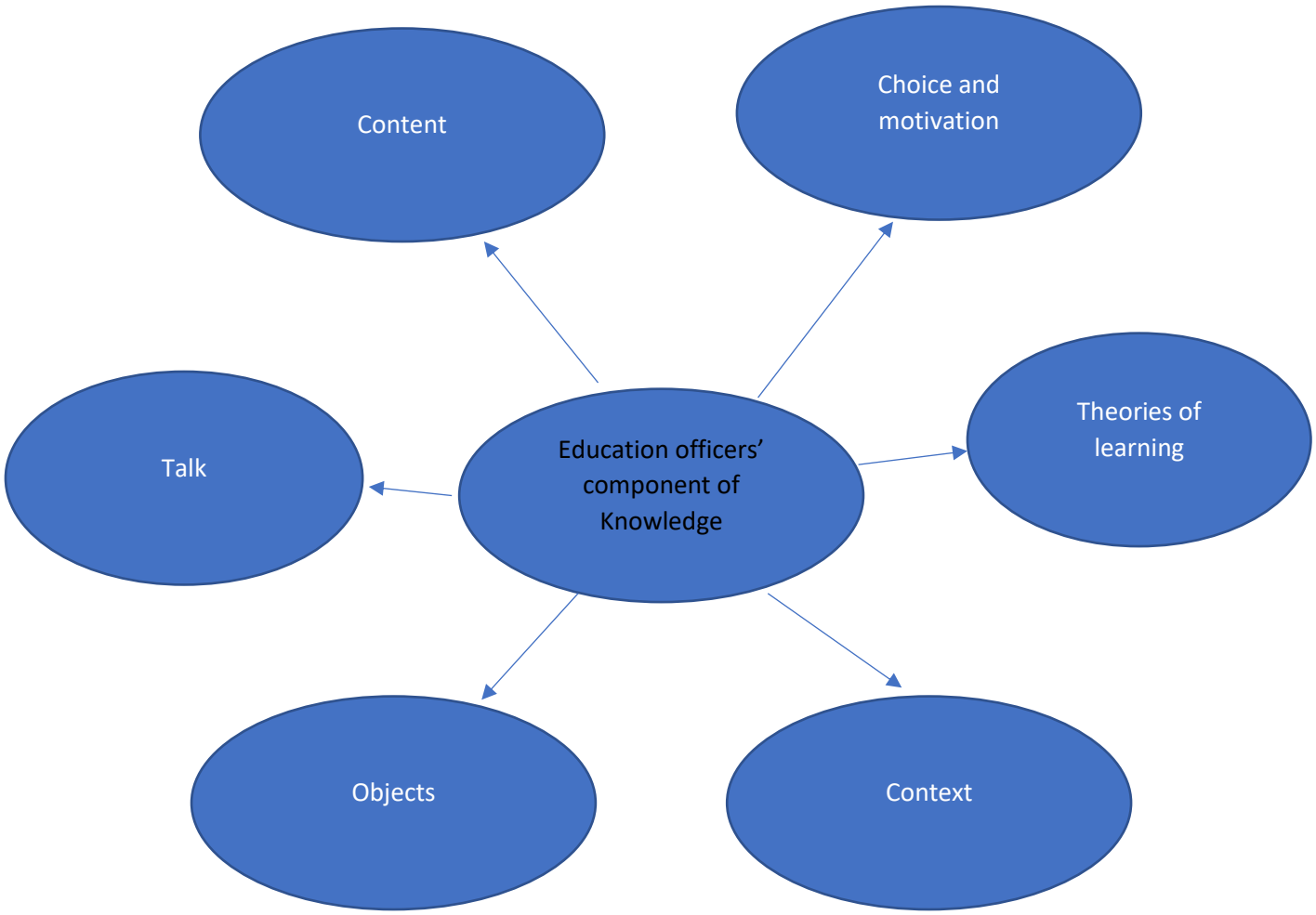


Figure. 2.3: Six components of knowledge that distinguish Science Centre education officers from formal school teachers (Tran & King, 2007)

Context: Whether lessons are taught within the building or outside, the building's design, together with the placement of the exhibits, typically serves as an inspirational and unforgettable experience (Tran & King, 2007). The social context in that setting is determined by the type of interaction between learners and the education officers. Additionally, these facilities serve as communal areas that reflect the neighbourhood in which they are located. According to Crooke (2006), The local, regional, national and international levels at which the science centre operates, including its goal and available funding as well as how the general public uses the facility, are referred to as the community context. Education officers should be aware of the various ways that the environment on the science centre may affect visitors when dealing with them.

Choice and motivation: Museums and science centres provide learners a variety of learning opportunities (Tran & King, 2007). The choice of what to learn and when to learn it is up to the learner. A learner's intrinsic drive is encouraged in this way. According to Tran and King (2007), although education officers may create the lesson and determine how the exhibits are exhibited, visitors can use the centre in their own way and at their own pace since they are motivated by their own intrinsic motivation to learn. In order to locate and capitalize on the visitors' interests, it is vital that the education officers feel at ease making changes to their connections.

Objects: According to Tran & King (2007), Objects are stored in science centres and museums and shown for their authenticity, relevance, interactivity, and cultural capital. In addition to the chance to gain a sense of scale, objects provide a level of knowledge not available in textbooks or in the classroom (Tran & King, 2007). Additionally, the object's size and connection to actual people and events make it truly memorable and improve the centre's experience (Tran & King, 2007). Ellis (2020), who contends that physical objects are recognized as the source of public knowledge because they visually provide scientific proof, supports this claim. Objects chosen especially for audience handling provide the learners with additional unforgettable experiences that they cannot have in other contexts.

Content: In comparison to their peers with little subject expertise, education officers with deeper topic knowledge employ higher degrees of operations and insights in their instruction (Tran & King, 2007; Eshack, 2007; Ellis, 2020; Cox, 2019, Griffin, 1998). According to Tran and King (2007), education officials must comprehend the subject matter, how they came to know it, why they think it is accurate, and its importance to both the scientific community and society at large. The experience of visitors is improved by education officials' ability to adapt to the preferences and interests of the visiting learners.

Theories of learning: Visitors to scientific centres and museums come from a variety of generations, social classes, economic statuses, and cultural backgrounds (Tran & King, 2007). To best support such a diverse group of visitors, education officers must integrate their practice with theoretical models of learning (Tran & King, 2007). Two theoretical stances—constructivism and socio-cultural theory—dominate teaching and

learning in science centres and museums, according to Hirsch and Silverman (2000). According to Piaget (1983), learning is an active process that involves interacting with and manipulating events and things in order to create a mental image of the world. This concept is provided by the constructivist approach to education officers. According to constructivist philosophy, visitors to science centres and museums learn by creating their own understanding (Cox, 2019). In social interactions, learning happens through discourse, in accordance with the sociocultural paradigm (Vygotsky, 1978). Education officers assist learners in shaping their thinking through social activities at science centres and museums using objects and symbols created by the local culture (Tran & King, 2007).

Talk: The spoken word is preferred in museums' social learning context, contrary to schools where the written word is prioritized (Tran & King, 2007:142). To connect learners with the items, content, and context, education officers at science centres and museums mostly rely on talk-based interactions (Tran & King, 2007). During casual dialogues between education officers and a single learner or a small group of learners on an exhibit, talk may include verbal and nonverbal interactions. According to Tran (2016), "talk" can also refer to times when an education officer interacts with a sizable group of learners during an organized event like a demonstration, class, or lecture. For education officers working at science centres and museums, their communication skills may include knowing how to talk to learners of different abilities, ages and interests. Reiss (2018) contends that education officers at science museums have come under fire for giving learners tedious lectures. The "show and tell" approach is frequently used by education officers in science centres and museums, which treats learners like empty learning vessels in need of knowledge. At science centres and museums, where visitors are expected to behave and refrain from touching any displays until specifically instructed to do so, education officers appear to view themselves as experts in the scientific field, according to Tal et al. (2004). Reiss (2001) contends that science museums and centres should market themselves as hubs for scientific activities to improve science education.

2.6 Interactions and discourse in science centres and museums

Interaction and discourse have been a subject of much interest among science education researchers (Tran, 2016). The understanding of discourse as a social phenomenon is predicated on the fact that talk is collaboratively constructed and negotiated for a particular purpose (Baker 2008). Argumentation is seen as an essential goal of science education, whereby learners have to support their claims using appropriate evidence and reasoning by considering alternative explanations of concepts when learning science (Cox, 2019) According to Gee (2012), social theories of discourse describe how language and speech are embedded in interactions between people. Learning is seen as a discoursive process where action occurs and encounters can be seen to affect discourse. Engaging learners in scientific discourse helps them to examine their own perspectives to evaluate concepts and identify conflicts that may lead to the reformulation of their beliefs (Gillies, et al, 2013). A dialogic pedagogy can better facilitate learners' process of constructing knowledge through questioning, interrogation and negotiation of ideas and opinions in an intellectual and respectful way (Teo, 2019). Set (2019) argues that the proper way of using language in knowledge construction is vital for successful learning. Science knowledge is not static and interaction and discourse help to reach a common understanding of scientific knowledge (Tran, 2016).

Ash and Wells (2006) contend that dialogic inquiry ought to be the cornerstone of science instruction in both formal and informal practice situations. They contend further that social interactions can foster cooperative knowledge creation in both circumstances. Any discussion's direction is determined by how instructors respond to learners' contributions (Ash & Wells, 2006). To maintain learners' active participation in acquiring knowledge, education officers must carefully balance their authoritative lecture with conversation. Effective education officers can adapt their teachings through conversation to the reactions of their learners in a series of teacher-learner exchanges, so meeting a variety of learners' needs in the classroom (Set, 2019). As a result, good education officers are believed to co-construct Knowledge with their learners through dialogical interaction rather than transfer it to them (Cox, 2019). Education officials that help learners build knowledge rather than merely communicate it are more effective (Set, 2019). Instead than waiting for someone else to offer the

answers, inquiry encourages learners to ask questions, study, discover, and come up with their own solutions (Killen, 2015).

Zhai and Dillon (2014) claim that one of the most popular methods in science instruction is questioning. It serves several objectives, including maintaining learners' activity and attention, arousing their curiosity, and motivating them to seek knowledge. According to Set (2019), teachers in a traditional scientific classroom frequently use closed questions and preset, succinct replies to gauge their learners' knowledge. He contends that closed questions give teachers more authority over the classroom discussion and, as a result, don't encourage learners to take more ownership of their thoughts. By allowing learners to participate in the discussion, open-ended questions are more likely to facilitate classroom debate (Set, 2019). Education officers are more likely to convey their ideas clearly if they ask open-ended questions and value the input of their learners.

2.7 Strategy development and implementation

Strategy development is a rational decision-making process where organisation resources are matched with opportunities (Feurer & Chaharbanghi, 1995). It is the primary means of reaching the objective of the organisation. According to Shah and Nair (2014), strategy development is a process by which an organisation such as a science centre or museum articulates where it wants to be in the future based on the analysis driven by the past, current and projected performance. The main objective of science education is to improve science literacy among learners (Talib, 2020). The purpose of science centres is to popularise science by making it more interesting and encourage learners to study science and pursue science careers (DST, 2016). Science centres and museums aim to achieve these objectives by using science exhibits and lessons that are linked to the school curriculum. A strategic framework is a means by which science centres and museums can achieve these objectives.

In order to achieve a dynamic approach to strategic development, a systematic and reliable process must be implemented (Shah & Nair, 2014). This study employed a SWOT analysis approach in the development of the strategic framework. SWOT is an acronym for **S**trength, **W**eakness, **O**pportunities and **T**hreats. The SWOT analysis aims to identify the strengths, weaknesses, opportunities and threats in the organization. By identifying their strengths, weaknesses, opportunities and threats,

science centres and museums can develop a strategy on their strengths with a view to eliminate weaknesses and exploit the opportunities in the fight against threats. The SWOT analysis identifies internal and external factors which can be prioritized by science centres and museums in the development of the strategic framework (Oreski, 2019). Organisations such as science centres and museums are faced with internal and external forces which can be stimulus for achieving their goals or threats that can hinder them from their performance (Shah & Nair, 2014). Internal and external factors are illustrated in Figure 2.7 below.

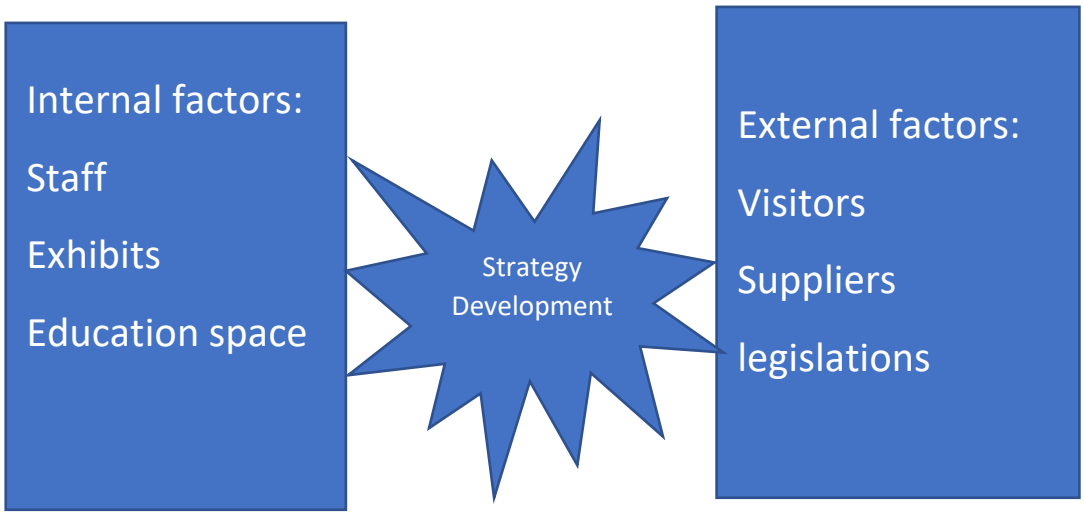


Figure 2.7: Internal and external factors (Shah & Nair, 2014)

The first step in strategic development is to identify forces that stimulate performance or hinder the achievement of goals using the SWOT analysis. The second step is to compare the SWOT factors looking at those with high impact, strength or weakness and pair them. The third step is to prioritise the pairs and compare them with objectives. The last step is to formulate strategies based on the analysis (Shah & Nair, 2014). Effective strategy development relies on the mission and goals of the science centre and how it is being communicated and agreed upon throughout the centre (EL-Sherkh, 2020). Strategic implementation at the science centre or museum refers to the extent to which the strategy is effectively implemented at the centre (Shah & Nair, 2014). In this study, the SWOT analysis was harnessed as a means to develop a strategic framework for enhancing science teaching and learning at a National Zoological Garden

2.8 Conclusion

This chapter reviewed literature relevant to the study. Insightful elucidation has been provided on the evolution of the role of science centres and museums across the globe. Chapter three describes the underlying theoretical and conceptual frameworks that underpin the study.

CHAPTER 3: THEORETICAL AND CONCEPTUAL FRAMEWORK

3.1 Introduction

This chapter provides an overview of teaching and learning theories such as positivism theory, critical theory, grounded theory and constructivism theory. Particular emphasis is placed on social constructivism as it was relevant to the development and implementation of the strategic framework for enhancing science teaching and learning at a National Zoological Garden. The chapter also outlines the conceptual framework based on social constructivism.

3.2 Positivism Theory

Positivism theory is based on the assumption that there is a single tangible reality (Park *et al*, 2020). This paradigm assumes that the truth can be identified, understood and measured (Taylor, 2011). According to Johnston *et al* (2018), positivism theory relies on objectivity and it dismisses the importance of individual influences and values. Positivism theory explains the relationship between variables and quantitative data using statistical inference to draw conclusions. Taylor (2016) argues that positivists use quantitative methodology that are based on experimental methods. The fact that positivism dismisses the importance of individual influence and values makes it unsuitable for this study as it involves the development and implementation of a strategic framework for enhancing science teaching and learning. The study was predicated on influences of others in teaching and learning science and the values of others in science development at a National Zoological Garden. This study is qualitative in nature and sought to capture participants' perspectives on science teaching and learning science at a National Zoological Garden which do not align with positivism perspective of a single tangible reality. It was a challenge to apply positivism in this study as it focused on human interactions and their feelings about science teaching and learning.

3.3 Critical Theory

According to Paradis (2020), critical theory's epistemological stance, all knowledge is generated from a certain viewpoint, and that position is defined by various social

systems that allocate power. In critical theory postulates that reality is shaped overtime by social, political, economic and cultural structures of the society (Kelly, 2007). Social structures can shape one's behaviour and thinking unconsciously. Critical theory favours an approach that emphasizes people's material circumstances and the impact on social and intellectual life rather than seeking to identify universal laws for human behaviour (Payne, 2019). Critical theory challenges the idea of universal standards, particularly those created and encapsulating Euro-American worldview. The notion offers hope for human resistance and transformation (Paradis, 2020). According to Kelly (2007), a distinguishing element of critical theory is that reality is recognized to be mediated by language. Social reality is shaped partly by discourse and the truth can always be challenged by competing groups with different agendas (Paradis, 2020). Critical theory cannot be used for this particular study because of its radical and controlling perception of forcing people to perceive other social structures as prescriptive to the understanding of knowledge (Young, 1992). This study is based on the interaction and collaboration between key stakeholders in the teaching and learning process.

3.4 Grounded Theory

Grounded theory was developed and advocated by Strauss and Glaser in the 1960s with the aim to produce a new theory as opposed to verification of an existing theory (Brik & Mills, 2011). Kennedy and Lingard (2006) and Allen (2003) explain grounded theory as a qualitative methodology which derives its name from the practice of generating theory from research which is grounded in data. Creswell (2012) argues that grounded theory is a powerful tool for a researcher who needs a broad theory or an explanation for a natural phenomenon. Apart from creating a new theory, grounded theory is a process of examining qualitative data to discover theories that are contained in data (Bound, 2011).

Graser (1992) highlighted that the main goal of grounded theory is to explain a "basic social process" by concentrating on the description of the links between the categories and emerging theories rather than the description of categories. Description and the relationships of the categories are important in this study (Hussein, 2014). Since the study was focusing on both the development and implementation of a strategic framework for enhancing science teaching and learning, it was vital to include both the

description and relationships of the categories. Hachtmanna (2012) states that massive data must be collected to be able to generate a theory using the grounded theory approach. This implies that grounded theory cannot be easily applied in this study because the study involved only three school groups from different areas visiting a National Zoological Garden at different times. In this study, data were collected through interviews and observations. Grounded theory requires data from documentation in addition to the data collected through interviews and observations Caswell (2012).

3.5 Constructivism

Constructivism is a psychological learning theory that describes how humans learn and gain knowledge (Hof, 2021). According to Aseeri (2020), constructivism is one of the contemporary educational movements that has become extremely popular across all cognitive domains, particularly in the teaching of science and mathematics. Piaget proposed constructivist concepts, which are based on five major elements: activating prior knowledge, learning and comprehending new information, applying newly learned information, and reflection (Clark, 2018). Therefore, constructivism has direct application to education.

This study was underpinned by constructivism theory because learners and teachers visit a National Zoological Garden to construct knowledge. In addition, the study involved the development and implementation of a strategic framework for enhancing science teaching and learning at a National Zoological Garden. The theory of constructivism postulates that humans construct knowledge and meaning from their experiences (Hof, 2021). A National Zoological Garden is an environment that provides a particular experience to visiting learners and teachers. Constructivism is a learning theory that explains how learners and teachers visiting the National Zoological Garden in Pretoria learn in that particular environment which is often different from their normal classroom. According to Clark (2018), learners actively construct new knowledge and meaning based on personal experiences and internal knowledge. The National Zoological Garden in Pretoria is visited by schools from different areas which have their unique way of learning science. Learners and teachers visit the National Zoological Garden with a particular knowledge of science. The National Zoological

Garden exposes learners and teachers to new and different exhibits that help them to construct scientific knowledge.

According to scientific research and observation, constructivism is a theory regarding how individuals learn (Clark, 2018). According to constructivism, people develop their own knowledge and understanding of the world by engaging in activities and reflecting on those activities (Bereiter, 1994). The National Zoological Garden is rich with materials/exhibits to be observed by both teachers and learners. According to Brau (2020), when we encounter something new, we must reconcile it with our previous ideas and experiences, which may require us to change our beliefs or dismiss the new information as irrelevant. Teachers and learners visiting the National Zoological Garden should be able to link the classroom science with the science provided by the National Zoological Garden. Constructivism emphasizes integrated curricula and teachers using materials in ways that actively engage learners. Constructivism has significant implications for teaching and curriculum development (Phillips, 1995).

Constructivism is concerned with learning as construction rather than acquisition (Clark, 2018). Learners construct new knowledge by building on previous knowledge and discovering connections between different ideas and areas of knowledge (Brau, 2020). New information is linked to prior knowledge as learners perceive each new experience. The National Zoological Garden offers scientific knowledge through exhibits and teachers and learners should see the link between knowledge provided and classroom scientific knowledge. Clark (2018) argue that every time a certain topic or concept is used in a new setting or from a new perspective, an individual's knowledge of that topic or concept evolves. Additionally, each time a certain topic or idea is used in a fresh context or from a different angle, it acquires new connotations (Clark, 2018). Aseeri (2020) argues that learners bring past experiences and knowledge to a situation. Past experiences and mental models that learners developed as a result of these experiences influence new learning. Thus, learning is a process of continuously modifying one's mental models to account for new experiences. Figure 3.3 illustrates the connection between new knowledge and experience. Learners come to the National Zoological Garden with experiences of science from the classroom. The new knowledge from the National Zoological Garden

should complement learners' experiences. The diagram illustrates the connections between knowledge and experience gain in the classroom and out-of-classroom.

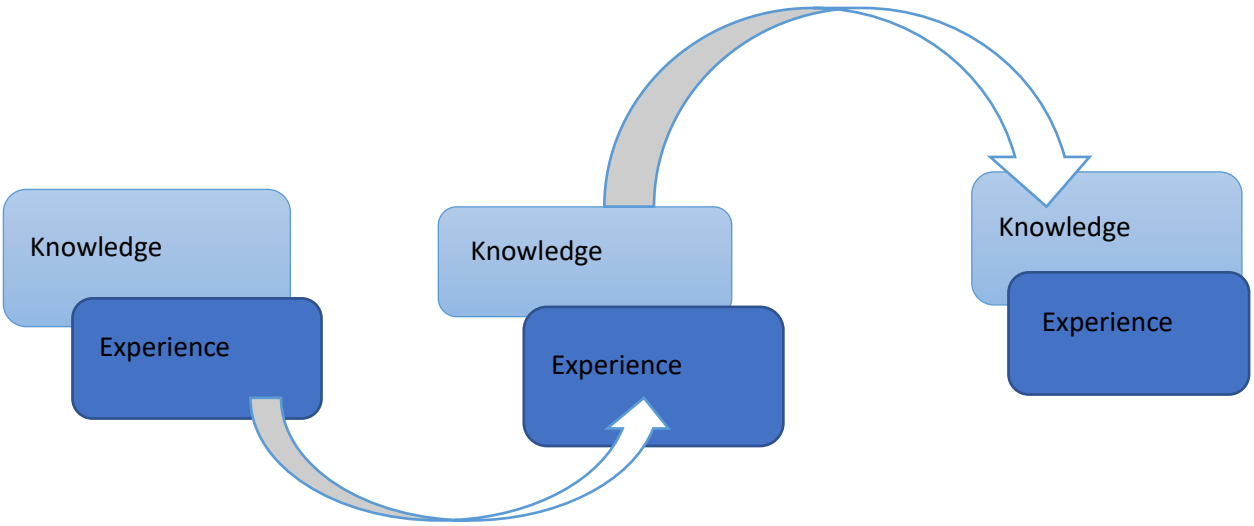


Figure 3.3: Connection between new knowledge and experience (Aseei, 2020)

Learning is an active rather than passive process (Piaget, 1973). Contrary to the passive approach, which views the learner as a blank slate waiting to be filled with knowledge, constructivism maintains that learners make sense of their world via active involvement and interaction (Aseeri, 2020). At the National Zoological Garden where the study was conducted, exhibits are designed to encourage interaction between learners and teachers. Learning is seen as an interactive process in which learners make use of prior knowledge to make sense of new information in order to create new concepts, alter existing ones, and recognize new relationships (Aseeri, 2020). Teachers and learners visiting the National Zoological Garden are expected to interact with the exhibits to reinforce understanding of the concepts learned in classroom. To create experiences that challenge their thinking and compel them to reconsider their views, learners must be actively involved in their learning (Cark, 2018).

Learning at the National Zoological Garden is structured in such a way that visiting schools can learn scientific concepts through activities and discover the link between

scientific concepts. Constructivism is more than just a method of imparting knowledge to learners. It is a method for fostering the attitude, feelings, and abilities of learners. Its goal is to help learners develop all facets of their personalities, therefore its main purpose is to teach them how to think rather than just repeat, giving them the ability to grasp relationships and find practical applications for them in daily life (Shabib, 2012). According to this educational paradigm, learners can expand their existing knowledge and experiences by creating new ones (Abo Daqah, 2017). According to Clare (2018), constructivism's fundamental tenet is that learning is an active process. On the other hand, understanding must come from inside and cannot be forced (Brooks & Brooks, 1993).

Constructivism encourages teachers to act as facilitators, helping learners take charge of their education and forging links between their past knowledge, new information, and the learning processes. (Brau, 2020). Therefore, the interest in this theory has prompted educational researchers to enhance the teaching and learning process and begin looking for new teaching techniques that will free teachers and learners from the constraints of conventional methods and enable them to experience the kind of meaningful learning that constructivism advocates (Al Omari, 2014). In this study, teachers' and education officers' facilitation role was important in the development and implementation of a strategic framework for enhancing science teaching and learning. When a school visits the National Zoological Garden, teachers who accompany learners are expected to continue playing their role while the education officers who are employees at the National Zoological Garden are also expected to facilitate learning.

According to Amineh and Asl (2015), constructivism can be divided in to three types, namely:

Cognitive constructivism. This theory states that learning should be tailored to the cognitive stage of the learner. Cognitive constructivism theory is more concerned about the development of individual learning (Derry, 1996). The theory is mostly oriented to understand the individual learner. The role of the teacher in cognitive constructivism is to help each learner to develop his/her cognitive understanding. The teachers' role is to help an individual learner develop at his/her own pace. Cognitive

constructivism cannot be used to unpack scientific concepts in situations where learners visit the National Zoological Garden in groups and learn in small groups.

Radical constructivism. This theory states that knowledge is created and not acquired and knowledge can be interpreted. The two basic beliefs of radical constructivism are that knowledge is produced by the learners actively rather than passively through the senses, and that the learner's job is to organize the experiencing world rather than reveal an independent reality. The theory cannot be used to unpack scientific concepts in this study as it focuses on an individual learner to the exclusion of other key education stakeholders.

Social constructivism. This theory states that learning is a collaborative process where people interact with one another (Clare, 2018). This theory is more relevant to this study as the study involved the development and implementation of a strategic framework for enhancing science teaching and learning at the National Zoological Garden.

Amineh and Asl (2015) argue that in social constructivism, understanding and meaning are developed in coordination and collaboration with other human beings. In this study, teachers, learners and education officers at the National Zoological Garden are expected to coordinate and collaborate to construct scientific knowledge. According to Clark (2018), the two most important elements of this theory are: Humans attempt to make sense of their experiences by building models of how society works, and they also hold the view that language is the most important tool for generating reality and understanding. At the National Zoological Garden, visiting schools always share their knowledge on the exhibits and are able to relate it to their experiences. Conversation is very important at the National Zoological Garden as it enables visitors to share knowledge of animals and others exhibits. (Brophy, 2004).

Before it can happen within an individual, cognitive development first happens on a social level (Clark, 2018). Making sense of others and building knowledge on such a social level enable learners to relate to situations (Brown, 1992). Before knowledge is internalized, interactions between people and their environment reveal the origins

of each person's knowledge (Roth, 2000). Social constructivism emphasizes culture and context in order to comprehend what happens in society and the formation of knowledge (Brau, 2020). According to social constructivism, reality is created by human activity rather than existing beforehand (Aseeri, 2020). According to social constructivism, individuals learn meaningfully when they participate in social activities like interaction and collaboration. (Aseeri, 2020). Social constructivist scholars such as Roth (2000), Brau (2020) and Aseeri (2020) view learning as an active process where learners should learn to discover principles, concepts and facts for themselves. At the National Zoological Garden, learners are guided through the exhibits to wonder and discover scientific knowledge. Exhibits are characterised by instruction on how they can be used to discover scientific principles. Learning, in accordance with Vygotsky (1978), is a continuous transition from the learner's present intellectual level to a higher level that more closely reflects their potential. According to Vygotsky (1978), social contact gives the cognitive process its power, and human thinking and knowing depend on having a grasp of social experience.

The most important role of education officer at the National Zoological Garden is to guide learners and ask or respond to questions from teachers and learners. The social constructivist method introduces instructors as facilitators rather than teachers (Aseeri, 2020). A facilitator aids the learner in developing his or her own comprehension of the subject matter after the teacher delivers a didactic lecture on it. Amineh and Asl (2015) indicated that a teacher tells, a facilitator poses a question; a teacher delivers a lecture from the front, a facilitator offers assistance from the rear; a teacher provides responses in accordance with a preset curriculum, a facilitator offers guidelines and fosters an environment that is suitable for the learner to come to his or her own conclusion; A facilitator engages in continuous, interactive discourse with the learners as opposed to a teacher who often delivers a monologue.

Learners at the National Zoological Garden are encouraged to interact and ask questions. According to Clark (2018) in the learning process, the learner's own perspective of reality, which is impacted by his or her background, culture, or general understanding of the world, is crucial. Amineh and Asl (2015) argue that learner's social interaction with knowledgeable members of society is very important. Education officers at the National Zoological Garden are considered more knowledgeable on the exhibits used to develop scientific understanding. Lombardo and Kantola (2021)

assert that Social connection with other more informed people is necessary for the acquisition of the social meaning of significant symbol systems and for learning how to use them.

3.6 Conceptual framework

The conceptual framework of this study was built around social constructivism theory which advocates for the importance of coordination and collaboration in knowledge construction (Aseeri, 2020). School groups visit the National Zoological Garden to learn and have fun. The role of Education Officers as employees at the National Zoological Garden is to assist visiting schools to have a good learning experience. Visitors' experience of learning can be achieved when all the parties involved are able to work together to enhance science teaching and learning. Teachers, learners and education officers at the Education officers must collaborate in the process of knowledge construction. The conceptual framework was built to assist in the development and implementation of a strategy for enhancing science teaching and learning at a National Zoological Garden. The main concepts for this study are: (a) The role of teachers visiting the National Zoological Garden (b) the role of learners visiting the National Zoological Garden (c) the role of education officer at the National Zoological Garden (d) the role of exhibits at the National Zoological Garden and (e) interaction and discourse at the National Zoological Garden.

3.6.1 The role of teachers visiting the National Zoological Garden

According to the social constructivist approach, the word "teacher" should be changed to "facilitator," as opposed to "teacher," because a facilitator assists the learner in developing his or her own understanding of knowledge. (Amineh & Asl, 2015). Constructivist theory-based pedagogies see teachers as facilitators of learners' inquiries and explorations. Learners shouldn't be thought of as bare vessels that need to be filled with information. Teachers are guilty of transmission if they do not stimulate learners' reflection and develop problem solving skills (Clark, 2018). Constructivist perspective view teaching and learning as a process of knowledge construction. This implies that teachers accompanying learners have a role to play at the National Zoological Garden. Teachers accompanying learners at the National Zoological Garden must assist learners to construct knowledge. According to Lombardo and

Kantola (2021), the critical and most important goal of the facilitator should be to help learners to be effective thinkers.

3.6.2 The role of education officers at the National Zoological Garden

Education officers at the National Zoological Garden are instructors who must play the role of facilitators by adopting social constructivism approach (Aseeri, 2020). Education officers are expected to be more knowledgeable about the exhibits and the environment of the National Zoological Garden. Effective science education officers understand how to create and direct learning experiences under specific constraints to support a broad set of learners in developing scientific knowledge and conceptual understanding (Lombardo & Kantola, 2021). It is the responsibility of education officers to foster learners' inherent curiosity and sense of wonder and to provide them the freedom to wonder, create, and reflect on self-reinforcing questions. When leading learners through the displays, education officers should engage them in open-ended discussions and recognize their contributions (Clark, 2018). Open-ended questions enable learners to expound on their ideas, elicit their opinions, and aid in the development of conceptual knowledge (Zhai & Dillon, 2014). Helping learners sort knowledge and understanding from a sea of information is one of the education officer's most crucial responsibilities (Killen, 2015).

3.6.3 The role of learners visiting the National Zoological Garden

According to Lombardo and Kantola (2021), social constructivism acknowledges the uniqueness and complexity of each learner. The learner’s own version of the truth that is influenced by his or her background, culture or knowledge of the world plays an important role in knowledge construction (Jung, 2019). The background and culture of the learner is very important in the learning process. Learners visit the National Zoological Garden with high excitement and expectation and they are mostly eager to know the “how” and the “why” of the scientific exhibits on display. According to Jung (2019), social engagement with other people who have greater experience with such symbol systems is necessary for both learning their social meanings and how to use

them. Jung (2019) goes on to claim that young children interact with other kids, adults, and the real world to improve their cognitive skills.

3.6.4 The role of exhibits at the National Zoological Garden

The National Zoological Garden in Pretoria has variety of exhibits. The main exhibits are the animals placed in their enclosures with each enclosure having an information board about the animal. There are also other exhibits such as microscopes, whispering dishes for sound, mass and weight exhibits and many more. The exhibits are meant to enable learners to understand the value of science. Science centres that focus on interactive exhibits which are simulative and have touch-feel experience are being celebrated for their adoption of social constructivism approach (Rennie & McClafferty, 2016). These exhibitions provide access to a depth of knowledge not available in textbooks or in the classroom, as well as the chance to get a sense of size (Clark, 2018). According to a social constructivist viewpoint, science museums should design learning settings that enable visitors to engage physically and cognitively with the exhibits and teaching materials through hands-on experimentation and introspective observation. The centres should work to provide information and guidance that helps make scientific theories real (Knapp, 2019). The teaching of science should be based on how learners learn it best, which is through hands-on activities and investigations using displays from science centres, according to documents calling for scientific education reform. This type of education encourages learners to maintain their innate curiosity and feeling of wonder while also generating and considering self-reinforcing questions (Amineh & Asl, 2015).

3.6.5 Interaction and discourse at the National Zoological Garden

The National Zoological Garden has structured its education activities based on talk. Visiting learners have to talk to each other and also talk to their teachers and education officers. Visiting schools go around the National Zoological Garden talking about what they see and the science concepts are illustrated through the use of exhibits. There is little writing or no writing that learners are expected to do at the National Zoological Garden. Many people believe that conversation is what motivates learning. Conversation with others enables one to actively engage in cognitive processes including probing, interpreting, elaborating, or relating new information to past knowledge (Knapp, 2019). Vygotsky and other social constructivists have advocated

that language-based social interactions serve as the foundation for higher-order cognitive processes (Vygotsky, 1978). People share and negotiate viewpoints through interaction and communication, change how they see the world in reaction to other people's perspectives, and so get a better understanding of it. Lave and Wenger (2019) contend that learning is basically a social activity in which community members negotiate on a constant basis to contribute to a bigger project.

Conversation plays an important role in facilitating understanding of science concepts at the National Zoological Garden. Visiting schools and education offices must always converse to build a better understanding of scientific principles. Learners, teachers and education officers at the National Zoological Garden must work together in the process of scientific knowledge construction. Henri (1992) claims that the social component is crucial because it promotes involvement, the growth of social cohesion, and a sense of belonging. The most fundamental epistemological principle that education officers, teachers and learners must comprehend is that individuals generate scientific knowledge, and that creativity plays a crucial role in this process (Lombardo & Kantola, 2021). Science knowledge is socially constructed and requires cooperation, collaboration and competition.

The conceptual framework underpinning this study is the Science Centre Knowledge Construction (SCKC) framework illustrated in Figure 3.4. The Science Centre Knowledge Construction (SCKC) framework is based on social constructivism. This framework is premised on the fact that in a science centre environment, effective teaching and learning should involve learners, teachers and education officers. The three parties must cooperate and collaborate with a common goal to foster effective knowledge construction. Interaction between teachers, education officers, learners and exhibits plays an important role in the enhancement of teaching and learning at a science centre environment such as the National Zoological Garden in Pretoria.

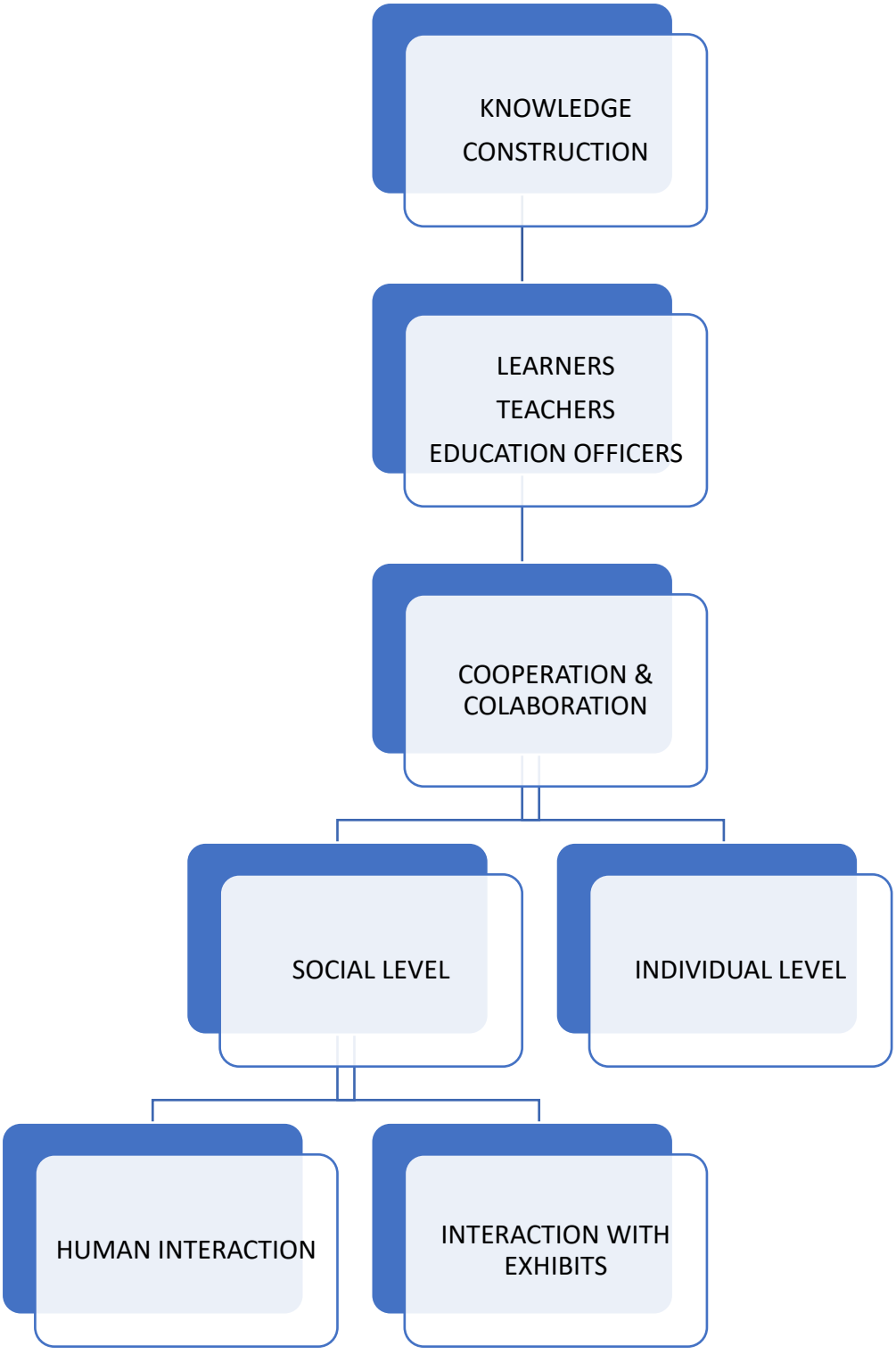


Figure 3.4: Science Centre Knowledge Construction (SCKC) Framewor

3.7 Conclusion

This chapter provided a description of the underlying theoretical and conceptual frameworks that underpin the study. Chapter 4 then provides an overview of the research methodologies adopted as part of the empirical investigation.

CHAPTER 4: RESEARCH DESIGN AND METHODOLOGY

4.1 Introduction

The research strategy and methodology used in this study are described in this chapter. It also considers how the research methodologies used to carry out the research were justified. The following research questions served as a guide for the empirical investigation.

- What are the opportunities and challenges associated with science teaching and learning at a National Zoological Garden?
- How can a framework for enhancing science teaching and learning at a National Zoological Garden be developed and implemented?
- How does the developed framework for enhancing science teaching and learning at a National Zoological Garden influence learner interaction and discourse?

The study was underpinned by the following objectives.

- To explore opportunities and challenges associated with science teaching and learning at a National Zoological Garden.
- To develop and implement a framework for enhancing science teaching and learning at a National Zoological Garden.
- To explore the influence of the framework for enhancing science teaching and learning at a National Zoological Garden on learner interaction and discourse.

4.2 Research site

The study was conducted at the National Zoological Garden which is situated in the Central Business District (CBD) of Pretoria in the Gauteng Province of South Africa. The map of the Pretoria CBD is depicted in Figure 4.1.

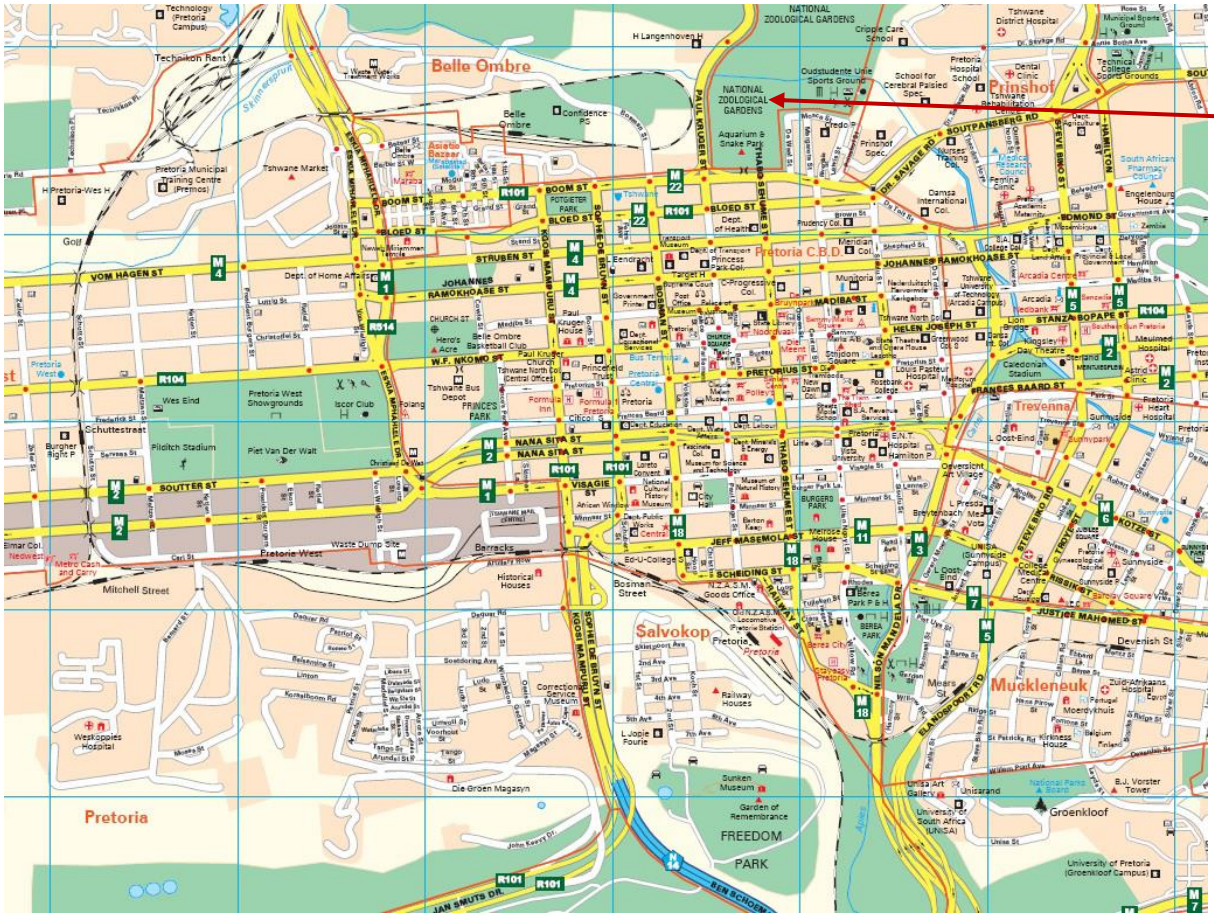


Figure 4.1: Map of Pretoria Central Business District

The National Zoological Garden has seven education officers who interact, guide and present lessons to school groups within the facility. Three officers who were interested and willing to participate in this study were selected. All officers have qualifications in Natural Sciences and they were all trained to guide and present lessons to school groups visiting the National Zoological Garden.

4.3 Research context

The study was conducted at the National Zoological Garden (NZG), which is one of the science centres located in Pretoria, South Africa. The NZG is a facility of the South African National Biodiversity Institute (SANBI) under the Department of Forestry Fisheries and Environment (DFFE) which houses collection of native and exotic animals, animal hospital, state-of-the-art research facility and the education centre

responsible for science education. The National Zoological Garden of South Africa is the largest zoological garden in the country and the only one with national status.

Pretoria's 85-hectare Zoological garden is home to 3117 specimens representing 209 mammal species, 1358 specimens representing 202 bird species, 3871 specimens representing 190 fish species, 388 specimens representing 4 invertebrate species, 309 specimens representing 93 reptile species, 44 specimens representing 7 amphibian species, and other artificial exhibits of scientific interest. The Pretoria complex also has a reptile park and an aquarium. The Aquarium is the country's biggest inland marine aquarium. The pathways in Pretoria's city center stretch for a total of about 6 kilometres. The map of the National Zoological Garden is depicted in Figure 4.1.

Figure 4.1: Map of the National Zoological Garden

More than 200 000 learners from different provinces in South Africa visit the National Zoological Garden annually. The facility is visited mostly by school groups from

Gauteng province and other school groups from neighbouring provinces such as Limpopo, North West, Mpumalanga, Free State and KwaZulu-Natal. The map of the provinces in South Africa is depicted in Figure 4.2.

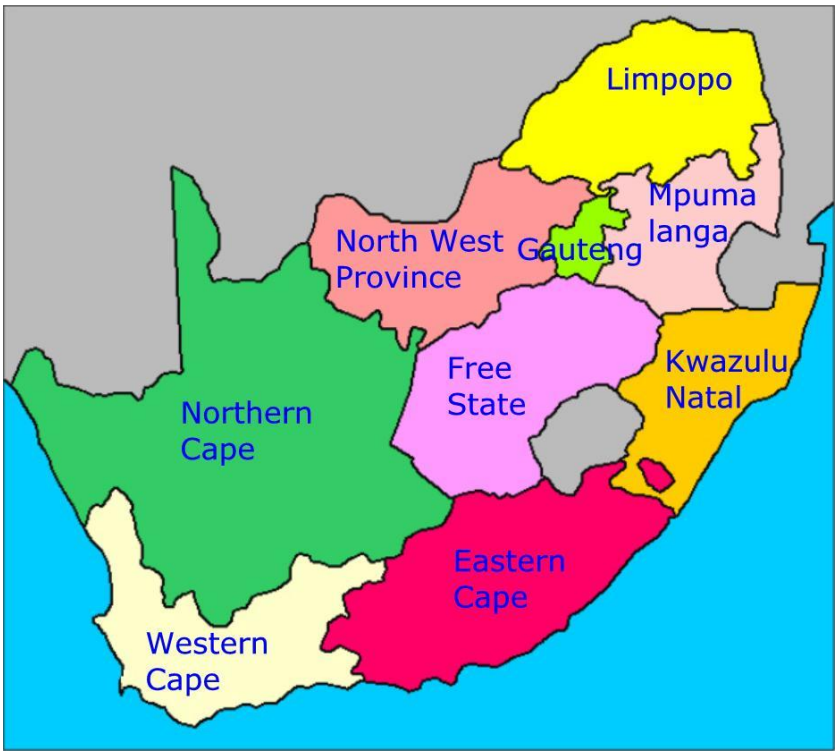


Figure 4.2: Map of the Provinces of South Africa

The researcher chose the National Zoological Garden for two reasons: it attracts a large number of teachers and learners in comparison to other science centres, and it is easily accessible to the researcher due to its location and other activities to which the researcher has access. There are currently more than 25 established science centres in South Africa (DST, 2019). According to DST (2019), science centres in South Africa are coordinated by the South African Agency for Science and Technology Advancement (SAASTA). SAASTA is a business unit of the National Research Foundation (NRF). The Department of Science and Technology (DST) assists science centres with funding through grant and other special programmes that promote science within the country. Most of the science centres in South Africa are located in the Gauteng province. All these science centres are mandated to popularise science, make it interesting and encourage learners to pursue science careers.

Developing a strategic framework for enhancing science teaching and learning at a National Zoological Garden is commensurate with the strategic mandate of science centres in South Africa as well as DST's strategic framework. One of the strategic pillars of DST's strategic framework is the popularization of science, mathematics, and technology by making these subject appealing, relevant, and accessible to learners across the country in order to improve scientific literacy and inspire learners to pursue science careers (DST, 2016). Structured school-based science engagement activities have been established in collaboration with the Department of Basic Education (DBE). The DST and DBE have signed a Memorandum of Understating (MoU) that allows the two departments to work together in promoting science education in South Africa (DST, 2015).

4.4 The research approach

This study adopted a qualitative approach. Braun and Clarke (2013) define qualitative research as research that uses words as data. Qualitative research seeks to understand and interpret more local meaning by using data gathered in a context to produce general understanding. Braun and Clarke (2013, 21) also argue that "qualitative research is exploratory, open-ended and produce in-depth, rich and detailed data from which to make claims". Doing qualitative research means that you understand that it is a craft which is marked by the challenges of doing original research where the researcher can also bring his or her own belief system as a motivating force for defining and conducting research (Yin, 2016).

The researcher chose this methodology because it connected well with the purpose and the research question of this study. As alluded by Richards and Morse (2013: 24). "The researcher actively creates the link between the purpose and the method to be used". The best way of developing and implementing a strategic framework to enhance the teaching and learning of science in science centres is to implement this methodology which has helped the researcher to interview, observe and interact with the participants.

The data gathered in a qualitative study is used to understand and interpret the local meaning of that particular context. Additionally, according to Braun and Clarke (2013), qualitative research is exploratory, open-ended, and generates in-depth, rich, and thorough data that can be used to support assertions.

According to Yin (2016), qualitative research offers the chance to produce original work and the researcher is free to bring their own worldview, which can serve as inspiration for designing and carrying out study. According to Richards and Morse (2013), the researcher deliberately forges the connection between the method to be utilized and the purpose of the study.

Yin(2016) confirms Richards and Morse (2013) that the problem with qualitative research is when the researcher get carried over with the study and become part of the research which can result in biasness. In this study the researcher minimised biasness by not allowing himself to be completely emersed into the study. The researcher allowed participants to express their views and feelings without any interruption. Qualitative research are mostly used for small samples to understand the context, as a results, qualitative research studies are criticised for their incapability to extend the findings to a wider population (Cresswell, 2013).

4.5 Research design

The study adopted a descriptive case study design. According to Liamputtong (2013), a case study research has boundaries. Common boundaries are mainly the place where the research is conducted and the time it takes to conduct the research. These boundaries of a descriptive case study design can be well explained by the description of the location, the institution where the research is conducted and the culture of the participants. Liamputtong (2013) further argues that case study research is mostly utilized to learn about the context of an organization or institution. According to Hatch (2002), a case study puts the researcher in a social setting. A case study is commonly understood to be an in-depth investigation or study of a certain unit. The unit of analysis in this study is the development and implementation of a strategic framework for enhancing science teaching and learning at a National Zoological Garden located in Pretoria, South Africa. According to Braun and Clarke (2013), a case study is important because it helps in the discovery of new processes and behaviours, and it is also useful because it can respond to how and why questions of the research. In addition, a case study cannot generalise more than the case being studied as it mostly ends with the particular case being investigated (Richards & Morse, 2013; Yin, 2016). In this study data was collected through semi-structured interviews, observations and

diary. An Ethnographic approach was used to analyse the data. In this approach, data is transcribe and organised in to themes for coding (Creswell, 2009).

4.6 Research paradigm

The study adopted a descriptive case study design located within the interpretive paradigm. Understanding the world as it is from people's subjective experiences is central to the interpretative paradigm. The interpretive paradigm relies on subjective relationships between the researcher and subjects and procedures that are meaning-oriented rather than measurement-oriented, including participant observation or interviewing (Angen, 2000). Additionally, interpretive approaches heavily rely on naturalistic techniques, including observation, interviews, and text analysis of already published materials. Positions taken by interpretivists are based on the theory that reality is socially constituted and dynamic (Angen, 2000). The interpretive paradigm is relevant to this study as qualitative data was collected through semi-structured interviews, observations and diaries.

4.7 Sampling

The process of choosing people who can offer rich data on the phenomenon of interest, according to Moser and Korstjens (2018), is known as sampling. According to Richards and Morse (2013), sampling is crucial for qualitative research since it enables the researcher to comprehend the problems with qualitative validity. The five most popular purposeful sampling methods are criterion sampling, theoretical sampling, convenience sampling, and snowball sampling (Moser & Korstjens, 2018). For this study, purposive sampling was selected because the researcher purposefully selected six schools (three schools per phase) from three different provinces visiting the National Zoological Garden. The purpose of selecting schools from the three different provinces it to get a better representation from different areas, because the National Zoological Garden caters for all types of schools, such as rural, Urban and semi—urban schools. The three provinces will be able to represent the variety of schools in South Africa. Participants were selected based on their availability, interest and willingness to participate in the study. Participating learners were those studying Natural Sciences at the Intermediate or Senior Phase because at this level learners have a better understanding of scientific concepts learned at school and they can be

able to apply and reflect on some of the concepts while learning science at the National Zoological Garden. The learners were accompanied by their teachers during visits to National Zoological Garden. Three learners and one teacher per school participated in the study

4.8 Data collection techniques

According to Richards and Morse (2013), the research topic influences the nature of the research context, and the researcher must choose and specify the types of participants and data collection methods. For this study, qualitative data was collected through interviews, observations and dairies. This type of method is called triangulation because multiple data sources were used to produce more depth and breadth which helped the researcher to have a better understanding of the concepts. The triangulation method is good for corroborating findings and building a holistic picture of the phenomenon (Billups, 2014). For this study, data was collected in two phases. The first phase involved identification of the challenges, shortcomings and opportunities associated with science teaching and learning at the National Zoological Garden. Insights gleaned from this data was used to develop a strategic framework for enhancing science teaching and learning at the National Zoological Garden. More specifically, the data was used to identify gaps within the present system science teaching and learning science at the National Zoological Garden with a view to generate appropriate solutions to address identified pervasive gaps. Data collected in the first phase of the study was used to answer the following research question:

What are the opportunities and challenges associated with science teaching and learning at a National Zoological Garden?

The data generated in the first phase was used to develop a strategic framework for enhancing science teaching and learning at the National Zoological Garden. This strategic framework was developed by identifying current challenges at the National Zoological Garden. Data collected in the second phase of the study was used to analyse and implement developed strategic framework for enhancing science teaching and learning at the National Zoological Garden. In particular, the data was analysed to implement possible solutions to the problems identified in the first phase

of the study. Data collected in the second phase of the study helped the researcher to answer the following research question:

How does the developed framework for enhancing science teaching and learning at a National Zoological Garden influence learner interaction and discourse?

Insights gleaned from data collected in the second phase of the study informed the implementation of the developed strategic framework for enhancing science teaching and learning. In addition, these insights were invoked to establish how the implementation of the strategic framework influences learner interaction and discourse.

4.8.1 Semi-structured Interviews

Opie (2004) argues that there are different types of interviews. There are three types of interviews, namely: structured, unstructured and semi-structured interviews. Structured interviews are normally straightforward questions that have a predetermined agenda. Structured interviews have questions that the interviewer can readily manage and are not adaptable. Questions in unstructured interviews are difficult to foresee since they often include follow-up questions, are not direct, and are open-ended in nature. The interviewer has less control over semi-structured interviews, which feature more flexible questions and are not totally chosen by the interviewer. In this study, semi-structured interviews were conducted with the participants. A semi-structured interview is more appropriate when the interviewer knows more about the study topic in order to frame the needed discussion in advance (Richards & Morse, 2013). The participants were recorded and data was transcribed and analysed. The interview schedule was guided by the following questions:

a. How do education officers use the resources at the science centre when interacting with learners?
b. What is the role of teachers when visiting with learners at the science centre?
c. How does the science content at the science centre relate to the school curriculum?
d. How do education officers use language to facilitate interaction and discourse?
e. How do learners interact with exhibits at the science centre

In the first phase of the study, semi-structured interviews were used to generate more data on the challenges and opportunities associated with science teaching and learning science at the National Zoological Garden. Learners were interviewed on how they are learning science in the present setting of the National Zoological Garden before the implementation of the strategic framework. Teachers were interviewed on how they see their role when accompanying learners at the National Zoological Garden. Education officers were interviewed on how they interact and teach learners at the National Zoological Garden. In the second phase of the study, semi-structured interviews were used to generate more data on the developed strategic framework and its implementation. Learners were interviewed on how they learn science using the developed framework. Teachers were interviewed to generate data on their role under the new strategic framework and education officers were interviewed on how they interact and facilitate learning using the new strategic framework.

The interviews lasted for 15 to 20 minutes depending on the willingness of the participants to explain and discuss in detail the questions posed. The researcher used open-ended questions to allow participants to talk more about their experiences of science teaching and learning at the National Zoological Garden. Brophy (2015) suggests that the best way to conduct interviews is to start with a question that can be answered easily by the participants and then proceed to ones that are not easy to answer or are sensitive in nature. This approach helped the researcher to get good responses from the participants. Brophy (2015) also argues that it is important for the interviewer to understand the meaning and feelings of the respondents than to rely on assumptions.

4.8.2 Observations

Richards and Morse (2013) claim that an observation is the most natural technique for gathering data since it allows the researcher to learn and uncover the content and setups. According to Good and Brophy (2015), observational research offers highly valuable information that has practical consequences for understanding and improving science teaching and learning in science centres. The researcher observed and recorded the interactions. The audio recording helped the researcher to retain more data and allowed the researcher to revisit and review the audible record (Richards & Morse, 2013). The most outstanding feature of observations is that it enables the

researcher to collect live data from naturally occurring social situations, where the researcher is able to be part of the situation to have a better understanding of the description (Creswell, 2009).

The observation schedule was used in both phases of the study. In the first phase, learners were observed when interacting with each other and when interacting with teachers, education officers and exhibits. Learners were observed on how they learn science at the National Zoological Garden before the implementation of the strategic framework. Teachers were observed on how they guide and assist learners in the learning process. Education officers were observed when facilitating learning and guiding learners through the use of exhibits. Interaction and discourse among all participants were observed. The observation in the first phase assisted the researcher to identify challenges and opportunities associated with science teaching and learning at the National Zoological Garden before the development and implementation of the strategic framework. In the second phase, all participants were observed. Learners were observed on how they learn science using the developed strategic framework. Teachers were observed when assisting learners to learn science using the developed strategic framework. Education officers were observed on how they facilitate learning using the developed strategic framework.

4.8.3 Dairies

According to Hyers (2018), a diary is a regular recording of observations, events and discussions. A diary is a treasure trove full of first-hand accounts from a wide range of themes. Dairies have developed into a popular medium for people to document their experiences and the world's events (Hyers, 2018). A diary is one of the tools used in qualitative research to provide the researcher with an in-depth understanding of the phenomenon of interest (Bryant, 2015). In this study, diaries were used to record observations and discussions about strategies that can be used to enhance science teaching and learning. The present method used at the National Zoological Garden to teach science was observed and conversations on science teaching and learning were continuously documented using diaries.

4.9 Data analysis

Organising the data in a more meaningful way immediately after data collection. I converted a large amount of data into vivid information that is understandable and trustworthy (Liamputtong, 2013). Furthermore, I read and re-read the information to make sense of the collected data. Data was organised into different and related themes by using a coding scheme (Creswell, 2009). Data was transcribed from the audio record system into rewritten words for analysis. Data was transcribed into words and organised for analysis. The ethnography approach was used for analysis. According to Richards and Morse (2013), data is viewed as parts of a jigsaw in an ethnographic approach, and these pieces must fit together to form a whole puzzle which represents a holistic and rich representation of the cultural perspective on the study subject. These pieces were placed to fit together to give a clear picture of the strategic framework for enhancing science teaching and learning science at the National Zoological Garden. Observation protocol guided analysis of observational data.

4.10 Ethical considerations

Ethical considerations must not be overlooked in all qualitative research programmes that involve human subjects. This is very important in all qualitative research designs because the researcher normally works with participants very closely (Roller & Lavrakas, 2015). In this study, the researcher worked very closely with participants to develop a strategic framework for enhancing science teaching and learning science at the National Zoological Garden. A workshop was held with education officers from the first phase to discuss the identified challenges. The developed framework and how to implement it was discuss in the workshop.

4.10.1. Confidentiality and Anonymity

The rights of teachers, learners and education officers were respected at all times. These individuals were duly informed about the purpose of the study goal as well as their rights to privacy and anonymity. A conducive working environment was created and encouraged to all the participants. Teachers were informed about the study on time and they were told that the information will remain anonymous. Participants were informed that their real names will not be used in the study.

4.10.2. Safety

The environment where the research was conducted was free from harm. The standard operation procedure of the organisation was discuss with the participants. All participants were aware of what to do in case on an emergency.

4.10.3. Ethical clearance

Ethics clearance was granted by the Research Ethics Committee of the University of South Africa. Permission to conduct research at the National Zoological Garden was obtained from the South African National Biodiversity Institute and the Gauteng Department of Education. Informed consent was duly obtained from the participants. Since the study involved minors, concert forms were signed by the parents giving permission for their children to participate on the study. All participants were freely and willing to participate in this research.

4.11 Trustworthiness of qualitative data

Rigour refers to the reliability of the research process and its results. To maintain rigour of qualitative findings, researchers must consider dependability, credibility, transferability, and conformability as trustworthiness criteria in qualitative research (Anney, 2014). To ensure credibility, I used a triangulation method which involved three techniques, namely: semi-structured interviews, observations and diaries. The results of a qualitative study must be understood in the context of the features of the research site to be transferable (Shenton, 2004). This study involved Teachers, learners and education officers at the National Zoological Garden. In respect of qualitative data, the following validity and reliability checks proposed by Merriam (1998) were adhered to:

Triangulation: Through several development sessions held during the research process and the utilization of numerous and various sources of data gathering methods, claims and tentative interpretations were triangulated.

Member checks: During reflection sessions, participants discussed the data collected and tentative interpretations and confirmed them.

Peer review: The research procedure and speculative interpretations were discussed frequently and critically with other scholars.

Critical self-reflection was done by the researcher with regards to any concealed assumptions, personal worldviews, theoretical orientations, and connections that might skew the interpretation of the data. Biases and presumptions were openly

Audit trails: Detailed explanations of the processes used and the justifications for decisions made were given.

Detailed description: To help readers contextualize the study and assess how much the conclusions might relate to their circumstance, each event was described in great detail.

4.12 Pilot study

The study was piloted first with one school and one education officer as participants. The same education officer also participated in the main study. Insights gleaned from the pilot phase were used to refine interview schedule and observation protocol.

4.13 Conclusion

This chapter outlined the research methodology used in this study. The next chapter presents findings emanating from the first phase of the study.

CHAPTER 5: SCIENCE TEACHING AND LEARNING AT THE NATIONAL ZOOLOGICAL GARDEN: CHALLENGES AND OPPORTUNITIES

5.1 Introduction

This chapter presents findings emanating from the first phase of the study. In particular, the findings relate to the challenges and opportunities associated with science teaching and learning at the National Zoological Garden. The three schools were classified as cases.

5.2 Generation of themes and categories

I generated themes and categories using a typology approach as reflected in Table 5.1.

Table 5.1: Generated themes and categories

Themes	Categories
Challenges and opportunities associated with science teaching and learning at the National Zoological Garden	Challenges
	Opportunities

5.3 Case 1

5.3.1 Challenges

Science centres and Museums expose learners to science activities and exhibits (Ellis, 2020). Learning makes more sense when these exhibits are used in such a way that learners are able to understand the connection between the exhibits and scientific concepts. The relationship between the exhibits and lessons plays an important role in the development of learners' understanding of scientific concepts. Education Officer 1 (EO1) was observed and interviewed based on the lesson he presented at the National Zoological Garden. The lesson was about "Water Conservation" where learners were taught the importance of water conservation. When asked about the challenges associated with science teaching and learning at the National Zoological Garden, he responded:

"I can say that one of the major challenges is teaching these learners next to big exhibits such as animals like an Elephant or that big telescope and I'm teaching about water conservation. They get distracted and focus on the animal, they can't hear what I'm saying because they look at the animal. I'm now competing with the animal for attention" (EO1).

EO1 indicated that learners are often distracted by other exhibits which are in close proximity. He presented a lesson on Water Conservation next to exhibits which were not related to water conservation. It was challenging for EO1 to teach learners about Water Conservation as a result of the distraction caused by other exhibits that were in close proximity. Delivery of lesson on Water Conservation is illustrated in Figure 5.1.

Figure 5.1: Delivery of lesson on Water Conservation

Science Centres using interactive exhibits and activities that are linked to particular science concepts enable learners to connect information (Watermayer, 2012). EO1 indicated that it was very difficult to teach learners next to an exhibit such as an Elephant and a telescope as learners were mostly distracted by these exhibits. While learners were learning about water conservation, their attention was also on the Elephant and the telescope which were in close proximity. These sentiments are encapsulated in the following excerpt.

"*Getting learners to be involved in the lesson, always being part of the lesson was a big challenge for me. Yes, they were listening but not always because of the other disturbances, they want to go see animals, I can tell that they want to go away from my station."* (EO1)

Reiss (2018) argues that activities and display at science centres must actively engage the learners. EO1 identified language barrier as one of the challenges influencing science teaching and learning at the National Zoological Garden. EO1 spoke isiZulu and English and did not know exactly what to do when teaching learners who use Xitsonga as their home language. At times when he asked learners to explain water conservation in their home language, one learner explained in Xitsonga and EO1 did not understand what the learner said. When EO1 was asked by the researcher during the interview about how language assisted him to unpack scientific concepts when teaching science at the National Zoological Garden he said:

> *"Sometimes explaining these concepts in English is not easy for these learners to understand. They keep quiet and look at you, but you can tell that they don't understand. Is better to ask them to explain in their home language. This English is foreign to all of us, is not easy and these kids do not understand English very well. I know the policy says we must teach the intermediate phase in English, but these learners don't understand". (EO1)*

Unlike in a school where the written word is emphasized, in a science centre setting the social learning context favours the spoken word (Tran & King, 2007). Education officers in science centres rely much on talk to connect learners to their lessons. Tran (2016) argues that engaging learners in a scientific discourse helps them to examine their own perspective and language plays important role in constructing knowledge. Ntuli (2022) argues that although English is a medium of instruction in most schools, it creates a language barrier in some rural schools where learners do not English proficiency. Set (2019) argue that when language is well understood by all learners, it can assist in knowledge construction. The use of the English language in knowledge construction was a challenge for EO1.

Language barrier in science teaching and learning remains a challenge for both learners and teachers. When asked about the challenges associated with science teaching and learning at the National Zoological Garden, EO1 said:

> "*Sometimes you find that there is a group that speaks Xitsonga, they don't understand English that well and then you are Tswana and you don't understand Xitsonga that much, so it kind of gives you that low confidence that they may not be understanding what I am telling them because of their*

language, but I find that the solution we found that is usually if you don't understand the language you find someone who understands the language to come and conduct the lesson. Like swap with someone who understands that language if you see that you are not confident to speak that language if it's hard." (EO1)

Language mediates communication between learners and education officers at the National Zoological Garden. If learners do not understand English very well, there will be a communication breakdown. Effective education officers can adapt their instruction to the answers of their learners through dialogue, facilitating teacher-learner exchanges (Set, 2019).

Learners are always accompanied by their teachers when they visit the National Zoological Garden. Most teachers were seen leaving the learners at the hands of the education officers, and did not get involved in the teaching and learning process (see Figure 5.2) Reflecting on teachers accompanying learners during visits to the National Zoological Garden, EO1 said:

"Some of the teachers are not cooperative, the minute the ushers like the people who are guiding the kids, bringing the kids the teachers are no longer involved, they just sit there and look at you. And you can't control the behaviour of all the kids you need help, but then they just sit there and look at you. Or they will just go and sit at one bench and leave us. And it's hard to control some of the kid's behaviours especially if the kids are a lot." (EO1)

Figure 5.2: Science teaching and learning process

Teacher 1 was asked about the preparation to the National Zoological Garden. She said

> " I am not part of the organising committee, I am responsible for teaching Natural sciences. But we are all informed on time. Learners love coming here. We bring them to the zoo every year"

When observing the lesson, the researcher realised that in most of the stations, teachers were not there. This poses a challenge to the education officers who are left alone with the learners. According to McClaffey (2014), some teachers visit science centres and museums to have fun. Falk and Dierking (2000) also found that teachers understand their role at science centres and see education officers as substitute teachers. Mosabala (2014) found that in a South African context, most schools see a visit to a science centre as an opportunity to be outside the formal classroom environment. In addition, some teachers see visit to a science centre as an opportunity to indulge in personal activities such as shopping which are not related to teaching and learning (Mosabala, 2014).

5.3.2 Opportunities

Science centres and Museums use exhibits to provide hands-on experiences to the learners (Ramey-Gassert, 2016). Science centres and Museums can connect with learners through intriguing activities and exhibits which empower learners to lead logical tasks and upgrade decisive reasoning (Bencze & Lemelin, 2011). In this regard, EO1 indicated:

> *"I think the use of exhibits and interactive activities are very effective. It's a very effective method of learning because from what I have noticed so far, the use of the resources makes the learners very interested to want to know how those resources work. The resources I think are a very main thing because it makes them want to learn more if they see something rather than hearing words about it. So, if you have a certain activity that you are using, they will be more interested in that, because when they approach the station, they will see all the activities. So, from the beginning, they will enter, they want to know more."* (EO1)

Science centres and museums that use interactive activities and displays which are simulative and have contact feel experience provide logical information to learners (Watermeyer, 2012). Interactive activities and displays at science centres and museums create stimulating learning environments (Cox, 2019). The use of resources in science teaching and learning cannot be over-emphasised. EO1 indicated that the National Zoological Garden should use its available resources such as Animals, laboratories and human resources to the benefit of learners visiting the centre. Reiss (2018) views science centres, museums, zoos and botanical gardens as repositories of the unique specimen and artefacts which are exhibited to form a reference point for the accumulation and enhancement of scientific knowledge.

While observing the lesson conducted by EO1, learners were seen moving closer to the station and asking each other questions about the model of water filtration on a wetland used to illustrate functions of wetlands. Science centres and museums are novel platforms for learning science outside the formal classroom setting (Cox, 2019). According to Hourdakis and Leronomakis (2020), learners' visit to a science centre or museum provides enduring impression to the learners. Science centres and museums can give a connection between the hypothetical part of science and its items of common sense and issues which influence us at our homes. The model of water filtration on a wetland developed learners' consciousness about water conservation as illustrated Figure 5.3.

Figure 5.3: Lesson on the model of water filtration on a wetland

Hourdakis and Ieronomakis (2020) contend that science centres can assist with creating perspectives, qualities and better comprehension of science which can help

learners to link what they learned in the classroom to what they learned at the science centre. The use of exhibits such as the wetland model serves to enhance science teaching and learning. Eshack (2026) argues that collection of exhibits provides learners with the opportunity to see and touch the exhibits, ask questions about them and place them within context for the development of scientific and technological understanding.

The National Zoological Garden has a variety of exhibits, including its animal collection, specimen, research and laboratory types of equipment such as microscopes and many more which can be used for science teaching and learning.

5.3.3 Overall reflection on key findings emanating from Case 1

5.3.3.1 The use of exhibits in science teaching and learning at the National Zoological Garden

The integration of exhibits into science teaching and learning at the National Zoological Garden illuminates the remarkable potential of experiential education. As one contemplates this approach, it becomes evident that exhibits are more than static displays – they are gateways to discovery, connecting learners with the marvels of the natural world in profound ways. Exhibits breathe life into scientific concepts, transforming theoretical abstractions into tangible realities. They offer a sensory feast, captivating learners with visual or, intriguing sounds, and interactive components. This multisensory engagement creates an immersive learning environment, inviting students to step beyond the confines of textbooks and lectures. The National Zoological Garden's exhibits are not isolated entities; they are living embodiments of scientific principles that draw students into a captivating narrative of biology, ecology, and conservation.

The allure of exhibits extends beyond their visual appeal. They empower learners to embark on their own intellectual journeys. Exhibits spark curiosity, beckoning students to ask questions, make observations, and form hypotheses. As they explore, they encounter opportunities for hands-on interaction that reinforce their understanding. The National Zoological Garden's exhibits invite learners to become active participants in their own education, fostering a sense of agency and ownership over the learning process. One of the most remarkable aspects of this approach is its capacity to stimulate discourse and collaboration. As students engage with exhibits, they naturally

engage in conversations with peers and educators. These discussions cultivate a culture of inquiry, as students share insights, compare observations, and construct knowledge collaboratively. The National Zoological Garden's exhibits become catalysts for dialogue, prompting learners to refine their thinking and expand their perspectives through meaningful interactions.

Equally vital is the role of educators in this process. Teachers assume the roles of guides, interpreters, and facilitators. They encourage students to think critically, guiding their attention to specific elements of exhibits that align with learning objectives. They craft questions that invite reflection and analysis, ensuring that the experiential encounter is linked to broader educational goals. The presence of educators transforms the zoo visit into an orchestrated educational experience, where every exhibit holds the potential to enrich students' understanding. Reflecting on the use of exhibits in science teaching and learning at the National Zoological Garden underscores the capacity of immersive experiences to transcend traditional teaching methods. Exhibits become portals to exploration, sparking curiosity, igniting dialogue, and fostering a profound connection between learners and the world of science. The fusion of theory and practice, guided by skilled educators, enables students to bridge the gap between the abstract and the concrete, the academic and the real-world. This integration creates an indelible impact on students' knowledge, attitudes, and appreciation for the intricate wonders of the natural world. In this reflection, one witnesses the transformative power of exhibits as catalysts for learning and inspiration.

5.3.3.2 Learner interaction and discourse in science teaching and learning at the National Zoological Garden

The National Zoological Garden stands as a remarkable testament to the potential of learner interaction and discourse in shaping a profound educational experience. As one reflects on this dynamic environment, it becomes evident that the garden is not just a collection of exhibits but a vibrant arena where learners engage, explore, and connect with the natural world on multiple levels. Learner interaction at the National Zoological Garden is a symphony of curiosity and discovery. Visitors of all ages become active participants, driven by their innate desire to understand the wonders of the living world. As they move from one exhibit to another, they are invited to explore, observe, and interpret. This interaction triggers questions that range from the basic to

the complex, spurring an ongoing dialogue between the learner and the environment. Whether it is marvelling at the behaviours of animals, deciphering adaptations, or contemplating the intricate web of ecosystems, each encounter becomes a stepping stone to deeper understanding.

Crucially, this interaction is not confined to solitary moments. The National Zoological Garden provides a canvas for discourse to flourish. Visitors share their observations, insights, and questions with family members, friends, and fellow explorers. This exchange of perspectives enhances the learning experience, as learners gain new insights and expand their thinking through discussions. This shared exploration fosters a sense of community, where diverse viewpoints merge to create a richer understanding of the natural world and its complexities. Teachers also play a pivotal role in shaping learner interaction and discourse at the National Zoological Garden. Their expertise transforms casual observations into profound learning opportunities. Through carefully crafted questions and prompts, educators guide learners' attention to critical details, encouraging them to make connections and think critically. These interactions spark thought-provoking discussions that encourage learners to delve deeper into the scientific concepts underlying the exhibits. By interacting with educators, learners gain not only factual knowledge but also the skills to analyze, synthesize, and evaluate information.

In reflection, the learner interaction and discourse at the National Zoological Garden offer a vivid illustration of the power of engagement in education. Through their interactions, learners move beyond passive absorption of information and become active participants in their own learning journey. The synergy of questions, observations, and discussions creates a dynamic learning ecosystem where curiosity thrives, understanding deepens, and perspectives broaden. This environment nurtures not just knowledge but also a sense of wonder, respect, and responsibility towards the natural world. The National Zoological Garden stands as a living testament to the transformative potential of interaction and discourse in shaping informed, engaged, and compassionate learners who appreciate the intricate beauty of our planet.

5.3.3.3 The role of teachers accompanying learners at the National Zoological Garden

The role of teachers accompanying learners at the National Zoological Garden is an embodiment of educational guidance and transformation. As one reflects on this essential role, it becomes clear that educators wield the power to amplify the impact of a zoo visit, turning it into a profound educational experience that extends far beyond the confines of the garden. Teachers are not mere chaperones; they are orchestrators of learning. Their presence transforms the zoo from a recreational outing into a curated journey of exploration and discovery. With their comprehensive understanding of the curriculum, teachers craft a narrative that weaves seamlessly between classroom learning and the real-world encounters at the garden. They guide students' attention to key concepts, enabling them to draw connections between the exhibits and their academic studies.

One of the most significant contributions teachers make is in the framing of questions. By asking thought-provoking questions, educators encourage students to look beyond the surface and delve into deeper layers of understanding. These inquiries prompt critical thinking and guide students to observe specific details that might otherwise go unnoticed. The skilful art of questioning fosters a habit of inquiry that empowers students to take ownership of their learning and explore the world with curiosity and purpose. Teachers also serve as interpreters, helping students decipher the language of nature. Whether it's explaining animal behaviours, describing ecological relationships, or discussing conservation efforts, educators provide context that enhances the learning experience. This interpretive role bridges the gap between textbook knowledge and real-world application, making abstract concepts tangible and relevant.

Perhaps the most transformative aspect of the teacher's role is their ability to spark wonder. Teachers kindle the flame of curiosity, igniting students' excitement to explore and learn. A well-prepared teacher infuses enthusiasm into the visit, turning each exhibit into an opportunity for discovery. This enthusiasm is infectious, motivating students to engage deeply and passionately with the subjects at hand. The relationship between teachers and students at the National Zoological Garden is symbiotic. Just as teachers guide students, students can also inspire teachers. The

unique environment of the zoo can reveal new facets of students' interests, curiosities, and strengths. Teachers gain insights into individual learning styles and can adapt their approaches accordingly, further customizing the educational experience.

In reflection, the role of teachers accompanying learners at the National Zoological Garden embodies the true essence of education: to ignite minds, inspire curiosity, and guide students towards deeper understanding. Through their guidance, educators create bridges between theory and practice, formal learning and real-world exploration. The teacher's presence transforms the zoo visit into an opportunity for holistic growth, fostering intellectual curiosity, critical thinking, and a lifelong connection to the natural world. In this role, teachers shape not just a single outing but a memorable educational journey that leaves a lasting impact on students' hearts and minds.

5.4. Case 2

5.4.1 Challenges

Education Officer 2 was observed and interviewed on her lesson. The lesson she presented was on “understanding South African Biodiversity”. She had a station and displayed different specimen, biofact materials and staffed animals to teach learners about South African Biodiversity.

Ramey-Gassert (2016) and Cox (2019) argue that science centres and museums are better placed to provide hands-on experiences to learners. However, when learners visit the National Zoological Garden in large numbers, it often becomes difficult to proper control the groups. Failure to properly control the groups sometimes leads to disruption of science teaching and learning. Reflecting on this logistical challenge, education officer 2 (EO2) said:

> **“***Challenges, I would say maybe some especially let’s say, when we have a lot of schools coming in a day, they all want to touch the exhibit, they break some of the exhibits, these learners do not have control. They don’t listen, they run around because they are many groups, so they have no time to learn. So for me, that kind of takes time away from other things, but then other than that I don’t have anything to tell*.” (EO2)

The Education Director at the National Zoological Garden indicated that the facility is visited by more than 100 000 learners and teachers annually. On a busy day, more than 10 schools visit the facility (see Figure 5.4). It has also been observed that many schools visit the National Zoological Garden before they go for school holidays. The influx of groups visiting the National Zoological Garden poses logistical challenges challenge to education officers. According to Tran and King (2007), education officers at science centres and museums should be able to connect and build on the experiences and wishes of different visiting school groups and be flexible with the programme.

Figure 5.4: Group of learners visiting the National Zoological Garden

There is no question that a visit to a science centre contributes the learner's logical reasoning, information and disposition (Mosabala, 2014). For some schools, a visit to the science centre is part of their culture. It is a challenge when many schools visit the National Zoological Garden at the same time because education officers do not have the capacity to manage large crowds. Teachers have a role to play at science centres when visiting with learners (see Figure 5.5) . If they do not play their role, it becomes a challenge for the education officers. Teacher 2 was asked on how they prepare lesson for the trip to the National Zoological Garden. She said.

> “ we encourage the to pay on time, we give them two months to prepare for the trip. They get very excited when we tell them to prepare for the trip to

the Zoo. They like seeing animals. They came here ready to have fun and run around the zoo. They enjoy being out of the classroom”

The teacher did not say anything about her learners learning at the National Zoological Garden. She did not mention any link between the curriculum and the teachings taking place at the centre. According to McClaffey (2014), teachers hardly perceive science centres and Museums activities as engaging socio-cultural learning experiences. McClaffey (2014) observed that teachers do not engage in the learning activities coordinated by Museums. Falk and Dierking (2000) also observed that some teachers only visit to have fun. In this regard, EO2 said:

“If a teacher does not want a lesson from the get-go it’s a challenge, because once a teacher says they don’t want lessons and it happens that the learners want it the teachers won’t be involved, and once the teachers are not involved they actually rush us into finishing the lessons, and they don’t want to actually rotate that’s one problem that we face. Again some teachers will leave the learners with us and say they want to prepare food for the learners same just disappear from the station or they are not interested at all in the lessons. Teachers do not understand that they are here for education”. (EO2)

Figure 5.5: Minimal teacher involvement in the lesson

Schep *et al* (2018) found that very little is done to prepare for visits to science centres and Museums. Most teachers hardly understand the objective of the visit to the

Museum. Some teachers only focus on issues such as clothing and food during the excursion. Reflecting on this challenge, EO2 indicated:

> "Some teachers don't understand that there is teaching and learning of science taking place at the National Zoological Garden. Teachers are always in a hurry, and are only interested in learners seeing the resources only, and they do not want learners to wait and learn from the exhibits". (EO2)

Language barrier still had a significant impact on science teaching and learning. When highlighting this challenge, EO2 said:

> *"Language barrier is something that is very challenging. So like I said you need to know the level of their understanding of the English language. So if you know that you will be dealing with learners who do not know much, I mean to express themselves in English you need to lower your language, you need to use examples that they can relate to on a daily basis, you don't need to use complicated scientific concepts, sometimes you have to divert away from English into their own language or mother tongue. And that will help them to learn more. When you ask them questions in English they don't respond, if you ask them in their mother tongue they respond. Interaction is sometimes difficult in English".* (EO2)

According to Cox (2018), argumentation is seen as an essential goal of science education. Argumentation enables learners to support their claims by using appropriate evidence and reasoning as well as consideration of alternative explanations. It was difficult for the learners to indulge in argumentation about science concepts due to language barrier. Set (2019) argues that the proper way of using language in knowledge construction is vital for successful learning to occur. Science knowledge is not static and interaction and discourse help learners to attain a common understanding of scientific concepts. EO2 indicated that code switching and translanguaging can be harnessed to foster learner interaction and discourse.

5.4.2 Opportunities

Reiss (2018) argues that interactive activities and displays at science centres and Museums provide stimulating learning environment. In support of this assertion, EO2 maintained that:

> *"It is important for learners to come to the National Zoological Garden to learn science because we have interesting activities and many exhibits that make us to teach science in an interesting way, they won't forget what they learned at the Zoo."* (EO2)

Hourdakis and Ieronomakis (2020) argue that science centres and museums can offer a model of experiential discovery. Griffith (2009) contends that science centres and Museums have the capacity to stimulate learners' interest to learn science using collection of exhibits and displays (see Figure 5.6). In this regard, EO2 said:

> *"So, with the resources that we use, is very important to use resources because, in school, children don't have resources so we don't want to go do just show or tell, they need to actually see what we are talking about since they don't have such things in school, so when they get to the Zoo, they need to have something different from what they do in classrooms and they won't forget such memorable experience of the zoo. So when they are here they have to experience something else, they have to feel and also see so that they can have something to talk about when they go back to school, something very interesting."* (EO2)

Figure 5.6: Learners interacting with exhibits and displays

Cullen (2005) argues that science centres and Museums can supplement the school curriculum by helping learners to comprehend logical ideas using exhibits and displays. In support of this notion, Cox (2019) posits that science centres and Museums are ideally poised to develop learners' intuitive understanding of science. In this regard, EO2 said:

> *"Normally, we look at the school curriculum let's say we going to deal with grade 4 we look at their school curriculum what actually do or actually what did they teach them in schools and then from there we look at the things that actually we can teach them based on what the curriculum says, so that how we link it, so our lesson have to link in with the school curriculum, cannot teachers or they don't or would not learn about we have teach them like something that actually corresponds to the curriculum."* (EO2)

5.4.3 Overall reflection on key findings emanating from Case 2

5.4.3.1 The use of exhibits to enhance science teaching and learning at the National Zoological Garden

The use of exhibits in science teaching and learning, especially in unique educational settings such as the National Zoological Garden, offers a dynamic and immersive approach that significantly enriches the educational experience. Exhibits provide a tangible bridge between theoretical knowledge and real-world applications, enabling learners to engage with scientific concepts in a meaningful way. The overall impact of exhibits on learner interaction and discourse within such environments is profound, fostering curiosity, critical thinking, and collaborative learning. Exhibits serve as powerful tools for sparking curiosity and inviting exploration. They captivate learners' attention by presenting complex scientific concepts in visually engaging formats. The multisensory experience of interacting with exhibits can ignite enthusiasm for learning and nurture a sense of wonder about the natural world. This type of engagement encourages learners to ask questions, seek answers, and engage in active discussions with peers and educators.

The use of exhibits in science teaching and learning, especially within environments like the National Zoological Garden, has a transformative impact on learner engagement, interaction, and discourse. Exhibits captivate learners' attention, encourage active exploration, and facilitate collaborative learning experiences. The role of teachers in this context is pivotal, as they guide learners to extract meaningful insights from the exhibits, foster critical thinking, and facilitate deep learning. The combination of immersive exhibits and skilled educators can create a powerful learning environment that not only imparts scientific knowledge but also cultivates a lifelong passion for learning and understanding the natural world.

5.4.3.2 Learner interaction and discourse in science teaching and learning at the National Zoological Garden

Language barrier hampered learner interaction and discourse in science teaching and learning at the National Zoological Garden. It has been observed that learners do not participate in a lesson being presented if they do not understand the language of instruction. There is a need for education officers to be proficient in other South African languages to be able to interact meaningfully with the learners. Proficiency in other South African languages would enable education office to use code switching and translanguaging as scaffolding techniques to foster meaningful science teaching and learning at the National Zoological Garden. Learner interaction at exhibits encourages a sense of agency and ownership over the learning process. The hands-on nature of interacting with displays allows individuals to manipulate objects, make observations, and draw conclusions independently. Such experiential learning can lead to a deeper understanding of scientific principles and concepts. Moreover, exhibits often facilitate collaborative learning experiences as learners share their discoveries and insights with others, fostering a culture of exploration and knowledge exchange.

5.4.3.3 The role of teachers accompanying learners at the National Zoological Garden

It has been observed that most teachers accompanying learners during visits to the National Zoological Garden do not actively participate in science teaching and learning activities. It is imperative to encourage teachers to play a meaningful role during science teaching and learning activities as key agents of educational change. Furthermore, teachers play a pivotal role in scaffolding learners' interactions with

exhibits. They can model effective observation techniques, encourage experimentation, and prompt learners to think beyond the surface-level content. Teachers also help learners develop skills in analysing information, making informed judgments, and considering ethical and conservation-related implications – skills that are crucial in nurturing scientifically literate citizens. In this context, the role of teachers accompanying learners at the National Zoological Garden takes on a multifaceted dimension. Teachers serve as guides, facilitators, and interpreters, helping students navigate the exhibits effectively and guiding them towards meaningful reflections. Teachers can frame questions that stimulate critical thinking, encouraging learners to connect the information presented at exhibits with their prior knowledge and experiences. The teacher's ability to initiate thought-provoking discussions, facilitate group activities, and provide context enhances the overall educational value of the visit.

5.4.3.4 The link between the school curriculum and the lessons provided by the National Zoological Garden

The lessons offered at the National Zoological Garden are linked to the school curriculum. Education officers at the National Zoological Garden develop their lessons based on the topics and objectives of the school curriculum. Education officers at the National Zoological Garden collaborate with the Department of Basic Education to develop science teaching and learning material. The link between the school curriculum and the lessons provided by the National Zoological Garden is a crucial aspect of ensuring effective and meaningful educational experiences for students. When properly aligned, this connection can bridge the gap between formal classroom learning and real-world applications, enhancing students' understanding and appreciation of scientific concepts, conservation principles, and the natural world.

Curriculum Relevance and Integration: A well-designed curriculum takes into account learning objectives, standards, and educational outcomes. The lessons provided by the National Zoological Garden should align with these curricular goals. By integrating zoo-based experiences into the curriculum, educators can provide students with concrete examples that illustrate abstract concepts taught in the classroom. For instance, lessons about biodiversity, ecosystems, adaptation, and

conservation can be reinforced through direct observation of zoo animals and their habitats.

Experiential Learning: The National Zoological Garden offers a unique opportunity for experiential learning, where students can engage with living organisms, observe animal behaviour, and interact with interactive exhibits. This hands-on approach not only deepens their understanding of scientific principles but also helps to make the learning process memorable and engaging. These experiences can spark curiosity and motivation to explore related topics more deeply within the classroom setting.

Multidisciplinary Connections: The lessons provided by the National Zoological Garden can often span multiple disciplines. Whether it's biology, environmental science, geography, ethics, or even art and design, the zoo's exhibits and programs can serve as rich contexts for interdisciplinary learning. This interdisciplinary approach encourages students to see connections between different subjects and fosters a holistic understanding of complex issues.

Contextualization and Application: Many concepts taught in the classroom can seem abstract or disconnected from real life. Visiting the National Zoological Garden provides a tangible context for students to apply theoretical knowledge to real-world situations. They can see how concepts like adaptation, symbiosis, and predator-prey relationships play out in actual animal habitats, which can enhance their comprehension and appreciation.

Cultivation of Environmental Stewardship: Today's curriculum often includes a focus on environmental literacy and conservation ethics. The National Zoological Garden can serve as a powerful platform for cultivating a sense of environmental stewardship and responsibility. Students can witness first-hand the importance of conservation efforts and gain insights into how humans impact ecosystems and wildlife.

Diverse Learning Styles: Every learner has a unique learning style, and some may thrive in non-traditional educational settings like a zoo. Lessons at the zoo cater to visual, auditory, and kinaesthetic learners by providing a multi-sensory experience. This diversity of learning opportunities can help reach students who may struggle with traditional classroom instruction.

In essence, the link between the school curriculum and the lessons provided by the National Zoological Garden enriches education by bringing abstract concepts to life, fostering experiential learning, and promoting interdisciplinary understanding. When educators and zoo staff collaborate to align educational goals, students can benefit from a holistic and well-rounded educational experience that bridges theory and practice, classroom and real-world, and academia and conservation.

5.5 Case 3

5.5.1 Challenges

Education officer 3 (EO3) was observed and interviewed on her lesson about "Microscopic world". The lesson was about microscopes and how they are used in science laboratories. Managing the learner groups proved to a serious challenge for EO3 (see Figure 5.7).

Figure 5.7: Schools groups congregated in one place

Highlighting this challenge, EO3 said:

> "*The challenges that we faced is that when learners arrive in large numbers and the space that we have, and the stations the number of stations that are going to be there because sometimes we can't accommodate all learners in our stations, some learners do not want to learn, they just want to go around seeing animals, you get many schools with a very huge amount of learners so we send some to the picnic area, mostly the once who do not want to learn. You cannot attend to all of them and some of them are not interested in learning they are here to see animals and to play. Some of the learners are*

not interested in learning, is not easy to control them. They are here for entertainment." (EO3)

The highlighted challenge hampered learner interaction and discourse (see Figure 5.8). In this regard, EO3 said:

> "*I think their concentration and behaviours at the centre is a big challenge. At first when they arrive at the station, learners want to behave like they are in the classroom, they are not relaxed. They want to follow classroom rules. If you are delivering the lesson they want to sit in rows like in the classroom. In a very serious manner sometimes they get scared, you can't interact back with them because now is like they are in a classroom sitting again. They must follow the rules, they should not say the wrong answers. They were scared to touch the resources and they can't learn how to use then if they don't touch these exhibits I think some of them are not familiar with microscopes, they see them for the first time, some are scared to touch them. They don't understand what to do, yes they have seen microscopes in their books but they have no idea how it works*." (EO3)

When asked about the preparations of the trip to the science centre, one of the teachers said

> " we prepare them on time, we give them letters to give their parents on at least a month before, so that parents can be able to pay for the trip. We encourage the learners to pay on time because the space in the transport is limited".

Visits to science centres and museums have turned into a lifestyle for many communities and school groups (Griffin, 2009). Mosabala (2014) observed visits science centres and Museums are perceived as entertainment opportunities. Rennie and McClafferty (2016) caution that science centres and Museums should not provide entertainment at the expense of meaningful science teaching and learning. Science centres and museums have been criticized for being playgrounds where learners are being entertained at the expense of meaningful science teaching and learning (Harington, 2001).

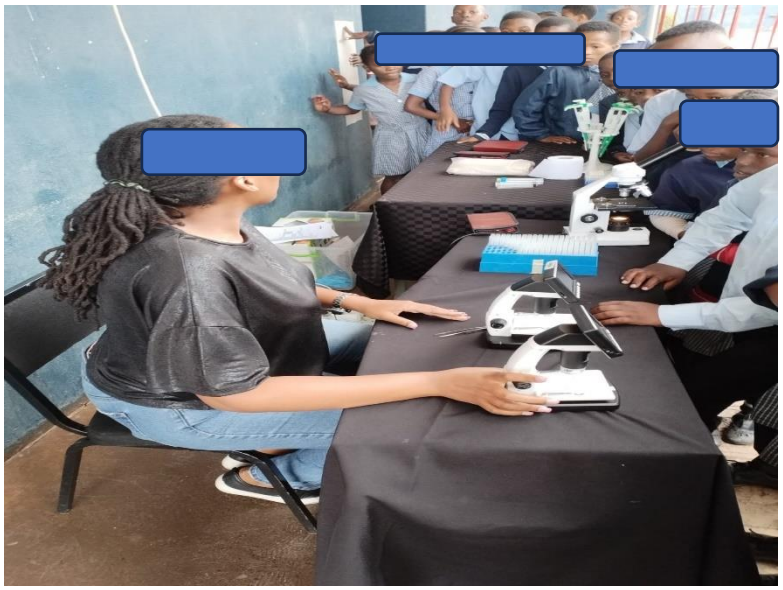


Figure 5.8: Learner interacting with microscopes within a confined space

Reiss (2018) argues science centres and Museums should provide learners with the opportunity to see and touch the exhibits and ask questions for development of scientific and technological understanding. According to Bandelli and Konijin (2011) science centres and Museums have the potential to be effective platforms for democratic development of scientific understanding.

Language barrier was also identified as a challenge hampering learner interaction and discourse. Reflecting on this challenge, EO3 said:

> *"In my observation there are kids who are familiar with English, they interact more. To some, scientific concepts are foreign to them, so if you try to explain to them in English, they are not going to understand you and they don't participate, so if you are using the language that they can understand or their native language it makes easier for them to comprehend even they concentrate more and participate because you are talking about something they can understand. ok, with most public schools, you have to deliver the lessons to them in their narrative language, because I do ask them which language they understand better, is it English, then they will tell those ones they will speak Sepedi, so if you don't know Sepedi, you have to call someone who knows Sepedi from different station to come and deliver the lesson to them. When I use Sepedi they start talking and ask questions showing that*

they understand the lesson. So English is a bit of a problem, but usually on public schools." (EO3)

The understanding of discourse as a social phenomenon is predicated on the fact that talk is collaboratively constructed and negotiated for a particular purpose (Tran, 2016). For the talk to make sense, language plays an important role. According to Gee (2012), social theories of discourse describe how language and speech are embedded in interactions between people. A dialogic pedagogy can better facilitate the learners' process of constructing knowledge through questioning, interrogation and negotiation of ideas and opinion in an intellectual and respectful way (Teo, 2019). Set (2019) argues that appropriate use of language in knowledge construction is vital for successful learning to occur. EO3 lamented teachers' lack of participation in science teaching and learning activities coordinated by the National Zoological Garden (see Figure 5.9). This can be attributed to lack of preparation for visits to the National Zoological Garden by teachers (Schep *et al,* 2018). Reflecting on this challenge, EO3 said:

"What I have noticed, teacher do not prepare learner for the education at the Zoo. They moment they arrive, they don't care what happens next. They leave learners, they either go out of the Zoo or go alone around the Zoo. Some teachers they sit down and have picnic, but you do get some schools where teachers get active in the lesson, but very few schools. Mostly white schools. These teachers they don't even know what we are teaching their learners they don't care". (EO3)

Figure 5.9: Minimal involvement of teachers in the lesson

5.5.2 Opportunities

Reiss (2018) argues that interactive activities and displays at science centres and Museums provide stimulating learning environment (see Figure 5.10).

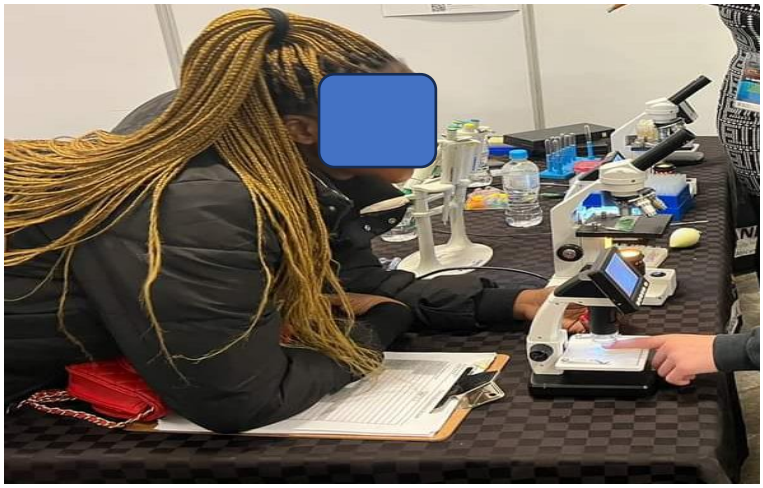


Figure 5.10: Learners interacting with microscopes

In support of this assertion, EO3 maintained that:

> "*Having to use microscopes, I mean real ones, to teach learners is a great opportunity to me and to the learners. It makes teaching easy and interesting. Learners were so fascinated by this resources, they all wanted to touch the*

microscope, some were seeing the microscopes for the first time, because they don't have at school, they could not believe the magnification on the insect. They did not want to leave my station even when time is up, they were still with me, exploring the microscopes." (EO3)

Education officer make every effort to ensure alignment between science teaching and learning material and the school curriculum. In this regard, EO3 said:

"We check first before developing the lesson that the grade 5 is supposed to be doing 1, 2, 3 and has to be within that curriculum. We invite subject specialist from the Department to assist us when developing this lessons. It has to be something that they should be studying and have not been taught at school, so it will be easy for them to comprehend according to the curriculum". (EO3)

5.5.3 Overall reflection on key findings emanating from Case 3

5.5.3.1 The use of exhibits to enhance science teaching and learning at the National Zoological Garden

The integration of exhibits in science teaching and learning at a place like the National Zoological Garden is a testament to the power of experiential education. It redefines the classroom, inviting learners to engage with the world in a tangible and memorable way. This approach not only enhances their understanding of scientific concepts but also fosters curiosity, critical thinking, and a deeper connection to the subject matter. Exhibits serve as immersive gateways to learning. They transform abstract ideas into concrete experiences, making complex concepts accessible and relevant. The combination of visual, auditory, and kinaesthetic elements sparks interest and facilitates understanding. Learners have the opportunity to interact directly with displays, fostering a hands-on exploration that deepens their grasp of scientific principles. In reflection, the use of exhibits in science teaching and learning at the National Zoological Garden embodies the essence of transformative education. It promotes active engagement, deepens understanding, and nurtures a lifelong passion for learning. The interaction and discourse among learners stimulate intellectual growth, encouraging them to become independent thinkers and problem solvers. The role of teachers as guides and facilitators enhances this experience, infusing the visit with educational purpose and ensuring that it aligns with broader learning objectives.

5.5.3.2 Learner interaction and discourse in science teaching and learning at the National Zoological Garden

Language barrier hampered learner interaction and discourse in science teaching and learning at the National Zoological Garden. It has been observed that learners do not participate in a lesson being presented if they do not understand the language of instruction. There is a need for education officers to be proficient in other South African languages to be able to interact meaningfully with the learners. Proficiency in other South African languages would enable education office to use code switching and translanguaging as scaffolding techniques to foster meaningful science teaching and learning at the National Zoological Garden.

The National Zoological Garden's exhibits provide a real-world context that complements classroom learning, offering students a chance to witness concepts in action and observe the intricacies of the natural world. Central to this experience is the learner's interaction and discourse. Visiting the National Zoological Garden encourages active participation and collaboration among students. They become investigators, asking questions, making observations, and formulating hypotheses. This engagement encourages peer discussions that promote critical thinking and knowledge sharing. Through dialogue, learners can challenge assumptions, refine their understanding, and develop a holistic view of the subject matter. The diversity of viewpoints and interpretations enriches the learning experience, fostering a dynamic and interactive atmosphere. Ultimately, the blend of immersive exhibits, learner interaction, and skilled educators at the National Zoological Garden results in an educational journey that transcends traditional classroom confines. It empowers learners to explore, question, and connect with the natural world, fostering a sense of wonder and discovery that leaves a lasting imprint on their educational journey and beyond.

5.5.3.3 The role of teachers accompanying learners at the National Zoological Garden

The role of teachers accompanying learners at the National Zoological Garden is pivotal. Teachers serve as facilitators of learning, guiding students' interactions with exhibits and helping them extract meaningful insights. They weave the visit into the broader curriculum, ensuring that the experience aligns with educational goals. Through thoughtfully crafted questions and prompts, teachers encourage students to connect what they observe to their existing knowledge, bridging the gap between theory and practice. The presence of teachers also provides a valuable opportunity for personalized guidance, addressing individual questions and tailoring the experience to meet diverse learning needs. Furthermore, teachers' expertise allows them to highlight connections between different exhibits and subjects, fostering interdisciplinary thinking. They can draw parallels between biology, geography, ethics, and environmental science, demonstrating the interconnectedness of knowledge. By contextualizing the learning experience within various disciplines, teachers help students see the relevance of their education beyond individual subjects.

5.5.3.4 The link between the school curriculum and the lessons provided by the National Zoological Garden

The symbiotic relationship between the school curriculum and the lessons offered by the National Zoological Garden is a testament to the power of bridging formal education with real-world experiences. This connection not only enhances students' academic journey but also nurtures their connection to the natural world and the principles that govern it. Reflecting on this link brings to light the profound impact it has on students' learning, engagement, and perspective. At the heart of this connection is the concept of contextualized learning. The National Zoological Garden serves as an expansive classroom where textbooks come to life, and theoretical concepts gain tangible form. As students step through the gates of the zoo, they step into a living laboratory, where scientific ideas transform into living realities. The school curriculum lays the foundation, providing the theoretical framework, while the lessons at the zoo breathe life into these theories, demonstrating their relevance and applicability.

This integration extends beyond the academic realm. It stokes the fires of curiosity, enabling students to ask questions that bridge the gap between theory and practice. Witnessing animals in their habitats, observing their behaviors, and understanding the delicate balance of ecosystems awaken a sense of wonder and intrigue that textbooks alone cannot replicate. This engagement fuels a desire to learn, encouraging students to delve deeper into related subjects and explore their intrinsic connections. Moreover, the link between the curriculum and zoo lessons embodies a holistic approach to education. It recognizes that learning doesn't occur within the confines of a classroom alone. Lessons provided by the National Zoological Garden encourage interdisciplinary thinking, connecting the dots between various subjects and illustrating how knowledge transcends traditional boundaries. Concepts in biology intersect with principles of ethics, conservation, geography, and even art and design. This interdisciplinary perspective nurtures well-rounded individuals who can approach complex issues from multiple angles.

The lessons offered at the zoo also foster a profound sense of stewardship. As students witness the intricacies of ecosystems and the fragility of biodiversity, they develop an understanding of their role in preserving and protecting the natural world. This link between education and environmental consciousness is invaluable, cultivating a generation of environmentally aware citizens who recognize their responsibility to the planet. In the reflection on the connection between the school curriculum and the lessons provided by the National Zoological Garden, one cannot overlook the role of educators. Teachers, armed with knowledge of both the curriculum and the zoo's offerings, become guides and facilitators, navigating students through this enriching experience. They foster discussions that encourage critical thinking, helping students extract deeper meanings from their observations. Educators amplify the impact of the zoo lessons, ensuring that they align with learning objectives and resonate with students' academic growth.

The intertwining of the school curriculum and the lessons offered by the National Zoological Garden is a harmonious blend of theory and practice, textbook and habitat, classroom and living laboratory. This connection transforms learning from a passive pursuit into an active, immersive experience. It nurtures curiosity, inspires interdisciplinary thinking, fosters environmental consciousness, and empowers students to become informed, engaged citizens of the world. The reflection on this link

serves as a reminder of the transformative potential of education that extends beyond the confines of four walls and ushers students into a realm of exploration, discovery, and connection with the natural world.

CHAPTER 6: DEVELOPMENT OF A STRATEGIC FRAMEWORK FOR ENHANCING SCIENCE TEACHING AND LEARNING AT THE NATIONAL ZOOLOGICAL GARDEN

6.1 Introduction

This chapter outlined the development of a strategic framework for enhancing science teaching and learning at the National Zoological Garden. The development of a strategic framework was largely informed by key findings emanating from the first phase of the study. The strategic framework was used in the second phase of the study. The developed strategic framework helped the researcher to answer the following research question:

How can a framework for enhancing science teaching and learning at a National Zoological Garden be developed and implemented?

6.2 Nature of the Strategic Framework

Science centres in South Africa are mandated by the Department of Science and Technology to promote science to stimulate learners' scientific curiosity, train learners in science communication, and expose learners to science projects (DST, 2015). One of the main objectives of the National Zoological Garden is to provide quality science education to visiting school groups. Falk and Dierking (2000) argue that enjoyable and memorable experiences of science education at a science centre environment require the involvement and commitment of all involved in the process of learning and teaching. The purpose of this strategic framework is to enhance science teaching and learning at science centre such as the National Zoological Garden.

The findings of the first phase of the study informed the development of a strategic framework for enhancing science teaching and learning at the National Zoological Garden. The strategic framework was developed using the SWOT analysis approach. In order to achieve a dynamic approach to strategic framework development, a systematic and reliable process was implemented (Shah & Nair, 2014). Based on the strengths, weaknesses, opportunities and threats identified, the researcher proposed a strategic framework that eliminates the weaknesses and threats and exploits the strengths and opportunities to enhance the science teaching and learning at the National Zoological Garden.

6.3 Summary of findings emanating from the first phase of the study that underpinned the development of the strategic framework

Table 6.1 summarises the findings emanating from the first phase of the study that underpinned the development of the strategic framework for enhancing science teaching and learning at the National Zoological Garden.

Table 6.1: Summary of findings emanating from the first phase of the study that underpinned the development of the strategic framework

Concepts	Findings
Exhibits/Resources	The National Zoological Garden has exhibits/ resources that can be used for teaching and learning science. These resources can be used to excite and encourage learners to study science. The use of exhibits and interactive displays can enhance science teaching and learning. Interactive exhibits at the National Zoological Garden are used to stimulate learners' interest in science and to encourage learners to pursue science careers.
The role Education Officers	National Zoological Garden staff is responsible for teaching visiting learners. Education Officers use the resources/exhibits to facilitate science teaching and learning at the facility. The influx of school groups visiting the National Zoological Garden is often overwhelming to Education Officers.
Learner interaction and discourse	Language barriers hamper meaningful interaction between education officers and learners. Code switching and

	translanguaging can be beneficial as scaffolding techniques.
The role of teachers accompanying learners	Teachers do not understand their role when visiting the National Zoological Garden. Most teachers accompanying learners to the National Zoological Garden do not assist with science teaching and learning. Teachers do not make adequate preparations for learner visits to the National Zoological Garden.
Alignment between the school curriculum and lessons presented by Education Officers at the National Zoological Garden	The lessons offered at the National Zoological Garden are linked to the school curriculum. The education officers at the National Zoological Garden work together with officials from the Department of Basic Education to develop the lessons for the centre. Education officers at the National Zoological Garden develop lessons focusing on the topics and objectives of the school curriculum.

6.4 Development of the Strategic Framework for enhancing science teaching and learning at the National Zoological Garden

The findings from the first phase were used to develop the strategic framework for enhancing science teaching and learning at the National Zoological Garden. The opportunities at the National Zoological Garden were exploited to mitigate against weaknesses and threats afflicting science teaching and learning science at the National Zoological Garden.

6.4.1 Resources/Exhibitions

The National Zoological Garden is well-resourced with exhibits/resources which can be used to improve the quality of science education. Animals in their enclosures,

biofact, specimen and other interactive resources are the main exhibits that attract learners to the centre. The resources at the National Zoological Garden are used to excite and encourage learners to study science. The development of the strategic framework is predicated on the fact that the use of interactive resources should be harnessed to enhance understanding of scientific concepts.

6.4.2 The Role of Education Officers

Education officers are the staff employees of the National Zoological Garden responsible to interact with visitors. They develop interactive activities to engage visiting teachers and learners. The staff has a major role in teaching visitors science concepts that relate to the school curriculum. Education officers interpret the exhibits and engage learners in activities that foster understanding of science concepts. The strategic framework calls for education officers to maximise interactions with learners with a view to enhance science teaching and learning.

6.4.3 The role of teachers accompanying learners

Learners do not visit the centre alone as they are always in the care of their science teachers. Teachers neglect their primary role of teaching when they are in the centre. They shift their responsibilities to the education officers. Teachers do not understand their role at the centre. This implies that the role of teachers should be clearly defined at the centre. The centre should ask teachers to prepare their learners before the visit. Teachers should identify a topic to be taught at the centre and incorporate the lesson at the National Zoological Garden into their daily lesson. Involving learners in practical investigation tasks before visiting the National Zoological Garden would be helpful. Teachers should be actively involved in science teaching and learning activities coordinated by the National Zoological Garden.

6.4.4 Interaction and discourse

The language barrier was identified as one of the main challenges in science teaching and learning science at the National Zoological Garden. English is used as a medium of instruction in most schools. Some learners are battling to interact and discuss with their peers and with education officers when English is the only language used for teaching, but when “code-switching” is used, learners start to participate in the lesson. The strategic framework proposed “code-switching” to be implemented as a

scaffolding technique. Home language should be used often, especially when learners are not comfortable expressing themselves in English. Teachers and education officers should create an environment where learners are encouraged to express themselves in their home language. This will serve to improve interaction and discourse in science teaching and learning at the National Zoological Garden.

6.4.5 Lessons aligned to the school curriculum

It is important for the lessons at the National Zoological Garden to be aligned to the school curriculum to ensure that there is value for both teachers and learners visiting the National Zoological Garden. This has been identified to be one of the opportunities at the centre. This opportunity can be exploited further by providing information to the visiting schools before they come to the centre. Schools should know beforehand that the lessons at the National Zoological Garden are developed following the guidelines of the school curriculum. This will encourage teachers and learners to participate in the activities at the centre.

6.5 Developed Strategic Framework for enhancing science teaching and learning at the National Zoological Garden

6.5.1 Teaching and Learning Science at the Science Centre (TLSSC) framework

The proposed TLSSC strategic framework can be used to enhance science teaching and learning at the National Zoological Garden. Successful science teaching at the National Zoological Garden requires a coordinated approach that makes provision for resources to be fully utilised to involve learners in lessons that are aligned to the school curriculum. These lessons should encourage interaction and discourse and education officers and teachers should work together to enhance science teaching and learning. The TLSSC framework requires a fully integrated approach in which all relevant participants can play their roles to enhance science teaching and learning. The following components of the TLSSC framework play a vital role in science teaching and learning science at the National Zoological Garden.

- Resources/Exhibits
- The role of education officers
- The role of teachers
- Interaction and discourse

- Lessons aligned to the school curriculum

The components of TLSSC strategic framework should be integrated to enhance the science teaching and learning at the National Zoological Garden. Organisations such as science centres and Museums are faced with internal and external forces which can be stimuli for achieving their goals (Oreski, 2019). The TLSSC framework components should stimulate the National Zoological Garden to achieving its goal of popularising science and making it more interesting to the visiting schools. The developed TLSSC strategic framework for enhancing science teaching and learning at the National Zoological Garden is illustrated in Figure 6.1.

The description of the TLSSC strategic framework

The TLSSC strategic framework calls for a coordinated approach to enhance the teaching and learning in a science centre environment. The teaching and learning of science at the science centre is the core of this strategy as indicated in the middle on figure 6.1.

To enhance the teaching and learning of science in a science centre the five main components, namely education officers, teachers, learners, exhibits and interaction and discourse should be well integrated to the framework. Arrows are used to indicate collaboration and coordination of the five concepts. The arrows have double pointing to indicate that the five concepts depend on each other to enhance the teaching and learning of science. These concepts can only achieve the objective of enhancing the teaching and learning of science when they are collaborating and well-coordinated. They all need each other to achieve the set objective.

Arrows are drawn from the five concepts to the centre indicating that the focus is in the centre which is about enhancing the teaching and learning of science. While the concept are working together, their strengths are in the core, which is to enhance the teaching and learning of science. They should all work together toward the centre which in the main objective of the strategic framework.

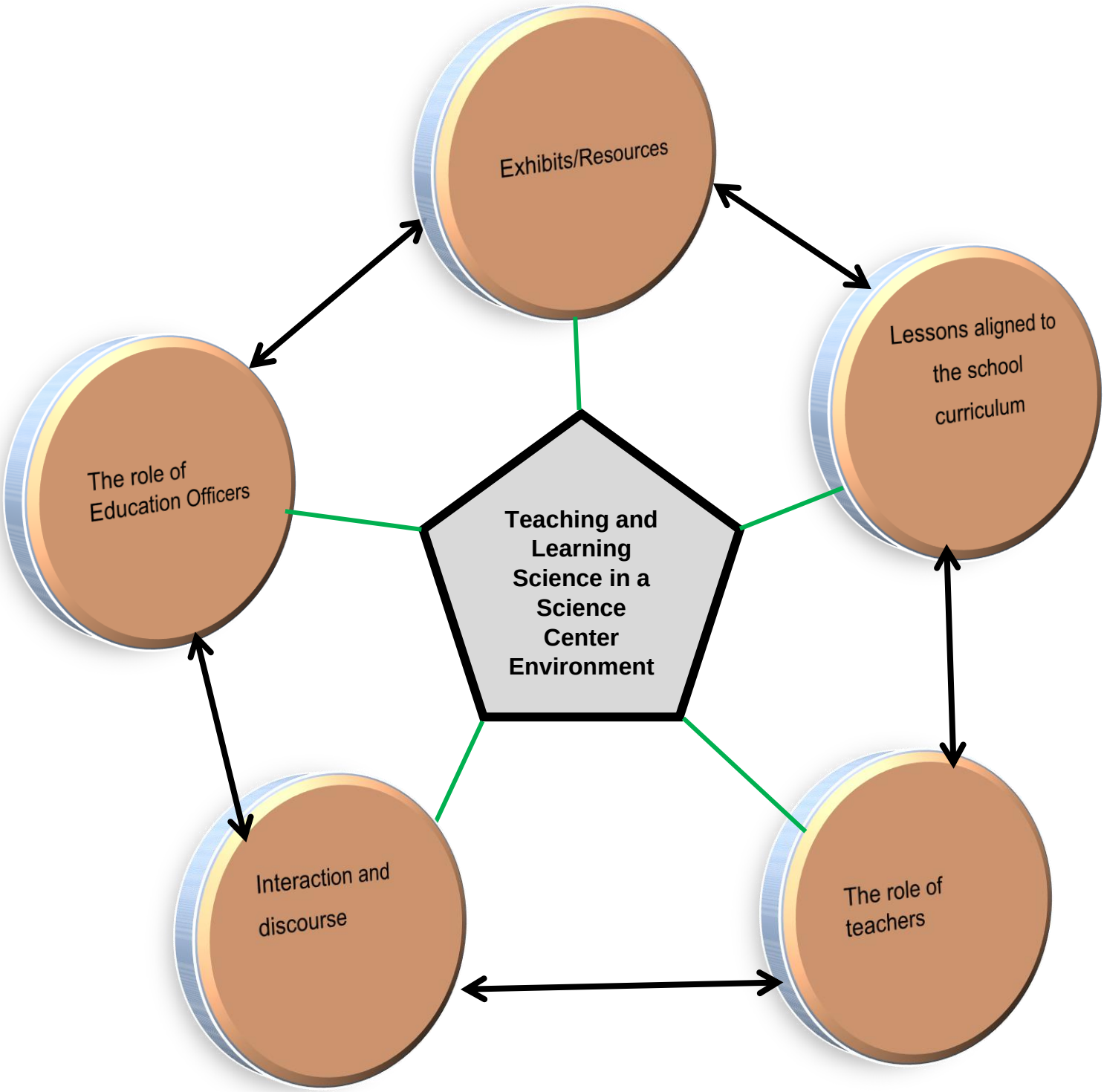


Figure 6.1: developed TLSSC strategic framework for enhancing science teaching and learning at the National Zoological Garden (Bilankulu, 2023)

CHAPTER 7: THE IMPLEMENTATION OF THE TLSSC STRATEGIC FRAMEWORK FOR ENHANCING SCIENCE TEACHING AND LEARNING AT THE NATIONAL ZOOLOGICAL GARDEN

7.1 Introduction

This chapter provides insights into the dynamics associated with the implementation of the TLSSC strategic framework for enhancing science teaching and learning at the National Zoological Garden. The influence of the developed strategic framework on interaction and discourse is also explored.

7.2 The influence of the developed strategic framework on interaction and discourse

The understanding of discourse as a social phenomenon is predicated on the fact that talk is collaboratively constructed and negotiated for a particular purpose. As an essential goal of science education, argumentation enables learners to support their claims by using appropriate evidence, reasoning, as well as consideration of alternative explanations (Cox, 2019). At the National Zoological Garden, interaction and discourse take place between learners, education officers, teachers and resources. The TLSSC strategic framework integrates learners, teachers, education officers, lessons and resources to enhance science teaching and learning by maximising interaction and discourse required for science knowledge construction. The integration of all components used in the TLSSC strategic framework can facilitate learners' process of constructing knowledge through questioning, interrogation and negotiation of ideas and opinion in an intellectual and respectful way (Teo, 2019).

The three education officers who participated in the study were called to the workshop. The researcher outlined the strategic framework and all concepts in the framework were discussed in the workshop. The researcher discussed all the details for implementing the TLSSC with the education officers. Details from welcoming schools, lesson presentation, activities and resources were discussed with education officers. The workshop lasted for three hours because of the details in the concepts and the interaction between the researcher and the education officers.

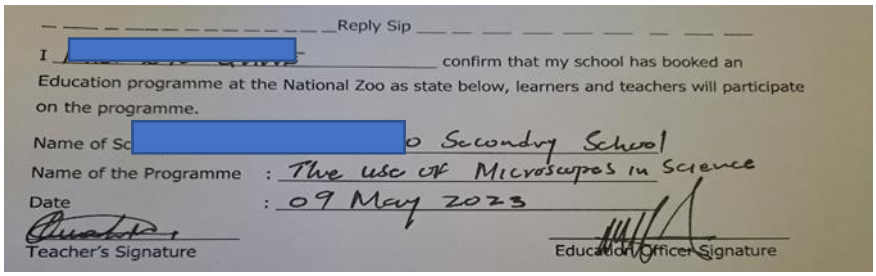
The developed strategic framework was used on three different cases. In addition, education officers were observed and interviewed when implementing the TLSSC strategic framework. Each case in presented and analysed separately.

7.3 Case 1

Education Officer 1 (EO1) was observed and interviewed when implementing the TLSSC strategic framework during science teaching and learning. The lesson observed involved the use of microscopes. EO1 was observed welcoming and confirming with the school that they booked a lesson on microscopes. Learners and teachers confirmed the booking by showing EO1 a confirmation booking slip. EO1 said to one of the teachers:

"…before we can start please let me see your confirmation slip. It is a requirement before we start with the lesson, I have to sign the slip." (EO1)

EO1 signed their slip to confirm that indeed the lesson on microscope was booked by that particular school. The slip signed by EO1 is illustrated in Figure 7.1.


Reply Sip

I [redacted] confirm that my school has booked an Education programme at the National Zoo as state below, learners and teachers will participate on the programme.

Name of Sc[redacted] o Secondry School

Name of the Programme : The use of Microscopes in Science

Date : 09 May 2023

Teacher's Signature

Education Officer Signature

Figure 7.1: The slip signed by EO1

7.3.1 Exhibits used to enhance interaction and discourse

A station was well prepared with five microscopes (three digital and two student light microscopes). Next to the microscope were slides, dissecting kits, pipette, petri dish and other tubes used to store specimen. These instruments were used to teach learners about the use of microscopes. The work station prepared by EO1 to teach learners about the use of microscopes is illustrated in Figure 7.2.

Figure 7.2: The work station prepared by EO1 to teach learners about the use of microscopes

According to Schep *et al* (2018), the exhibits in science centres and Museums make these institutions a special place for learning science. EO1 used the TLSSC strategy to arrange exhibits in a special way that attracts both teachers and learners to the station to come and learn about the use of microscopes. When asked about the arrangement of resources at the station, EO1 said:

> *"For me, is very important to have the sources well arranged, as per the TLSSC strategy that emphasise that resources are the main components which attracts schools to the National Zoological Garden and that they must be well arranged and attractive to the learners in order to make the lesson to be more interesting".* (EO1)

EO1 mentioned during the interview that the arrangement and display of the resources at her station was in such a way that the station was able to inculcate knowledge on the use of microscopes in science laboratories. She said:

> *"You see, resources are a major component in this strategy, I can't just place any resource on my table, I have to make sure that I'm using correct and relevant resources that relate very well to the lesson of microscopes, I don't want resources that will take me out of the topic. Only resources that support the content of the lesson are on my station".* (EO1)

She further said that her station represented a mini laboratory with the necessary equipment needed to perform an experiment that required the use of microscopes.

The authenticity, immediacy, interactivity, and cultural capital of the objects are shown in science centres and museums (Tran & King, 2007). According to Schep *et al*. (2018), objects provide access to knowledge that cannot be found in textbooks or learned in the classroom as well as the chance to feel a feeling of scale. Learners were excited to see the resources at the station. Some learners did not wait to be told what to do. They started to pip through the microscope to see through the lenses. In addition, some learners started touching other resources and asking questions about the resources. The behaviour of learners at the work station is illustrated in Figure 7.3.

Figure 7.3: The behaviour of learners at the work station

According to Reiss (2018), the use of resources play a major role in science teaching and learning as they spark dialogue amongst learners. Tran and King (2007) argue that science centres should create learning environments which allow learners to interact physically and intellectually with exhibits through hands-on experimentation and reflection. The use of the TLSSC strategic framework afforded learners opportunities to physically interact with the microscopes. The learners interacted intellectually by asking questions about the resources on display. Learners were heard arguing about what can be seen through the microscope with some placing their hands on the lenses to see how the hand will look like under a microscope. Other learners were heard discouraging others to put their hands, suggesting that they should place small objects, like hair or nails. Below is the conversation between learners:

Learner 1: *Do you know what is this?*

Learner 2: *yes, is a telescope… no a microscope.*

Learner 1: *haaah.. you are not sure.*

Learner 1: *you are not sure ask Jane.*

Learner 3: *is used to see the micro organisms*

Learner 1: *put your hand you will see*

Learner 3: *not your hand, your hair or nails will do.*

Learner 3*: this is a microscope…. For micro organisms*

Learner 1: *you can use it for anything, I know this thing*

When asked about the importance of the resources when using the TLSSC strategy framework for interaction and discourse in her lesson on the use of microscopes, EO1 said:

> *"This resources are used spark the debate among the learners and the teachers they ask each other as to what these instruments are and what are they used for."* (EO1)

Tran and King (2007) assert that resources at science centres can create a dialogue amongst learners. Learners discussed and related the exhibits to their existing science knowledge.

7.3.2 Learner interaction and discourse at the station

Learners did not wait to be told what to do at the station. They spontaneously started with the conversation about the resources. Some learners were seen looking through the microscopes being inquisitive and willing to learn about the use of microscopes displayed by EO1 when using the TLSSC strategy. Figure 7.4 depicts a group of learners looking through the microscopes.

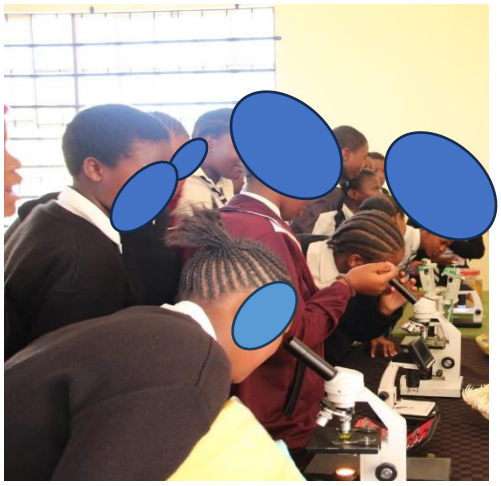


Figure 7.4: Group of learners looking through the microscopes

Reiss (2018) argues that collection of resources at science centres should provide afford learners opportunities to see and touch the exhibits and ask questions to facilitate development of scientific and technological understanding. Tran and King (2007) posit that the social learning context at Museums and science centres favours the spoken word. Learners interacted and asked questions about the displays at. They asked each other questions and some of the questions were directed to either their teachers or the education officer. Below is a conversation between learners and teachers:

Learner 1: *What do you see in there, move I want to see.*

Learner 2: *Wait… I will give you a chance.*

Learner 1: *What is there.. you don't see anything, let me see.*

Teacher 1: *Give her a change, to rush her.*

Learner 2: *I see bocks like cells sir, you remember the cell structure sir.*

Teacher 1*: What kind of a cell plant or animal?*

Teacher 1: *Let me see also.*

Learner 3: *Sir come and see this side… is so big.*

Learner 1*: Sir when will our school buy one for us? This is interesting.*

Teacher 1: What organelles are you able to see, do you see the nucleus?

Learner 2: I think is a plant cell

Learner 1: It does not look like a cell to me.

Learners explored the use of microscopes with little assistance from education officer and teachers. The constructivist viewpoint gives learners and teachers a comprehension that learning is an active process that involves interacting with and manipulating events and things in order to create a mental image of the outside world

(Piaget, 1983). Museums and science centres can provide a model of experiential learning (Eshack, 2016). Learners experienced the use of microscopes through an active process of touching and feeling the instruments. They constructed knowledge through dialogue and questioning. Figure 7.4 shows learners exploring the use of micro pipette.

Figure 7.4: Learners exploring the use of micro pipette

Learners asked each other questions about some of the apparatus displayed at the work station. Below is an argument about the use of micro pipette among learns.

Learner 1: *What are you holding there, don't break it*

Learner 2: *Hahaha. Is that a syringe Tumi? It looks like a Syringe.*

Learner 1: *That is used by scientist, you are not a scientist, let me see.*

Learner 3: *They say is a micro pipette ask her (EO1).*

Learner 3: *Do you know how to use a pipette?*

When asked about the interaction of learners at the station, EO1 said:

"It was so amazing to see learners so kin to learn, honestly, I did not do much, this kids were so overwhelmed, the way exhibits were placed did the magic for me at my station. Learners were asking each other "what is this? do you know how it works? and they were teaching each other and demonstrating how microscopes work, the discussion was so interesting. I only had to come in here and there to assist. I think the strategy works best and this must always be used". (EO1)

A dialogic pedagogy can facilitate learners' process of constructing knowledge through questioning, interrogation and negotiation of ideas and opinion in an intellectual and respectful way (Teo, 2019). Set (2019) argues that the proper way of using language in knowledge construction is vital for successful learning to occur. Science knowledge is not static and interaction and discourse help to develop a common understanding of scientific knowledge (Tran, 2016). The implementation of TLSSC strategic framework for enhancing teaching and learning calls for a systematic way of using resources and creation of a conducive environment for learners to construct knowledge in a non-threatening and non-evaluative manner. EO1 indicated that when resources are selected carefully, used effectively and relate well to the topic, learners are able to interact well and construct scientific knowledge. The handling of things such as exhibits chosen expressly for the audience provides the learners with additional unforgettable experiences, claims Ellis (2020). EO1 indicated that the microscopes at the work station were carefully selected for the purpose of teaching learners about the use of microscopes in science laboratories and the learners were encouraged to use them for that specific purpose.

EO1 indicated that learners were willing to learn about microscopes and the other apparatus that are used together with microscope in the science field. According to Bandelli and Konijin (2011), science centres can serve as effective platforms for discussions and debates that enable learners to be well informed and participate in the democratic development of science. In support of this assertion, Watermayer (2012) asserts that science centres and Museums which place emphasis on interactive activities and displays which are simulative and have contact feel experience are recommended. EO1 highlighted language barrier as one of the factors

influencing science teaching and learning. Freeman (2018) argues that second language speakers often experience problems with English as a medium if instruction.

7.3.3 Teacher involvement in science teaching and learning activities

The involvement of teachers accompanying learners in science teaching and learning activities is of vital significance. One of the teachers was seen confirming the booking and the topic of the lesson for the day with EO1. A confirmation slip was presented to EO1 indicating the agreed date and the topic for the lesson. The confirmation slip is designed to help teachers prepare for their trip to the National Zoological Garden. Two teachers were involved in the lesson about the use of microscopes. A teacher was seen arranging learners accordingly at the work station. Two teachers assisted EO1 with the arrangement of learners and keeping order at the station. One teacher was heard from the back saying:

> "Short learners please go and stand in front, you won't see anything at the back here. All of you must be able to see and learn here". (Teacher)

Figure 7.5 shows education officer (EO1) welcoming learners at the work station with the teacher at the back assisting with the arrangement of learners.

Figure 7.5: Education officer (EO1) welcoming learners at the work station

Teachers interacted with the exhibits and helped learners to identify some of the interactive displays. One of the teachers said:

> *"You must learn and understand the functions of different parts of the microscope because it will form part of the test back at school I'm not going to teach that section in detail again, learners must master the section as they are already learning about it here at the National Zoological Garden".* (Teacher)

Tal et al (2005) argues that meaningful learning in science centres and Museums happen when teachers get involved in the preparation of the visits. Many programs at science centres and Museums are developed to support and complement the school curriculum (Rennie & McClaffety, 2014). The lesson on the use of microscopes was developed using CAPS guidelines.

When asked about the role of teachers at the station when implementing the TLSSC framework, EO1 said:

> *"Teachers are important partners in this process of teaching and learning of science here at the National Zoological Garden…. when we use the developed strategy. The learners were many, I could not be able to control them alone. The teachers helped me a lot with arranging the learners. We are a team, working together. I enjoyed it, teachers were also learning, they also looked through the microscopes, the other teachers even asked me where to buy those digital microscopes. Teachers are very helpful, I had a good interaction with them".* (EO1)

A successful visit to a science centre or Museum involves active participation of learners, teachers and science centre staff (Graffin, 2014). EO1 encouraged learners to work together to foster collaborative construction of scientific knowledge. The implementation of TLSSC framework advocates for active participation of teachers in science teaching and learning activities at the National Zoological Garden. Teachers participated and assisted learners to learn about the use of microscopes. EO1 indicated that active participation of teachers is essential for presentation of successful science lessons at the National Zoological Garden. Teachers assisted EO1 with discipline and arrangement of learners at work stations.

McClaffey (2014) argues that when science centres neglect teachers and focus on learners only, teaching and learning objectives cannot be fully achieved. According to Reiss (2018), collaborative partnership between teachers, education officers and learners can revolutionise the way societies view science. The collaboration can result in meaningful implementation of authentic science curriculum (Reiss, 2018). Teachers participated in the lesson and informed learners that what they have learnt would be assessed using a formal test at school. When asked about the level interaction and discourse, EO1 said:

> *"You see, teachers nee, they played an important role in encouraging learners to engage and interact with one another. They were encouraging learners to ask questions and interact with the exhibits at the station. The teachers of that school were also learning and assisting me to teach learners about microscope. I liked it when the teacher was telling learners that he will ask the functions of the microscope in their test. Learners paid attention and asked question about microscopes".* (EO1)

Teachers should encourage learners to actively engage in inquiry-based learning (Teo, 2019). Science centres and museum can use interactive resources to promote inquiry-based learning. The interaction between learners, teachers and education officers and resources is of crucial significance. In this regard, EO1 said:

> *"It was amazing and very interesting at my station because learners were willing and interested to learn. You see, those resources displayed on my station and the corporations brought in by their teachers made my lesson to be interesting"*. (EO1)

Figure 7.5 shows learner interaction at the work station.

Figure 7.5 shows learner interaction at the work station

According to Hourdakis and Leronimakis (2020), science teaching and learning process becomes very interesting when teachers, learners and education officers are fully involved in the lesson. EO1 indicated that the implementation of TLSSC strategy requires education officers to work together with teachers to assist learners to learn science at the National Zoological Garden. EO1 mentioned that this collaboration enables learners to construct scientific knowledge. Hourdakis and Leronomakis (2020) posit that collaboration can create perspectives and better comprehension of science.

7.4 Case 2

Education Officer 2 (EO2) was observed and interviewed when implementing the TLSSC strategic framework to present a lesson about the DNA and DNA extraction experiment. Self-discovery learning of science is a cornerstone for the contemporary Science, Technology, Engineering and Mathematics (STEM). This approach can provide learners with critical thinking skills required to help them to be creative problem solvers (Islek & Danju, 2019). EO2 was observed preparing the work station to teach learners about DNA extraction using TLSSC strategy. The strategy emphasizes the use of relevant resources and collaboration between teachers, learners and education officers in knowledge construction. Figure 7.6 shows EO2 teaching learners about DNA extraction.

Figure 7.6: EO2 teaching learners about DNA extraction

7.4.1 The use of exhibits to enhance interaction and discourse

Hourdakis and Leronimakis (2020) argue that science centres and Museums can offer an astonishing encounters with science learning outside the formal classroom environment through the use of exhibits. EO2 created a laboratory-like work station with all instruments required to extract DNA. All learners were given surgical cloves to wear. The learners were also afforded opportunities to use the resources for DNA extraction. EO2 said to the learners:

> *"Today we are going do an experiment, this experiment is about DNA extraction. I want you to do it on your own. You have all relevant equipment on table together with the instruction sheet. For you to perform this experiment successfully you have to follow all the instructions as per the instruction sheet. Please explore all the apparatus before you can start the experiment and ask questions if you don't know or understand what to do".* (EO2)

EO2 informed learners about the importance of experimental procedure when performing the DNA extraction experiment. EO2 said:

> *"It is very important to follow experimental procedure to get good result, you will see the DNA clear, more like the picture on your text book".* (EO2)

Learners interacted with the resources on the table and practised how to use Pipette before they can start with the experiment. Teachers and learners participated in the performance of the experiment. Figure 7.7 shows learners and teachers performing DNA extraction experiment.

Figure 7.7: Teachers learners and performing DNA extraction experiment

Teacher and learners interacted with the resources. They were heard talking to each other saying:

Learner 1: *Sir, were have to use the beaker next to you.*

Teacher 1: *We must start by identify all the resource we need.*

Learner 2: Y*es, sir is right. Bring the instruction sheet, let me see.*

Learner 1: *You must wear the clove proper Nancy in both hands, we don't want Contamination.*

Learner 3: *What is that, contamination! What does it mean?*

Learner 1: *I will use the pipette.*

Learner 2*: Tell us sir what is contamination.*

Teacher 1*: Ask Nthabi to google it.*

7.4.2 Learner interaction and discourse

According to Ash and Wells (2006), social interactions can promote collaborative knowledge building. Learners interacted with each other and asked questions about DNA extraction. EO2 moved around the table to check whether learner were following instructions. When asked about the influence of TLSSC strategy on learner interaction and discourse, EO2 said:

> *"I created the atmosphere for discussion and gave them the opportunity to discuss the experiment on their own. I did not interfere much as per the TLSSC strategy that requires flexibility for interaction amongst learners, yes I could see that these learners enjoy working on their own at their own pace without me getting involved too much. These learners can do it on their own, they require minimum intervention. They worked throughout with interest"*. (EO2)

To keep learners actively engaged in knowledge production, education officials must carefully balance their authoritative lecture with conversation (Set, 2019). EO2

afforded learners opportunities to freely perform the DNA extraction experiment. EO2 played a facilitative role during the performance of the DNA extraction experiment. The TLSSC strategy requires learners to be actively involved in knowledge construction. EO2 did not interfere with the learner discourse. Education officers are able to calibrate their instruction to promote effective science teaching and learning through dialogue (Set, 2019). Killen (2015) asserts that instead of looking to others for answers, inquiry encourages learners to ask questions, study, discover, and come up with their own solutions. EO2 indicated that the DNA extraction experiment provide inquiry-based learning opportunities for learners. When asked about learner interaction and discourse, EO2 said:

> "*Learners are so interesting, I placed all the apparatus on the table and the instruction sheet. I gave an introduction on what we are going to do. I did not give a lecture, I gave some clues and left every process on them to work it out. I asked them to work in groups of three. They had to discuss and discover what to be done in their groups. They started discussing and arguing about the apparatus and how to use them. I did not get too much involved, I allowed them to discover the process on their own following the instructional sheet on the table. One other challenge I noticed was the use of the English language, it is problematic, some learners were not confident to ask question in English, I had to encourage them to ask in their home language".* (EO2)

A dialogic pedagogy can facilitate knowledge construction through questioning, interrogation and negotiation of ideas and opinion in an intellectual and respectful way (Teo, 2019). When implementing the TLSSC strategy, EO2 encouraged learners to discuss and ask questions about the DNA extraction experiment. However, EO2 highlighted language barrier as one of the factors influencing science teaching and learning. Freeman (2018) argues that second language speakers often experience problems with English as a medium if instruction.

7.4.3 Teacher involvement in science teaching and learning activities

When asked about teacher involvement in science teaching and learning activities, EO2 said:

> *"Yes it is working very well, I did not realised that teachers can work so well with their learners learning together to extract DNA and arguing about how to*

follow instructions. I feel so proud about this new approach. I as a facilitator have also learned a lot from the teachers. They told me to emphasize the reasons of adding salt and alcohol on the mixture, some of the things I did not know, it was a great experience. Their knowledge and experience in working with these learners was very useful in my station. The lesson went smoothly because of the teachers' involvement". (EO2)

According to Reiss (2018), the use of resources play a major role in science teaching and learning as they spark dialogue amongst learners. Science centres and museums, according to Tran and King (2007), should design learning settings that enable visitors to engage physically and cognitively with the exhibits through practical experimentation and reflection.

The use of the TLSSC strategic framework afforded learners opportunities to physically perform the DNA extraction experiment. EO2 indicated that collaboration between education offices, teachers and learners facilitated successful performance of the DNA extraction experiment. Teachers assisted learners to extract the DNA from plants cells. One of the teacher said:

"You must always state reasons why you add salt and alcohol on the mixture prepared for the DNA extraction, in everything that you do you must have a reason, there is a specific purpose for adding those ingredients. They will ask you in the exam to state the reasons". (Teacher)

Science centres and museums, according to Rennie and McClaffety (2014), can foster curiosity, enhance motivation and attitudes, and engage learners through involvement and teamwork. When learner work together with teachers, they modify their actions to accomplish common objectives (Ellis, 2020). Visits to science centres and Museum can stimulate and motivate learners to study science and develop scientific and social skills when the visit is well coordinated by both teachers and education officers (Rennie & McClaffey, 2014). When asked about interaction between teachers and learners, EO2 said:

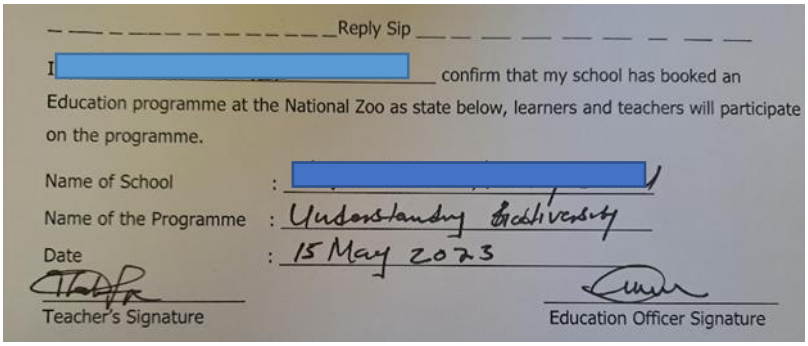
"Yes, learners are ready to learn and interact with the resources. They need support from their teachers. These learners worked very well with their teacher, they were well supported in this experiment by their teachers. They worked with their teachers very well. They were committed and excited to do

the experiment together. I did not have much to do. My role was to facilitate the learning process I was there to assist to extract the DNA. I am happy because I managed to fulfil my role and I could see that they were happy to see the DNA, the DNA that they have extracted themselves". (EO2)

EO2 played a facilitative role and afforded teachers opportunities to share their knowledge and experience during the performance of the DNA extraction experiment. Education officers need to be aware that learning is an active process that involves interacting with and manipulating events and objects in order to create a mental image of the outside world (Cox, 2018). Social interactions can encourage the creation of shared knowledge amongst the visiting learners and teachers (Tran, 2016).

7.5 Case 3

Education Officer 3 (EO3) was observed and interviewed when implementing the TLSSC strategic framework on a lesson about South African Biodiversity. EO3 was observed welcoming and confirming with the school that they booked a lesson on microscopes. Learners and teachers confirmed the booking by showing EO3 a confirmation booking slip. EO3 signed their slip to confirm that indeed the lesson on microscope was booked by that particular school. The slip signed by EO3 is illustrated in Figure 7.8.


Reply Sip

I [redacted] confirm that my school has booked an Education programme at the National Zoo as state below, learners and teachers will participate on the programme.

Name of School : [redacted]

Name of the Programme : Understanding Biodiversity

Date : 15 May 2023

Teacher's Signature

Education Officer Signature

Figure 7.8: Slip signed by EO3

The work station was well prepared with resources such as Bio-facts, specimen and posters. The resources were used to enhance science teaching and learning of science. Garden. Laanements (2018) argues that a well planned visit to the science centre yields positive results.

7.5.1 Exhibits used to enhance science teaching and learning

Gerber *et al* (2017) contend that proper science learning institutions such as science centres and Museums use exhibits to expose learners to science concepts. Laanements (2018) concurs that resources at science centres and Museums can be used to expose learners to real life science. EO3 was observed arranging learners in such a way that all are able to see what was happening at the work station. Resources used by science centres provide authentic learning experiences to learners (Islek & Danju, 2019).

When asked about the use of resources during the lesson on Biodiversity, EO3 said:

> *"The placement of resources at my station links with biodiversity concepts that learners are expected to learner as per the school curriculum. I identified the relevant resources and placed them there to assist when I unpack the concepts of Biodiversity". (EO3)*

Figure 7.9 shows learners interacting with resources during the lesson on Biodiversity.

Figure 7.9: Learners interacting with resources during the lesson on Biodiversity

EO3 indicated that learners were fascinated by the resources used during the lesson on Biodiversity. The learners touched and felt the bio-facts and preserved specimen. In this regard, EO3 said:

> *"Learners were stimulated by the preserved specimen, they were interested to learn and understand how the specimen were preserved, this helped me*

to explain biodiversity in details, where learners were able to see different kind of life and understand how life works."

Furthermore, EO3 indicated that learners used the resources at the work station to construct scientific knowledge. Figure 7.10 shows learners using the resources at the work station to construct scientific knowledge.

Figure 7.10: Learners using the resources at the work station to construct scientific knowledge

7.5.2 **Learner interaction and discourse**

Learners were observed interacting and asking each other questions about the exhibits. Below is an argument between learners:

Learner 1: Are these things alive?

Learner 2: Yes, can't you see.

Learner 3: No they are alive.

Learner 3: They were alive but now no.

Learner 2: What is life?

Learner: Alive like us.

Yapicis (2018) posits that the resources used at science centres and Museums can stimulates debates about scientific concepts and phenomena. When channelled

correctly, these debates can empower learners with scientific knowledge. Figure 7.11 shows learners debating about scientific concepts and phenomena.

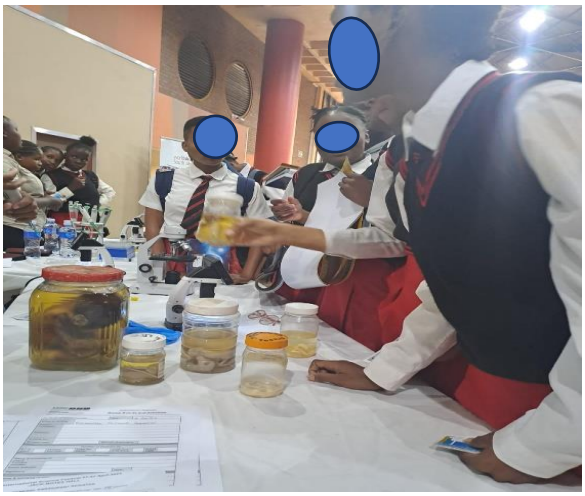


Figure 7.11: Learners debating about scientific concepts and phenomena

When asked about learner interaction and discourse during the implementation of TLSSC strategy, EO3 said:

> *"It was to amazing to see learners interacting in that way when you create an environment for them to be free and learn on their own. I could see that they were interested and the discussing was interesting. I liked their debate on what is life and whether those preserved specimen are dead or alive, some were so convinced that those preserved specimen are alive. These learners can talk hey. They have knowledge of animals, they just need help here and there. They did not want to stop on the issue of life, they wanted to go on and on".* (EO3)

According to EO3, the Exhibits were used to stimulate discussion concerning living and non-living stuff. According to Killen (2018), inquiry encourages learners to ask questions, investigate, find, and come up with their own solutions. Engaging learners

in scientific discourse enables them to examine their own perspective, evaluate concepts and identify conflicts that may lead to the reformulation of their beliefs (Tran, 2016). Figure 7.12 shows leaners examining preserved specimen.

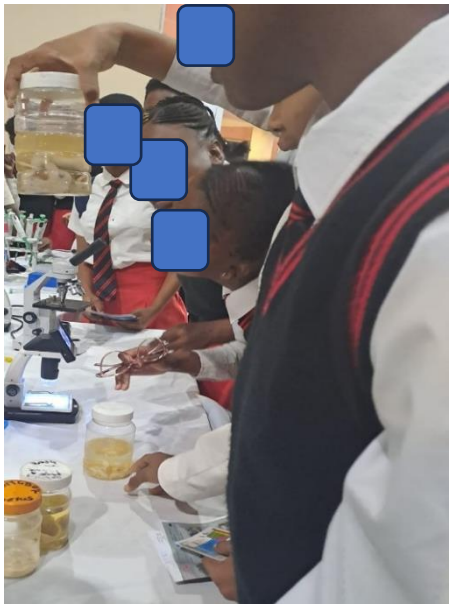


Figure 7.12: Leaners examining preserved specimen

A dialogic pedagogy can facilitate knowledge construction through questioning, interrogation and negotiation of ideas and opinion in an intellectual and respectful way (Teo, 2019). When implementing the TLSSC strategy, EO2 encouraged learners to discuss and ask questions about Biodiversity. However, EO3 highlighted language barrier as one of the factors influencing science teaching and learning. Freeman (2018) argues that second language speakers often experience problems with English as a medium if instruction.

7.5.3 Teacher involvement in science teaching and learning activities

When asked about teacher involvement in science teaching and learning activities, EO3 said:

"Yes teachers are helpful, apart from assisting with discipline… they become part of the lesson. They confirm most of the information I discuss with the learners. They remind their lesson about what they taught them in class, mainly when it relates to my lesson. I have seen them interacting with learners, yes they touch my resources and ask learners questions. I am happy when they get involved, I could tell that they like the lesson". (EO3)

EO3 indicated that the TLSSC strategy encourages teachers to participate in the education activities at the National Zoological Garden. EO3 played a facilitative role and afforded teachers opportunities to share their knowledge and experience about Biodiversity. Education officers need to be aware that learning is an active process that involves interacting with and manipulating events and objects in order to create a mental image of the outside world (Cox, 2018). Collaboration on knowledge creation can be facilitated through social interactions (Tran, 2016).

7.6 Conclusion

This chapter provided a reflection on key findings that emerged from this study. Chapter 8 outlines summary of findings, limitations, conclusion and recommendations arising from the study.

CHAPTER 8: SUMMARY OF FINDINGS, CONCLUSION AND RECOMMENDATIONS

8.1 Introduction

This chapter presents summary of findings, conclusion and recommendations. A discussion of the ramifications of the main findings that emerged is included with the results of the research conducted for this study.The findings relate to the opportunities and challenges associated with science teaching and learning, development and implementation of a strategic framework for enhancing science teaching and learning and the influence of the developed strategic framework on learner interaction and discourse.

8.2 Research questions

The study was guided by the following research questions:

- What are the opportunities and challenges associated with science teaching and learning at a National Zoological Garden?
- How can a framework for enhancing science teaching and learning at a National Zoological Garden be developed and implemented?
- How does the developed framework for enhancing science teaching and learning at a National Zoological Garden influence learner interaction and discourse?

The development and implementation of TLSSC strategic framework was informed by literature on science teaching and learning in science centres and Museums around the world and anecdotal evidence from the activities and interactions within the National Zoological Garden in Pretoria.

8.3.1 Opportunities and challenges associated with science teaching and learning at a National Zoological Garden

The National Zoological Garden provides opportunities for science teaching and learning through the use of exhibits and other interactive resources. The National Zoological Garden has rich collection of animal displays, science laboratories, science exhibits and human resources. The exhibits attract school groups to the National

Zoological Garden. School groups visit the centre mainly to see and explore the exhibits that are on display. Schools groups come to the National Zoological Garden to interact with animal displays and other exhibits. These resources are used by education officers to stimulate and foster meaningful science teaching and learning. Learners used available resources to construct scientific knowledge. However, managing large groups of learners during the presentation of lessons was challenging to education officers. Education officers played a facilitative role and afforded teachers opportunities to share their knowledge and experience. Language barrier often stifles meaningful science teaching and learning. As scaffolding techniques, code switching and translanguaging can be embraced by education officers to circumvent challenges posed by language barrier to the realisation of meaningful science teaching and learning. Education officers made every effort to ensure that lessons were CAPS aligned. When accompanying learners during visits to the National Zoological Garden, teachers do not actively participate in science teaching and learning activities. There is a need for teachers to fully embrace science teaching and learning opportunities provided by the National Zoological Garden.

8.3.2 Development and implementation of a strategic framework for enhancing science teaching and learning at a National Zoological Garden

The findings from the first phase were used to develop the strategic framework for enhancing science teaching and learning at the National Zoological Garden. The opportunities at the National Zoological Garden were exploited to mitigate against weaknesses and threats afflicting science teaching and learning science at the National Zoological Garden. The development of the strategic framework is predicated on the fact that the use of interactive resources should be harnessed to enhance understanding of scientific concepts. The strategic framework advocates for education officers to maximise interactions with learners with a view to enhance science teaching and learning. The TLSSC strategic framework was designed to enhance science teaching and learning at the National Zoological Garden. Successful science teaching at the National Zoological Garden requires a coordinated approach that makes provision for resources to be fully utilised to involve learners in lessons that are aligned to the school curriculum. These lessons should encourage interaction and discourse and education officers and teachers should work together to enhance science teaching

and learning. The TLSSC framework requires a fully integrated approach in which all relevant participants can play their roles to enhance science teaching and learning. The following components of the TLSSC framework play a vital role in science teaching and learning science at the National Zoological Garden.

- Resources/Exhibits
- The role of education officers
- The role of teachers
- Interaction and discourse
- Lessons aligned to the school curriculum

8.3.3 The influence of the developed strategic framework on learner interaction and discourse

The understanding of discourse as a social phenomenon is predicated on the fact that talk is collaboratively constructed and negotiated for a particular purpose. At the National Zoological Garden, interaction and discourse take place between learners, education officers, teachers and resources. The TLSSC strategic framework integrates learners, teachers, education officers, lessons and resources to enhance science teaching and learning by maximising interaction and discourse required for collaborative construction of scientific knowledge. The integration of key components of the TLSSC strategic framework provides opportunities for learners to engage in inquiry-based learning.

8.4 Key contribution of the study

The study proposed the TLSSC strategic framework for enhancing science teaching and learning. The framework provides guidelines on the enactment of meaningful science teaching and learning in both formal and informal teaching and learning environments. The proposed the TLSSC strategic framework is presented below.

The proposed TLSSC strategic framework (Bilankulu, 2023)

8.5 Limitations of the study

The study was confined to six school groups that visited the National Zoological Garden in Pretoria, South Africa. As a result, it is unrealistic to extrapolate the study's results to a broader sample. The study's major conclusions, however, could have a significant impact on how science is meaningfully taught and learned in science centres within a South Africa context.

8.6 Recommendations arising from the study

The findings emanating from this study underscore the critical need to develop and implement strategic interventions to enhance science teaching and learning. The South African Department of Basic Education faces the key imperative to establish a vibrant partnership with the National Zoological Garden to foster development of scientific literacy. There is a crucial need for learners and teachers to fully embrace science teaching and learning opportunities provided by the National Zoological Garden. This imperative requires teachers and learners to pedagogic innovation in its broadest sense.

8.7 Recommendations for further studies

Meaningful development of scientific literacy remains a key strategic imperative. The enhancement of meaningful science teaching and learning requires the adoption of innovative pedagogical strategies. To this end, the long term efficacy of the TLSSC strategic framework could be examined as an integral part of further research endeavours. Contextual factors that influence the implementation of the TLSSC strategic framework can be examined as part of a formal empirical investigation.

8.8 Conclusion

In conclusion, the study sheds light on the intricate process of synergizing formal education and experiential learning within the dynamic context of a renowned zoological garden. The journey through this case study has illuminated the multifaceted nature of this endeavour, underscoring the significance of strategic planning, collaborative efforts, and the transformative potential of innovative educational initiatives. The exploration of the strategic framework's development and

implementation has highlighted the complexities inherent in harmonizing conservation objectives, recreational aspects, and educational goals. The stakeholders' perspectives, ranging from educators and curators to administrators and visitors, underscored the importance of aligning these sometimes divergent objectives to create a cohesive and impactful educational experience. Through strategic allocation of resources, thoughtful curriculum design, and targeted teacher training, the National Zoological Garden in Pretoria successfully harnessed its potential as an educational institution, fostering a meaningful connection between learners and the natural world.

This study also underscored the pivotal role of experiential learning in science education. The integration of exhibits, immersive experiences, and educator-guided interactions offered learners a tangible bridge between theoretical concepts and real-world applications. Through the engagement of visitors with diverse learning styles, the zoo exemplified how dynamic learning environments can spark curiosity, encourage critical thinking, and inspire a lifelong passion for scientific inquiry. Furthermore, the study unveiled the indispensable role of educators in this transformative process. Teachers, acting as interpreters, guides, and facilitators, played a pivotal role in navigating learners through the exhibits and fostering meaningful discussions. Their expertise enriched the educational journey, ensuring that students could extract deeper meanings from their experiences and connect them with broader learning objectives.

In a broader context, this study contributes to the discourse on enhancing science education through unconventional educational settings. It serves as a beacon for institutions seeking to leverage their unique attributes, such as zoological gardens, to promote interdisciplinary learning, environmental stewardship, and holistic educational experiences. By unveiling the successes, challenges, and lessons learned from the National Zoological Garden's strategic framework, this study provides valuable insights that educators, administrators, and policymakers can use to enrich science education globally. Ultimately, this study reiterates the transformative power of strategic planning and collaboration in shaping the educational landscape. Through the lens of the National Zoological Garden in Pretoria, it has demonstrated that when educational institutions harness their resources, align their goals, and prioritize innovative teaching methodologies, they can create immersive, impactful, and

enduring learning experiences that shape the next generation of curious minds and engaged global citizens.

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Vedder-Weiss, D. (2011). Adolescents' Declining Motivation to Learn Science: Inevitable or Not? *Journal of Research in Science Teaching*, 48(2), 199-216.

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10. APPENDICES

APPENDIX A

OBSERVATION SCHEDULE

Part one: General information

<table>
<tr><td colspan="2">Observation Dates: 02/03/2023 – 30/03/2023</td><td colspan="2">Researcher’s name: Bilankulu Hasani Justice</td></tr>
<tr><td colspan="2">Science Centre in Pretoria</td><td colspan="2">Names of Education Officers/ educator/ Learner (pseudonym):
Education Officer 1, 2 & 3
Teacher 1,2 & 3
Learner 1,2 & 1</td></tr>
<tr><td>Grades: 5, 6 & 7</td><td>Learners : 35 per lesson</td><td>Subject: NS</td><td>Interaction at the science centre:
• Interaction among learners
• Interaction between learners teachers and education officers
• Interaction with exhibits</td></tr>
<tr><td colspan="4"></td></tr>
<tr><td colspan="4">Aim(s):
• To understand how the interaction between humans takes place at the science centre
• To explore how learners interact with exhibits.
• To investigate how knowledge is constructed at the science centre.</td></tr>
<tr><td>Scheduled time</td><td>Start time: 10h00</td><td>Time ended: 10h45</td><td>Duration: 45min</td></tr>
</table>

Statement	**Researcher’s comment**	**Observer’s comment**

1. Evidence of preparedness on learners teachers and education officers		
2. The strength on education officers in creating a conducive environment for learning		
3. Evidence of interaction		
4. The use of exhibits to illustrate scientific concepts		
5. Evidence of teachers understanding their role at the science centre		
6. The preparedness of the education officers to present the lesson		
7. The involvement of all participants in the process of knowledge construction		
8. The lesson is learner-centered or teacher-centered.		
9. The area where the lesson is conducted, is it conducive for teaching and learning?		
10. Facilitating and monitoring of the lesson activities.		
11. The pedagogical strategies of the education officers		
12. The use of the facility (science centre) as a teaching resource		
13. The education officers understanding of the subject matter		
14. The involvement of teachers in the subject matter		
15. The relevance of the lesson to the scientific activities of the centre		

APPENDIX B: INTERVIEW SCHEDULE

SEMI-STRUCTURED INTERVIEW SCHEDULE.

1: Education officer 1, 2 &

1. Do you have any training or experience in science education/ guide or facilitation?
2. Have you received any training on teaching/presenting / guiding of facilitation at the science centre?
3. What are the challenges of teaching science at the science centre
4. What is your view on science education at the science centre?
5. Which exhibits do like most to explain/ guide learners through and why?
6. What is your view on the use of interactive exhibits in teaching science at the science centre?
7. Do you think that is necessary to guide/present to the school groups at the science centre? Please explain.
8. What are the opportunities of teaching science at the science centre?

2: Teacher 1, 2 & 3

9. Do you have criteria at school to choose the teacher accompanying learners?
10. How do you prepare for your trip to the science centre?
11. What is your role when you arrive at the science centre?
12. When learners asked you questions and you didn't know the answer what did you do?
13. If you realize that learners didn't understand what the education officer is presenting, what did you do?
14. Do have a specific exhibit you wish learners can learn more about it?
15. Do you interact with learners while at the science centre?
16. Did you achieve your goals by bringing learners to the science centre?

3. **Learners 1, 2, & 3**

21. What is the main thing you would like to do at the science centre?
22. Do you think is necessary to be guided through the science centre?

23. Do you prefer to walk alone or with your mates through the centre? Explain why?

24. What would you like to see or learn about in future at the science centre

25. Did you achieve your goals for coming at the science centre?

APPENDIX C: PERMISSION LETTER TO THE DISTRICT MANAGER

LETTER TO THE DISTRIC MANAGER

College of Education

Department of science and technology education

Request for permission to conduct research with your learners and teachers when they visit the National Zoological Garden

25 October 2022

The DISTRICT MANAGER

Tshwane North District Department of Basic Education

Dear Sir/ Madam

I, Hasani Justice Bilankulu, am doing research under the supervision of A. V. Mudau, a professor in the Department of Science and Technology Education. I am working towards my Doctoral Degree in education with specialisation in Natural Sciences at the University of South Africa. There is no funding involved in this study. I am requesting written permission to use your visiting teachers and learners at the National Zoological Garden that will be interested to participate in a study entitled: “Developing and implementing a strategic framework to enhance teaching and learning of science: A case study of the National Zoological Gardens science centre in Pretoria”

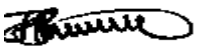
The aim of the study is to develop a strategic framework to enhance teaching and learning at the science centre in Pretoria. The study will also explore challenges and opportunities for developing a strategic framework that can enhance teaching and learning. The study will request consent from Natural Sciences teachers and learners from your schools to participate in this study, prior to interviews and observations,

participants' permission will be requested, and a recording device will be used. Upon the granted permission from the participants to take part in the study, I will then work with them throughout the research process. In this study three schools will be selected to participate, one teacher from each school will be observed and interviewed, and one group of learners from each selected school will be interviewed.

The benefits of this study will be for all schools situated in Gauteng Province even the neighbouring ones. There are no known risks associated with this study. Confidentiality will be maintained by not disclosing the names of schools and participants. The data that will be collected from the participants will be kept confidential and will be strictly used for research purposes. Participants will not be reimbursed or receive any incentives for participating in this study. Up on request participants will receive the summary of the research findings.

For more information regarding the study, please contact me on: 082 227 5612 or email: justicebilankulu@gmail.com and my supervisor professor A.V. Mudau can be reached at: 012 429 6353 or email: mudauav@unisa.ac.za

Yours sincerely



Bilankulu H.J (Researcher)

APPENDIX D: PERMISSION LETTER TO THE SCIENCE CENTRE MANAGER

LETTER TO THE SCIENCE CENTRE MANAGER

university of south africa
UNISA

College of education

Department of science and technology education

Request for permission to conduct research with your learners and teachers when they visit the National Zoological Garden

25 October 2022

The SCIENCE CENTRE MANAGER

NATIONAL ZOOLOGICAL GARDEN

Dear Sir/ Madam

I, Hasani Justice Bilankulu, am doing research under the supervision of A. V. Mudau, a professor in the Department of Science and Technology Education. I am working towards my Doctoral Degree in education with specialisation in Natural Sciences at the University of South Africa. There is no funding involved in this study. I am requesting written permission to use your visiting teachers and learners at the National Zoological Garden that will be interested to participate in a study entitled: “Developing and implementing a strategic framework to enhance teaching and learning of science: A case study of the National Zoological Gardens science centre in Pretoria”

The aim of the study is to develop a strategic framework to enhance teaching and learning at the science centre in Pretoria. The study will also explore challenges and opportunities for developing a strategic framework that can enhance teaching and learning. The study will request consent from Education officers to participate in this study, prior to interviews and observations, participants’ permission will be requested,

and a recording device will be used. Upon the granted permission from the participants to take part in the study, I will then work with them throughout the research process. In this study three education officers and three schools will be selected to participate, one teacher from each school will be observed and interviewed, and one group of learners from each selected school will be interviewed.

The benefits of this study will be for all schools situated in Gauteng Province even the neighbouring ones. There are no known risks associated with this study. Confidentiality will be maintained by not disclosing the names of schools and participants. The data that will be collected from the participants will be kept confidential and will be strictly used for research purposes. Participants will not be reimbursed or receive any incentives for participating in this study. Up on request participants will receive the summary of the research findings.

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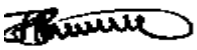

Bilankulu H.J (Researcher)

APPENDIX E: PERMISSION LETTER TO THE PRINCIPALS

LETTER TO THE PRINCIPALS

College of education

Department of science and technology education

Request for permission to conduct research with your learners and teachers when they visit the National Zoological Garden

25 October 2022

The School Principal

Department of Basic Education

Dear Sir/ Madam

I, Hasani Justice Bilankulu, am doing research under the supervision of A. V. Mudau, a professor in the Department of Science and Technology Education. I am working towards my Doctoral Degree in education with specialisation in Natural Sciences at the University of South Africa. There is no funding involved in this study. I am requesting written permission to use your visiting teachers and learners at the National Zoological Garden that will be interested to participate in a study entitled: “Developing and implementing a strategic framework to enhance teaching and learning of science: A case study of the National Zoological Gardens science centre in Pretoria”

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participants' permission will be requested, and a recording device will be used. Upon the granted permission from the participants to take part in the study, I will then work with them throughout the research process. In this study three schools will be selected to participate, one teacher from each school will be observed and interviewed, and one group of learners from each selected school will be interviewed.

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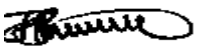


Bilankulu H.J (Researcher)

APPENDIX F: LETTER TO THE TEACHER

LETTER TO THE TEACHER

College of education

Department of science and technology education

Title: “Developing and implementing a strategic framework to enhance teaching and learning of science: A case study of the National Zoological Gardens science centre in Pretoria”

DEAR PROSPECTIVE PARTICIPANT

I, Hasani Justice Bilankulu, am doing research under the supervision of A. V. Mudau, a professor in the Department of Science and Technology Education. I am working towards my Doctoral Degree in education with specialisation in Natural Sciences at the University of South Africa. There is no funding involved in this study. I am inviting you to participate in a study entitled: “Developing and implementing a strategic framework to enhance teaching and learning of science: A case study of the National Zoological Gardens science centre in Pretoria”

The main objective of this study is to explore the challenges and opportunities of developing this strategic framework that can enhance the teaching and learning of science and how it shapes the interactions and discourses in the classroom. You are requested to participate in this study because you are a suitable candidate as you are one of the teachers accompanying learners at the National Zoological Garden in Pretoria

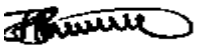
I hereby request your permission to interview you. The time allocation for every interview will be 40 minutes maximum and research will be conducted for a period of one month.

Participating in this study is voluntary and you are under no obligation to consent to participation. If you 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. In this study there are no potential benefits for taking part. There are no negative consequences for any participant if they participate in this study. The information that you provide will not be disclosed to your colleagues or seniors your identity will be kept confidential. Hard copies of your answers will be stored by the researcher for a period of five years in a locked cupboard/filling cabinet at the researcher's workplace 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 proposal. The researcher will destroy the information two years after the completion of study by shredding the hard copies and by permanently deleting the soft copies using software applications. In this study there will be no incentives and no receipt of payment for participation. Up on request participants will be provided with the summary of the research findings.

For more information regarding the study, please contact me on: 082227 5612 or email: justicebilankulu@gmail.com and my supervisor professor A.V. Mudau can be reached at: 012 429 6353 or email: mudauav@unisa.ac.za

Thank you for taking the time reading this information sheet.

Regards,



Bilankulu H. J (Researcher)

APPENDIX G: LETTER TO THE EDUCATION OFFICER

LETTER TO THE EDUCATION OFFICER

College of education

Department of science and technology education

Title: “Developing and implementing a strategic framework to enhance teaching and learning of science: A case study of the National Zoological Gardens science centre in Pretoria”

DEAR PROSPECTIVE PARTICIPANT

I, Hasani Justice Bilankulu, am doing research under the supervision of A. V. Mudau, a professor in the Department of Science and Technology Education. I am working towards my Doctoral Degree in education with specialisation in Natural Sciences at the University of South Africa. There is no funding involved in this study. I am inviting you to participate in a study entitled: “Developing and implementing a strategic framework to enhance teaching and learning of science: A case study of the National Zoological Gardens science centre in Pretoria”

The main objective of this study is to explore the challenges and opportunities of developing this strategic framework that can enhance the teaching and learning of science and how it shapes the interactions and discourses in the classroom. You are requested to participate in this study because you are a suitable candidate as you are one of the education officers at the National Zoological Garden in Pretoria

I hereby request your permission to interview you. The time allocation for every interview will be 40 minutes maximum and research will be conducted for a period of one month.

Participating in this study is voluntary and you are under no obligation to consent to participation. If you 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. In this study there are no potential benefits for taking part. There are no negative consequences for any participant if they participate in this study. The information that you provide will not be disclosed to your colleagues or seniors your identity will be kept confidential. Hard copies of your answers will be stored by the researcher for a period of five years in a locked cupboard/filling cabinet at the researcher's workplace 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 proposal. The researcher will destroy the information two years after the completion of study by shredding the hard copies and by permanently deleting the soft copies using software applications. In this study there will be no incentives and no receipt of payment for participation. Up on request participants will be provided with the summary of the research findings.

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Thank you for taking the time reading this information sheet.

Regards,

Bilankulu H. J (Researcher)

APPENDIX H: LETTER TO THE PARENT OF THE LEARNER

LETTER TO THE PARENT OF THE LEARNER

College of education

Department of science and technology education

Title: “Developing and implementing a strategic framework to enhance teaching and learning of science: A case study of the National Zoological Gardens science centre in Pretoria”

DEAR PARENT OF THE LEARNER

I, Hasani Justice Bilankulu, am doing research under the supervision of A. V. Mudau, a professor in the Department of Science and Technology Education. I am working towards my Doctoral Degree in education with specialisation in Natural Sciences at the University of South Africa. There is no funding involved in this study. I am inviting you to participate in a study entitled: “Developing and implementing a strategic framework to enhance teaching and learning of science: A case study of the National Zoological Gardens science centre in Pretoria”

The main objective of this study is to explore the challenges and opportunities of developing this strategic framework that can enhance the teaching and learning of science and how it shapes the interactions and discourses in the classroom. Your child is requested to participate in this study because s/he is a suitable candidate as a learner visiting the National Zoological Garden in Pretoria

I hereby request your permission to interview your child. The time allocation for every interview will be 40 minutes maximum and research will be conducted for a period of one month.

Participating in this study is voluntary and your child is under no obligation to consent to participation. If you decide that your child can 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 your child at any time and without giving a reason. In this study there are no potential benefits for taking part. There are no negative consequences for any participant if they participate in this study. The information that you provide will not be disclosed to your colleagues or seniors your identity will be kept confidential. Hard copies of your answers will be stored by the researcher for a period of five years in a locked cupboard/filling cabinet at the researcher's workplace 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 proposal. The researcher will destroy the information two years after the completion of study by shredding the hard copies and by permanently deleting the soft copies using software applications. In this study there will be no incentives and no receipt of payment for participation. Up on request participants will be provided with the summary of the research findings.

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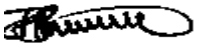


Bilankulu H. J (Researcher)

APPENDIX I: CONSENT FORM FOR TEACHERS

CONSENT FORM FOR TEACHERS ACCOMPANYING LEARNERS

I,

_____

(participant name), confirm that the researcher asking for my consent to take part in this research has told me about the nature, procedure, potential benefits and anticipated inconveniences of participation.

I have read (or had explained to me) and understand the study as explained in the information sheet.

I have had sufficient opportunities 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.

I am aware that the findings of this study will be processed into research report, journal publications and/or conference proceedings, butt that my participation will be kept confidential unless otherwise specified.

I agree to be recorded in the interviews and observations

_____

I have received a signed copy of the informed consent agreement.

Participant Name & Surname (please print)

_____

APPENDIX J: CONSENT FORM FOR EDUCATION OFFICER

CONSENT FORM FOR EDUCATION OFFICER

I,

_____

(participant name), confirm that the researcher asking for my consent to take part in this research has told me about the nature, procedure, potential benefits and anticipated inconveniences of participation.

I have read and (or had explained to me) and understand the study as explained in the information sheet.

I have had sufficient opportunities 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.

I am aware that the findings of this study will be processed into research report, journal publications and/or conference proceedings, butt that my participation will be kept confidential unless otherwise specified.

I agree to be recorded in the interviews.

_____

I have received a signed copy of the informed consent agreement.

Participant Name & Surname (please print)

_____

APPENDIX K: CONSENT FORM FOR LEARNERS (PARENTS)

CONSENT FORM FOR PARENTS OF LEARNERS PARTICIPATING IN THE RESEARCH PROJECT

I_____ (full name of parent / guardian), the parent of_____ (name of a learner / participant) hereby confirm and give consent to the researcher (Ms Thuli Gladys Ntuli) for my child to take part in her study entitled : **"Developing and Implementing a strategic framework to enhance teaching and learning"**

Mr Hasani Justice Bilankulu has discussed or explained the purpose of the research with the principal and understands the study he wishes to undertake as the researcher. He has also received consent for our District manager on behalf of the department.

I understand that my child will have sufficient opportunities to participate in the research and ask questions as he/she participates in the study.

I understand that my child's participation is voluntary and that he/she is free to withdraw at any time without penalty or negative repercussions.

I understand aware that the findings of this study will be processed into research reports, journal publications and/or conference proceedings, but that his / her participation will be kept confidential unless otherwise specified.

I agree or give consent that my child be a participant in the research project and be recorded in the interviews and observations if need be and the recordings will solely be utilised for the purpose of research.

_____ _____

Surname and name of the parent/guardian Participant / learner name & surname

_____ _____

Signature of the parent/guardian Signature of the participant/ learner

DATE : _____ DATE : _____

CELL NO : _____

APPENDIX L: NZG LESSON PLAN

SANBI
Biodiversity for Life
South African National Biodiversity Institute

National Zoological Garden, Pretoria

NATIONAL ZOOLOGICAL GARDEN

LESSONS FOR SCHOOLS VISITING THE MBC
LESSON PREPARATION

GRADE	**10**	**SUBJECT**	**Natural & Life Sciences**	**DURATION**	**1 Hour**	**TOPIC**	**Understanding Ecosystems:** Practical Investigation
LESSON	Biosphere to Ecosystems					**VENUE**	**National Zoological Garden**
LINK TO CAPS DOCUMENT	**Grade 9** **Environmental Studies** • Structure and ecosystem functioning: • Abiotic factors: • Biotic factors: producers, consumers, decomposers						
LESSON SUMMARY	This practical programme for the grade 10 is designed to improve the learners' understanding of ecosystems. Learners will be introduced to the ecosystem's functional units of interacting abiotic and biotic components. The learners will explore aspects that compose ecosystems such as the population, community and habitats. The learners will do a practical investigation of an ecosystem.						
OBJECTIVES	At the end of this lesson learners will be able to: • understand the ecosystem • identify abiotic and biotic components • determine abiotic components: physiographic factors, temperature, pH of soil, soil texture and water-holding capacity • understand and interpret food webs • explain the energy flow process • draw a distribution map of abiotic factors						

PRESENTER ACTIVITIES	LEARNER ACTIVITIES	TIMING	RESOURCES
1. Introduction • **Identifying Ecosystems** The facilitator will use the poster to discuss and explain the concept of an ecosystem. The facilitator will then help learners to identify the ecosystem they are going to study.	**1. Introduction** • **Identifying Ecosystems** The learners will explore the available poster and understand the ecosystem concepts. The learners will identify and mark a 2m x 2m size area within an ecosystem. The learners will follow the worksheet to answer questions.	15 min	• Poster of ecosystem • Cards on ecosystem concepts

			and explanations
2. <u>Lesson development</u> • **Abiotic Factors** The facilitator will explain, discuss and show leaners how to identify the abiotic components of the ecosystem. • **Biotic Factors** The facilitator will ask the learners to explore and explain how energy is transferred from one organism to the other using a poster. The facilitator will explain the source of energy and show the learners how energy can be transferred using water and containers. The principle of energy not being created or destroyed will be discussed with the learners. • **Draw a Sketch** The facilitator will discuss, explain and also show learners how food chains and food webs are interwoven in an ecosystem. The facilitator will divide the learners into smaller groups to work out the puzzle. • **Ecosystem Balance** The facilitator will show the learners the balance in the ecosystem. The facilitator will ask the learners to explain how prey and predator, disease, alien species and natural disasters influence the balance of ecosystem. The effect of poaching of rhinos will be discussed.	**2. <u>Lesson development</u>** **Abiotic Factors** The leaners will explore and identify the abiotic components of their ecosystem. The leaners will also determine the physiographic factors of their ecosystem such as temperature, soil pH, soil texture and water-holding capacity. • **Biotic Factors** The learners will explore how energy is transferred from one organism to the other using a poster. The learners will explore the importance of energy in different organisms. Types of energy will be discussed. • **Draw a sketch** The learners will complete a food web puzzle and also explain the reasons. The learners will outline the concepts of herbivore, carnivores, omnivores and decomposers with the relevant examples. • **Ecosystem Balance** The learners will explore aspects that will influence the balance in the ecosystem. The learners will explain how prey and predator, disease, alien species and natural disasters influence the balance of ecosystem.	30 min	• Food webs activity panel • Poster illustrating energy flow • Containers for illustrating energy flow • Pictures of biotic (incorporated in a poster) • Pictures of abiotic (incorporated in a poster) • Worksheet • Enclosures in the zoo.
3. <u>Conclusion</u> Career choices in ecology will be discussed with the learners. Ecologists conduct research studies into problems such as the effects of mining, forestry and recreational use on natural habitats, the development of biological control strategies and the effects of pollutants on natural vegetation.	**3. <u>Conclusion</u>** The learners join in the discussion about career choices in ecology.	5 min	

APPENDIX M:CODED INTERVIEW TRANSCRIPT

12 13	**Researcher**: How do you decide on the resources you use for that particular lesson?	Use of exhibits
14 15 16 17 18 19 20 21 22	**Education Officer**: What we do is, we test them first with our group before we even go, we decide if it's going to be suitable for the learners. we assess whether the resources that we are going to use is not needed in large numbers and also is going to be a problem for us to replicate. so expected resources we rather not use that one because it's going to require us to pay money every time when we use the resources. So we try to look for things that are very visible and judging on the number of students or learners that we going to be delivering the lesson to,	Using exhibits
23	so it has to align with that as well.	Interaction
24 25	**Researcher:** What your view on the use of interactive exhibit in teaching science here at the national Zoo?	and discourse
26 27 28 29	**Education officer**: What I would say is that it works, I feel it works better that the set up, but it gets the kids engaging, they engage much more when they are interacting more than their stations and also activities that needed to participate on.	Interaction
30 31	**Researcher**: What are the challenges of using this interacting exhibit when teaching learners?	Interaction and
32 33 34 35 36 37 38	**Education Officer**: The challenges that we faced is that when arranging the kids and the space that we have, and the stations the number of stations that are going to be there because sometimes they cannot attend all of them, you get maybe schools with a very huge amount of students so you cannot attend to all of them and some of them they want to go each and every station, so they don't understand. So if they see that a	discourse Space challenge
39 40 41 42 43 44	different school has attended, maybe 3 stations and then they come you telling them that they can only attend that exhibit because sometimes there is a clash there. So they might feel like maybe you are chasing them. It just goes with the numbers of people who are in there at the same time, so if the numbers are huge, obviously we limit who goes there.	Use of exhibits
45 46 47 48	**Researcher:** How do you engage your learners in a lesson? Can you also give an examples of a particular lesson? And tell us how do you engage to make sure that learners are engaged in that lesson?	Interaction and discourse
49 50 51 52 53 54 55 56 57	**Education Officer**: The first thing that we usually look when delivering these lessons, is the age group obviously, so whatever language we use must align with grade R, so you must try and make sure that maybe you use their language if they can't understand English and then from there on, one of the lesson that we have like water pollution, so if you are doing that one, let's say you are delivering to learners from the third grade if you ask them what language do they speak and you figure it out which language you must use, so what I usually prefer to do	Language barrier Language barrier

58	I don't like feeding them information, I want to hear from first if	
59	they know something, so what I actually do ask them first if they	
60	understand what is water pollution is instead of me just	
61	explaining to them directly. So if they don't understand then my	
62	second thought would be it's the word pollution that they don't	
63	understand because they are familiar with the words, then I try	
64	to break down the word into simpler term for them to understand	Language
65	and afterward I ask again the question.	barrier
66	So one of the challenges that we have is that sometimes they	
67	are not confident enough to say their answers, so what we	Interaction
68	usually do say is that no answer is incorrect, just feel free, say	and
59	what is on your mind and then afterward they ease on the	discourse
70	lesson, they start to interact raising their hands and then we	
71	always have pictures on display board.	Interaction
72	**Researcher:** You mention something like the challenges where	and
73	learners they don't feel confident when you are interacting with	discourse
74	them, is there any other challenge that you feel learners or	
75	during the interaction that you have actually encountered?	
76	**Education Officer**: I think is concentration, if you are delivering	
77	the lesson in a very serious manner sometimes they get scared,	
78	you can't interact back with them because now is like they are	
79	in a classroom sitting again. They must follow the rules, they	
80	should not say that answers are wrong, so we always try to	
81	make them feel like it is. So we do have eye breakers for that	
82	like if you see they are grasping what you talk about, we try to	
83	have ice breakers before and then other challenges in terms of	
84	concentration as well because we have so many stations n we	
85	have so many schools is that will be delivering a lesson and then	
86	another school passes, so the attention now shift, they all	
87	looking on the other way around, so we actually need to try bring	
88	them back and which is a part where I feel like the teachers are	
89	not been assisting with things like that I don't know whether they	
90	think they are not allowed to or what.	
91	**Researcher:** Do you think is necessary to guide or to teach	
92	learners here at the National Zoo?	Use of
93	**Education Officer**: I think it is, I feel it wrong because it gives	exhibits
94	them a purpose, sometimes a kid can come here and the only	
95	thing they are going to tell you is I only saw a lion, that just it	
96	because there's nobody who tells them a lion comes from this	
97	and that... there is no education activities that are available at	
98	the Zoo other than the ones that we have, so I feel like this also	
99	its exciting to them, something valuable that they can also take	
100	home and teach others instead of them just coming here and	
101	eating ending there.	Teacher
102	**Researcher:** how do you involved the teachers in your lessons?	involvement
103	**Education Officer**: in that manner, what I have seen others	
104	doing, is that if maybe a school group comes and they don't	
105	understand English and you as a presenter you	

APPENDIX N: UNISA CLEARENCE ERTIFICATE

UNISA COLLEGE OF EDUCATION ETHICS REVIEW COMMITTEE

UNISA university of south africa

Date: 2022/11/09

Ref: **2022/11/09/32134541/35/AM**
Name: Mr HJ Bilankulu
Student No.: 32134541

Dear Mr HJ Bilankulu

Decision: Ethics Approval from 2022/11/09 to 2027/11/09

Researcher(s): Name: Mr HJ Bilankulu
E-mail address: justicebilankulu@gmail.com
Telephone: 0822275612

Supervisor(s): Name: Prof. A V Mudau
E-mail address: Mudaav@unisa.ac.za
Telephone: 012 429 6353

Name: Dr TG Ntuli
E-mail address: ntulit@unisa.ac.za
Telephone: 012 429 6353

Title of research:

DEVELOPING AND IMPLEMENTING A STRATEGIC FRAMEWORK TO ENHANCE TEACHING AND LEARNING OF SCIENCE: A CASE STUDY OF THE NATIONAL ZOOLOGICAL GARDEN SCIENCE CENTRE IN PRETORIA

Qualification: PhD Natural Science 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 2022/11/09 to 2027/11/09.

*The **medium risk** application was reviewed by the Ethics Review Committee on 2022/11/09 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 College position statement on research ethics attached.

SANBI
Biodiversity for Life
South African National Biodiversity Institute

SANBI/RES/P2023/04

08 March 2023

Hasani Justice Bilankulu UNISA and SANBI

OUTCOME OF RESUBMITTED RESEARCH PROPOSAL

This letter serves to inform you that your re-submitted research proposal titled “Developing a strategic framework to enhance the teaching and learning of science in a science centre environment: A case study of the National Zoological Garden” is **approved** by the SANBI NZG Animal Research Ethics and Scientific Committee (ARESC).

The following provisos should be taken into consideration:

1. Inform the ARESC of completion or termination (with reason) of your research at the SANBI.
2. Submission of an annual progress report in November of each year. Failure to submit a progress report may result in approval to be withdrawn.
3. Submission of a written request for any extension or modification of the research project.
4. SANBI should be acknowledged in all reports, scientific publications and conference contributions.

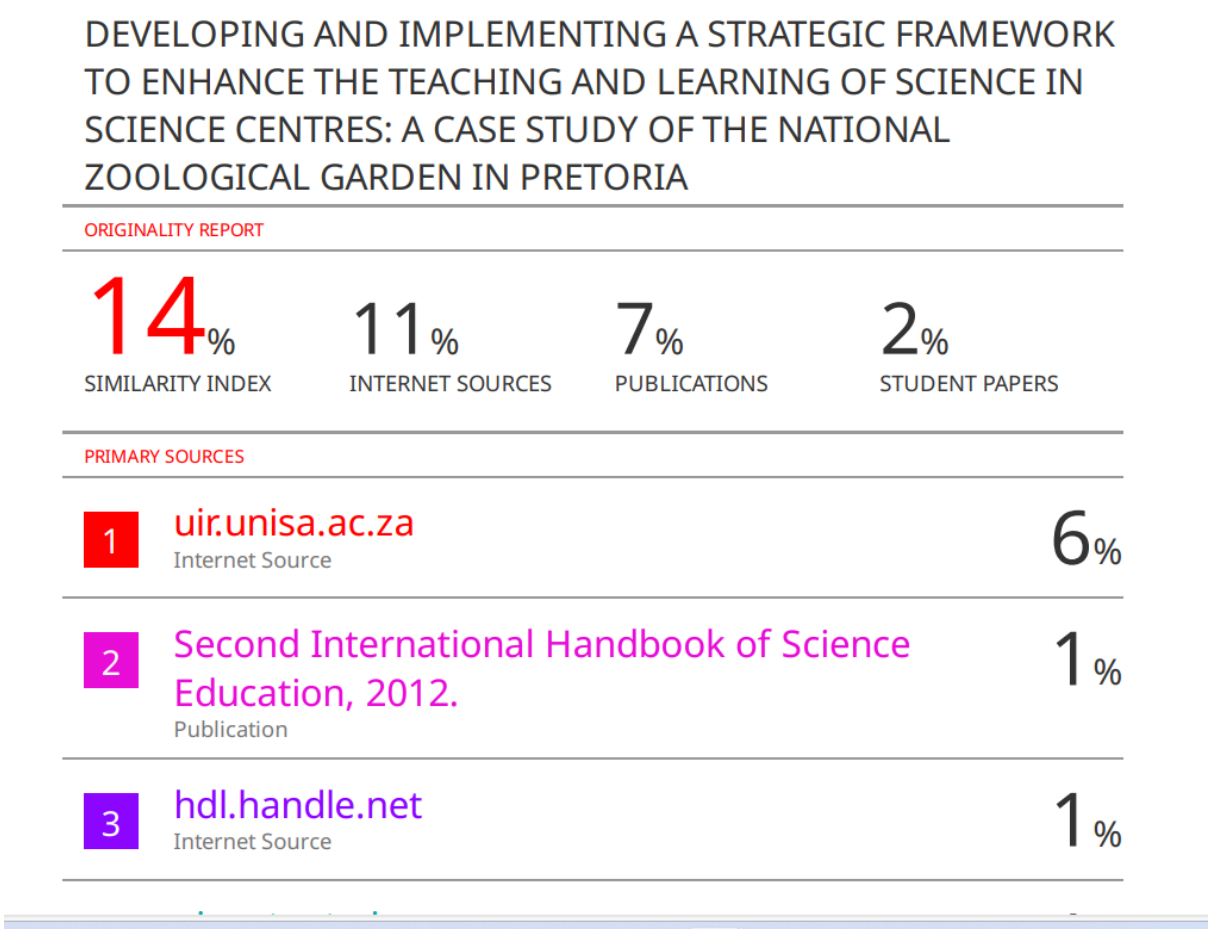
The research proposal has been registered on the database as P2023/04. Please use this project number in all future correspondence.

Thank you for making use of SANBI as a research platform.

Yours sincerely

Prof Antoinette Kotze Chairperson: SANBI NZG Animal Research Ethics & Scientific Committee

APPENDIX O: TURNITIN REPORT



DEVELOPING AND IMPLEMENTING A STRATEGIC FRAMEWORK TO ENHANCE THE TEACHING AND LEARNING OF SCIENCE IN SCIENCE CENTRES: A CASE STUDY OF THE NATIONAL ZOOLOGICAL GARDEN IN PRETORIA

ORIGINALITY REPORT

14%	11%	7%	2%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	uir.unisa.ac.za Internet Source	6%
2	Second International Handbook of Science Education, 2012. Publication	1%
3	hdl.handle.net Internet Source	1%

APPENDIX U: EDITOR'S CERTIFICATE

Shiraz 16

50 Quail Avenue

Thatchfield Close

Centurion, Pretoria

0157

Date: 18 August 2023

To whom it may concern

This letter confirms that the thesis entitled: **Developing and implementing a strategic framework to enhance teaching and learning of science: A case study of the National Zoological Garden in Pretoria** written by **Hasani Justice Bilankulu** has been edited by Sam Ramaila.

Sincerely,

Sam Ramaila (PhD)

Cell: 0646566387