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Teachers' Indigenous Knowledge awareness and how to implement it in teaching and learning sciences in South African schools

by

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A dissertation submitted to the Faculty of Science, University of the Witwatersrand, Johannesburg, in fulfilment of the requirements for the degree of Master of Science.

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Abstract

This study aimed to elicit Life and Physical Sciences teacher's awareness of Indigenous Knowledge (IK) and how they use it in the teaching and learning of their classrooms. This is because South Africa has one of the most unequal education systems with racist, sexist, and outdated content in its curricula. As such, the goal of the current curricula policy documents for Life Sciences and Physical Sciences: National Curriculum Statement (NCS)/ Curriculum Assessment Policy Statements (CAPS) is to redress the injustices left behind by apartheid and enhance westernized science concepts to the previously disadvantaged learners. The documents recommend that science teachers engage with learners in ways that value their IK so that learners may apply this knowledge and skills in ways that are meaningful to their daily lives. Additionally, the policy documents inform teachers that some IK concepts lend themselves to explanation using scientific methods. This study explored FET science teachers' IK awareness and interrogated how they implement IK concepts in their teaching and learning. A qualitative case study approach, as well as theoretical frameworks, were used. The theoretical frameworks included social constructivism theories -Vygotsky's social development theory, Zone of Proximal Development (ZPD), More Knowledgeable Other (MKO), Jean's Piaget's theory of cognitive development-, border-crossing, collateral learning, situated learning, and culturally relevant pedagogy.

Further Education and Training (FET) science teachers were purposively selected to participate in the study. Data were collected from Physical and Life Sciences teachers, first in the form of questionnaires and then later to gain deeper insight from the questionnaire analyses, semi-structured interviews were conducted with selected participants. Thematic content analysis was used to analyse data from which themes were developed, that answered the research questions. The findings were that teachers defined IK as cultural and place-

based, they also placed deep value on it. Furthermore, they had a positive attitude toward Indigenous Knowledge Systems (IKS), and some integrated it into their science teaching using methods such as argumentation during classroom discussions. However, given the challenges teachers have, integration does not translate into an implemented practice in the classroom that would accomplish the intended curriculum set out for IKS. This study is significant because it centres around teachers, their classroom practices, and their local (indigenous) knowledge. The results furnished information regarding teachers' cultural awareness, which is the cornerstone of IK integration in science classrooms. Findings from this study may, in some ways, contribute to the production of appropriate learning materials for curriculum developers as they expand on IKS learning materials for science classrooms.

Declaration

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

School of Animal, Plant and Environmental Sciences

SENATE PLAGIARISM POLICY

Declaration by students

I, Ms. Flavia Kigozi (Student number: 0701690R) am a Student registered for Master of Science (Dissertation) in the year 2021 . I hereby declare the following:

- I am aware that plagiarism (the use of someone else's work without their permission and/or acknowledging the original source) is wrong.
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- I confirm that the work submitted for assessment for the above course is my own unaided work except where I have explicitly indicated otherwise.
- I have followed the required conventions in referencing the thoughts and ideas of others.
- I understand that the University of the Witwatersrand may take disciplinary action against me if there is a belief that this is not my own unaided work or that I have failed to acknowledge the source of the ideas or words in my writing.

Signature: _____ Date: 18 June 2021

Dedication

To my late mother, Angela Nashakhoma Kigozi (1956-2004), I made it mama. To my father, Disan Kigozi, I dedicate this to you. Thank you for everything you have done for me.

To my ever-supportive siblings Dr John Kigozi, Mrs Racheal Kigozi, Dr Gladys Kigozi, Mrs Esther Caroline Malo and Mr Mashat Malo, may God return to you sevenfold for the support you have shown me during this time.

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Chapter One

Introduction to the Study

Recent efforts by the post-independent South African government were borne out of the necessity to remedy the social, cultural, educational, and other injustices of the past that were perpetrated by the colonial and apartheid systems on marginalized groups in South Africa (Jansen & Taylor, 2003). For instance, decades of social and economic injustice against black South Africans resulted in inequalities among schools. As such, for two and a half decades, post-independence, the current government has been making concerted efforts to enact a new education system forwarded by the new curriculum starting with the introduction of outcomes-based education (OBE) in 1997 to overcome the curricular divisions of the past. The curriculum development process has undergone several reviews post-independence which culminated in the current National Curriculum Statement (NCS) 2011/Curriculum and Assessment Policy Statement (CAPS) 2011 that are meant to ensure that the previously disadvantaged groups no longer continued to be disadvantaged or marginalized. Of importance to this study is that throughout recent series of curricula changes, the use of Indigenous Knowledge (IK) or Indigenous Knowledge Systems (IKS) in the classroom is promoted (Botha, 2010) in curriculum policies to foster and enhance IK's contribution to South Africa's social and economic growth (Department of Science and Technology, n.d.). As such, the post-independent education system encourages the integration of IKS into the teaching and learning of sciences to accommodate indigenous cultures in the science classroom.

NCS/CAPS 2011 (Department of Basic Education, 2011, p.17) state that "Science should therefore be taught in an integrated way to both enhance the subject and to clarify the relationship between the subject and society i.e., indigenous knowledge systems that relate to a specific topic, related history of scientific discoveries and the applications of science in

everyday life". This encourages science teachers to include IK and teach in ways that will help them and their learners become aware of their IK so that they use it to help their learners value their local (indigenous) knowledge and improve their academic performances. This study engaged a qualitative approach in teasing out Physical and Life Sciences teachers' IK awareness in the Further Education and Training (FET) classroom. Data were generated from questionnaires and semi-structured interviews, as well as field notes. Findings from this research are intended to contribute to the current dialogue on integrating IK concepts into science's teaching and learning.

Purpose of the Study

Therefore, the purpose of this study was to determine FET science teachers' IK awareness and how they used this awareness in the teaching and learning of Life Sciences and Physical Sciences in their classrooms to integrate IK and classroom science (Ogunniyi, 2004). NCS 2011 promotes the integration of IKS in classroom sciences at the FET band to provide learners with knowledge and skills that are relevant to their everyday lives (Department of Basic Education, 2011). Therefore, teachers as gatekeepers of knowledge in the science classroom (Moichela, 2017), have a huge role to play in integrating IK concepts with classroom science and help learners to make sense of their lived-experiences.

Ogawa (1995) argued that every community has its own culture and science and that such science is indigenous to them (Snively & Corsiglia, 2001). To have good grasps of the scientific world, learners' cultural identities and practices provide good entry points (De Beer & Mothwa, 2013). Therefore, indigenous learners, with their cultural identities, can improve on their academic performances when provided access as Ladson-Billings (1995) alluded to through culturally relevant teaching that affirms learners' cultural identities.

Context of the Study

This study was conducted in three peri-urban township secondary schools near a metropolitan city in South Africa. The secondary schools were under the care of the Department of Basic Education (DBE), which runs the affairs of all public primary (grades 0 - 7) and secondary (grades 8 to 12) schools. Public schools, under DBE, are divided into bands, namely, the General Education and Training (GET) band (Grade 0/R – 9) and the Future Education and Training (FET) band (Grade 10 - 12). The GET band is further divided into three phases, namely, the foundation (grades 0/R – 3), the intermediate (grades 4 – 6) and the senior (grades 7- 9) phase. The study took place in quintile 5 schools, which are no-fee paying (section 20) schools in the township. The quintile system was established in 2006 to provide equity in fund allocation to public schools in the South African education system. Prior to this mechanism, during the apartheid system, Bantu education programs were often allocated the lowest fund possible. Post-independence, the School Governing Board (SGB), the School Management Team (SMT) in addition to the Student Representative Council (SRC) were created and are now mandated to run the affairs of each public school, locally, by the South African Schools Act of 1996.

The schools were part of the Dinaledi schools' program that was launched in 2001 by the then Minister of Education as part of efforts to expand the number of learners who pass mathematics and science subjects in preparation for higher education. Dinaledi schools are the most under-resourced, no-fee paying schools. They obtain grants from private and public funders that furnish the schools with additional resources for Mathematics, Physical and Life Sciences subjects. Each learner receives textbooks as well as maths, and science kits while the teachers are trained on the subject content to help improve their teaching and learning. This study focused on Physical Sciences and Life Sciences subjects at the FET band. The Life Sciences subject is called Biology in countries like Zimbabwe and Malawi, while the

Physical Sciences subject is composed of Chemistry and Physics combined (Samuel & Dudu, 2018).

The Rationale for the Study

The rationale for this study is the necessity to comply with the mandate of the NCS/CAPS policy of 2011 in which the call to valuing IK (S) in the teaching and learning of Life Sciences and Physical Sciences was promulgated. The expectation according to NCS/CAPS policy documents of 2011 was for teachers to include IK in the teaching and learning of Life Sciences and Physical Sciences concepts to make the sciences more accessible to learners and to promote social change and equity (Duit, 2016). Also, this was intended to assist learners in applying their learned skills in manners that impact their lived-experiences (Mavuru & Ramnarain, 2017). The NCS/CAPS 2011 policy documents acknowledged teachers as gatekeepers of the curricula reform efforts because "teachers must ensure that, by the end of the year, the assessments provide evidence that the range of different skills has been assessed for each learner" (Department of Basic Education, 2011, p.17) hence, teachers' awareness of their own IK and how they could use this knowledge in Physical Sciences, and Life Sciences classrooms become of paramount importance for this study. Most science teachers tend to be of Eurocentric persuasion due to their training, whereas most of them grew up in cultural/indigenous knowledge contexts. Aikenhead and Jegede (1999) asserted that the pre-existing IK that teachers bring into the classroom could help learners in engaging or awakening their own IK. Souza Barros and Elia (1997) warned that a lack of confidence by teachers in a subject's content can lead to a negative attitude toward the subject which can be detrimental to the educational process and vice versa. Attitude was described as a dynamic mental state made up of values and emotions, and it is a crucial term in understanding human behaviour (Latchanna & Dagnew, 2009), hence the need

to explore what IK concepts FET teachers bring into their science classrooms to help determine their awareness of their own IK and their attitude/perception toward integration.

Significance of the Study

This study is significant because South African learners do not perform well in Science subjects compared to international levels. This study focuses on Physical Sciences and Life Sciences, subjects that are regarded as challenging by South African learners, as seen from their poor academic performances in such subjects (Writer, 2018; Samuel & Dudu, 2018). Therefore, South Africa performs poorly compared to other countries that take part in assessments like the Trends in International Mathematics and Science Study (TIMSS) or the Progress on International Literacy Study (PIRLS) (Crouch & Hoadley, 2018). For instance, South Africa was ranked last in its performance of mathematics and science education at the secondary school level in the World Economic Forum's 2015 Global Information Technology Report (Writer, 2015).

Because education is both important and influential in building societies that are better equipped to meet the demands of the twenty-first century, learners must be prepared with the necessary knowledge and skills to function effectively as members of society. The conventional consensus holds that science influences a country’s economic growth by enabling technology to expand (Jaffe, 2014). Therefore, for South Africa to be internationally competitive in research and technology, it needs to expand the pool of talent available in the Physical Sciences and Life Sciences subjects. As a result, it becomes important to find ways to inspire students to succeed in science subjects and to enhance their learning experiences of Physical Sciences and Life Sciences through IK-related initiatives.

The IK awareness of FET science teachers in township schools was documented in this study so that it can contribute to the growing body of knowledge (Jacobs, 2015; Mavuru & Ramnarain, 2017) surrounding IK in science classrooms. Therefore, findings from this

study may, in some ways, contribute to the production of appropriate learning materials for curriculum developers as they expand on IKS learning materials.

Personal Experience

Being born in Kampala in Uganda, I was raised in a village in the northwestern region of South Africa. My parents were English language teachers who moved from country to country to find a better life for their children. My mother was from a linguistically different cultural group (tribe) from my father. This cultural group, within Uganda, called the Bagisu; was traditionally marginalized by people from my father's tribe, the Baganda. During the 1970s', when members of the two tribes intermarried, it was often considered a shameful thing, especially by people from my father's side of the family as they believed it brought shame unto the family and such families are usually shunned. As such, when my father moved from country to country, my mother followed as she was not really welcomed by her in-laws including my late grandmother, who later acquiesce and began to love my mother after the arrival of the grandchildren who reminded my grandmother of her late husband, my grandfather.

I spent twelve years with my parents in the village in the northwest region of South Africa where I learned, in a day school, subjects such as Mathematics, Religion, History, and Biology in Setswana. I was taught English at school and at home by my father, who insisted that we must speak only English and Luganda at home. As such, I became fluent in all three languages at an early age without ever learning my mothers' language, Lugisu.

I later learned Sesotho when I started high school at a Catholic school in the Free State Province of South Africa because my mother believed that it would instil some moral and values in my older sister and me as we ventured into the social life of teenage hood. I undertook several leadership roles in high school and later used the opportunities I was given to start extra classes in Biology for other learners. In this way, I was able to use some of the

knowledge I had learned in the village to interact with my peers and in explaining certain scientific concepts to them as we prepare for the matric examinations.

I started my higher education journey at the University of Cape Town (UCT) and graduated with a BSc in Applied Biology. However, I was very worried and sad that out of all the other Black students I had started higher education with, only two of us managed to get our degrees on time; myself and a Zimbabwean student, while others finished later or dropped out.

When I did my honours degree at the University of Witwatersrand, I worked on a project in science education, while I took science coursework subjects. This got me started on my journey as a researcher. This study became significant to me because, from that experience, it became evident that the people I learned with from primary until university never seem to have understood the relationship of science in their daily lives. Yet learning some of those abstract concepts is what helped the few of us get to where we are today. It is interesting for me as a novice in IKS to put meaning to what I have experienced at home and during my years of learning in schools; that the knowledge my parents passed, on to me regarding my identity, where I came from and how other cultures and religions (Tswana, Sotho, Muslim, and Coloreds) have their own way of knowing and how this knowledge has helped my ancestors to survive, regardless of urbanization and globalization was not made known to me until now.

I am humbled to be part of a study on a topic that has been close to my heart for so many years because of the experiences I have been through; therefore, this study is significant to me because I will be able to contribute, through research, to helping to make IK relevant to learners lived experience.

Research Questions

This study aimed to explore and interrogate, using questionnaires and interviews, the IK awareness of FET teachers in the teaching and learning of Life Sciences and Physical Sciences. It aimed to answer the following research questions:

1. What awareness of IKS do FET science teachers have and how do they use IK(S) in the teaching and learning of Life Sciences and Physical Sciences in peri-urban schools?

2. To what extent do FET Life Sciences and Physical Sciences teachers integrate IK (S) into their teaching and learning?

Outline of Chapters

In Chapter One, I introduced the study and gave a brief overview of the whole study. I discussed the purpose, context, problem statements, rationale, and significance of the study, the research questions that guided the study and I also placed myself as a researcher through my personal experience.

Chapter Two provides the background of the study by giving a historical view of the development of the study. I discussed the history of the South African education system starting with indigenous education, slave education by the Dutch settlers, colonial education by the British and Christian National Education. I later discuss the socio-political transformation of education by looking at Bantu education and education after democracy. The literature review focuses on what other researchers have done on the issue of IKS and IK in the classroom.

In Chapter Three, I discussed the various theoretical frameworks that ground the study. I discussed the theories, how I intended to use them in unpacking what I find in the study. The theories are learning theories which include 1) constructivism: Vygotsky's social development theory, which includes the Zone of Proximal Development (ZPD) and More

Knowledgeable Other (MKO), 2) Jean Piaget's theory of cognitive development, 3) cultural border-crossing, collateral learning, situated learning and culturally responsive teaching.

In Chapter Four, I discussed the research method and findings. The research method included the research design I used to collect and analyse data. In the research design section, I discussed the research instruments which are the questionnaires and semi-structured interviews. I also discussed the data collection process and described the research participants. For the data analysis and interpretation, I discussed content analysis for both the questionnaires and the semi-structured interviews. I later discussed the trustworthiness of the study, delimitations, ethical considerations of this study and a summary of the section.

In the section that followed, I presented the research findings. These addressed the research questions outlined in chapter one. There are three themes that I discussed for both research questions. Also, both themes each have an umbrella theme that had three subthemes discussed. I later discussed the challenges faced by teachers when integrating IK(S) into their science classrooms. The challenges are how to explain the mechanism of IK in their classrooms, and the secrecy associated with IK, time management issues, as well as the lack of parental engagement. Finally, I presented an integrated discussion of this section.

In the end, in Chapter Five, I discussed the conclusion for the study, recommendations, as well as further studies. The recommendations are for the teachers and curriculum developers.

Summary of the Chapter

The purpose of this study was to determine FET Life Sciences and Physical Sciences teachers' IK awareness and how they implement IK(S) in their teaching and learning. The study took place at three Dinaledi schools in a peri-urban township near a South African metropolitan city. Six teachers for both subjects were purposefully sampled and invited to partake in the study. The rationale for the study was the necessity for teachers to comply with

the NCS/CAPS 2011 mandate of valuing IK in their teaching and learning so that they can enhance learner's experiences and make classroom science more accessible and meaningful to learner's lived-experiences. This study was significant because secondary school learners were ranked last in Science education performance by the World Economic Forum's 2015 Global Information Technology Report. While Science subjects are needed to improve a country's economy, it was imperative to explore FET science teacher's IK awareness and how they use it in their teaching and learning to enhance learner's understanding of classroom science concepts. This study sought to understand the IK awareness that FET Life Sciences and Physical Sciences have and how they implement IK (S) in their teaching and learning.

Chapter Two

Background of the Study and the Literature Review

Introduction

South Africa inherited one of the most unequal education systems that had racist, sexist, and outdated content in its curricula (Jansen, 2001). Therefore, once South Africa turned into a democratic country, the government had a lot of work set out for it to rid the curriculum of past injustices. The process of educational transformation has not been easy; it faced many challenges which included curriculum reforms. To understand the transformations that took place since the dawn of democracy, the background and progress of education in South Africa had to be explored. As such, in this chapter, the background of the study was discussed by giving an overview of the four phases of the development of education in South Africa: education during the pre-colonial times, education during the colonial times, education during apartheid then finally education during democracy. This is to understand how history has shaped the current education system and how the education system shaped the history of South Africa.

In the literature review, I explored the previous educational works that have been done by others in relation to education, science, IK and IKS and their relevance to education and how teachers could integrate IK in the westernized classroom science in South Africa.

Background

The History of the South African Education System

Education is defined as a universal process in which society's knowledge, customs, social values, and skills are enculturated in learners from one generation to another (Mathunyane, 1996). For a society to thrive, it must succeed economically, socially, culturally, and politically; school is a formalized institution where this type of formal education can be conveyed to learners (Legodi, 2001). South African history has played a fundamental role in the education system (Thorp, 2016). The history of education has played an important role in how current education policies are shaped, considering the past of the first occupants, the indigenous South Africans. The current curriculum policies value IK, and the role it has played and continues to play in indigenous communities. As such, the accounts below provide an overview of the processes that paved the way for the current education system in South Africa.

The phases of the history of South African education can be divided into six categories: the way indigenous people educated their communities before colonialism is called 1) Indigenous education, the type and the way that the Dutch colonialists educated indigenous communities is called 2) Slave education, which lasted up to the year 1800, 3) Colonial education after 1815 by the British, 4) Christian National Education: Trekker states, 5) Bantu education and 6) Democratic education (Christie, 1991). These phases are described in detail below.

Indigenous Education

Before European settlers arrived in South Africa, there were various groups of Black people who lived in the country. They were categorized into the Nguni, Xhosa, Sotho, and the Khoi groups of people (Christie, 1991). In this study, the term Black people depicts the Indigenous South African people and includes those who lived in the country before the

arrival of colonialism (Ndimande, 2013). Indigenous education for Black people before colonialism prepared children for their various roles in society (Jansen, 1990; Seroto, 2011). By then, education was considered a lifelong learning experience that started from childhood and continued without pausing, straight into adulthood. It was instructed in various ways and by various community members during the various phases and years of a child's life. In the early years, the child's biological mother instructed the infant child while later on, the community as a whole instructed the adolescent child (Seroto, 2011). Children that grew up within indigenous communities learned about rituals, hunting, work, their language, relevant skills necessary to survive in their natural environment and the changing world around them. They learned about cultural practices through experience by performing various tasks (Seroto, 2011). This informal education system changed when colonialism started.

Slave Education by the Dutch Settlers (Education up to the year 1800)

Colonial education in South Africa began in 1652 when the first European settlers arrived; and evolved into slave education in 1910 when the Union of South Africa was formed (Randall, 1995). Dutch settler/farmers in the Cape liked the use of cheap labour from the Black people that they found in/on the land and ended up treating them as slaves. This cheap labour was not enough and eventually, slaves from other African countries were introduced to meet their needs (Christie, 1991). During this time, education was administered by the church in mission schools. Slave education was founded in 1789 to replace traditional education in indigenous societies, which missionaries considered preliterate (Jansen, 1990; Ndlovu, 2002). Slave education aimed to convert Black people to the colonizers' religion and to impress in them a life of subservience to white people (Ndlovu, 2002). In addition, mission schools had industrial education and manual labour which they inferred in the form of basic reading, writing, and arithmetic (Christie, 1991). The Dutch settlers had a powerful impact on the development of education for Black people; however, when the British arrived, they had a

greater influence on education for Black communities because, in addition to slavery and subservience, they used education to spread their culture (Seroto, 2011).

Colonial Education by British Colonizers (Education after 1815)

Due to the wars in Europe, some of the British people moved permanently to South Africa and took control of the Cape from Dutch settlers (Christie, 1991). In turn, they paid more attention to education than the Dutch did because they wanted to use it to spread their culture and language to other colonies. During this time, education for Black people was fully provided by the missionaries who came from European and American countries (Christie, 1991). At this point, the missionaries educated Black people for different reasons. They needed Black people to help them spread the gospel, to partake in manual labour and church activities. Most missionary schools did not emphasize secondary and higher education; however, those who did, accentuated Christian values as well as practical and technical work because missionaries wanted to train Black people to have the right attitude to work toward manual jobs and not necessarily develop them professionally (Christie, 1991; Ndlovu, 2002). This education system did not last long for the Afrikaner group as they wanted an education system that promoted their culture as described in the text below; as such, they formed the Trekker States.

Christian National Education: Trekker States

The great Trek began in the year 1836 when Boer farmers got away from the British government because they did not want English to be their medium of instruction (Christie, 1991; McKeever, 2017; Msila, 2007). They set up their own education systems in schools called the Christian National Education (CNE) in the trekker states; the Orange Free State and Transvaal (Msila, 2007). Afrikaans speaking people did not want to mix with non-Afrikaaners claiming that “we want no mixing of languages, no mixing of religions and no mixing of races” (Christie, 1991, p. 174). Their underlying belief was that their Calvinist

church should have the most power in schools. CNE, which originated in the 15th century, was at the centre of school establishments in the Netherlands, Germany, France, and Scotland (Van Eeden & Vermeulen, 2005). Mission schools provided little education to Black people because most of them worked for the farmers. Therefore, reading and writing was not a priority, in addition to the general lack of funding for schools (Christie, 1991).

The Socio-political Transformation of Education (1880-1940)

The discovery of gold in Witwatersrand and Diamonds in Kimberley came with economic and political changes for South Africa (Christie,1991). The colonial authorities' reaction to the industrial revolution at this point was fundamentally racist in nature (Pinar, 2010). For instance, free and compulsory education was introduced for White people which was funded by the government but not for Black people who were still being taught by the missionaries (Christie, 1991).

Bantu education

Before the establishment of Bantu education, the development of formal education in schools for Black learners was interrupted twice by wars. The Boer War interrupted educational progress between the years 1899 and 1902, while the Second World War interrupted educational progress between the years 1939 and 1945 (Christie, 1991; Hall et al., 2019; McKeever, 2017;). While the end of the Boer War in 1910 resulted in a bilingual state with English and Afrikaans-speaking schools, which exacerbated the pattern of excluding non-whites from society, the end of the Second World War changed the entire educational system for Black learners (Hall et al., 2019; McKeever, 2017). In 1948, the National Party (NP) came to power in South Africa, bringing with it the apartheid system: a term that refers to racial segregation. From this, the Eiselen Commission was established by the NP government to look into Bantu education, or education for Black people (Legodi, 2001).

Apartheid was used at the time for political purposes, dividing society based on race (Msila, 2007). Therefore, four racial groups emerged: Asians (from now on referred to as Indians), Coloureds (mixed race), Whites (English and Afrikaans-speaking groups), and Blacks (various ethnic groups that shared cultures, culture, and some traditions) (Legodi, 2001). The Bantu Education Act, passed by the Eiselen Commission in 1953, influenced education for Black learners mainly because of unequal resource allocation (Msila, 2007; Thobejane, 2013). In addition, Bantu education had a mandated curriculum that varied from that of white schools (Legodi, 2001).

Since the curriculum was politically motivated, Black learners were educated by the British to only partake in church activities, while the Afrikaans-speaking people educated the Black learners to be able to communicate with their oppressors and maintain a permanent state of political and economic subordination (Legodi, 2001; Msila, 2007). As such, Bantu education never prepared Black learners to participate in science and technology because it was designed to restrict their development and control their intellect (Msila, 2007). White schools accentuated more academic subjects while for Bantu education, schools included more practical subjects that prepared them for manual labour (McKeever, 2017). Bantu education included reading and writing in primary schools while in secondary schools they had drilling (technical), drawing, Biblical education, English history, French, Latin, grammar, Geography, Physics, and Physiology. These subjects had content that would not develop Black learners professionally but rather restrict them to perform farm labour and other menial jobs (Legodi, 2001).

During the primary school years, Black learners were taught in their mother tongue, but in 1974, the minister of Bantu Education and development: MC Botha published a decree that mandated the use of English and Afrikaans as mediums of instruction for Black learners from Standard five upwards (Boddy-Evans, 2019; Tomlin, 2016). The publishing of this

decree led to the Soweto uprising which began on the 13th of June 1976 where 20 000 learners marched against the use of Afrikaans as a medium of instruction on the 16th of June (Christie, 1991). Subjects for secondary schools included General Science, practical subjects: Homecraft, Needlework, Wood, Metalwork, Art, Agricultural Science, Mathematics, Arithmetic and Social Studies (Boddy-Evans, 2019). Because cultural acquisition is part of teaching and learning, "The deliberate exclusion of Black culture in education was also experienced in curricula that were too Westernised." (Legodi, 2001, p. 124), therefore, Black learners regarded the Bantu curriculum as insignificant and irrelevant to them because it only promoted values that had theoretical concepts which were foreign to them and alienated their own culture (Msila, 2007). Nonetheless, when apartheid came to an end in 1994 with educational independence, the South African education system seemingly took a positive turn for the Black learners, relative to the previous education system that existed during apartheid.

Democratic Education (South African Education System Post-Apartheid)

In 1994 there was a new era for the South African education system. Once the apartheid system ended, there was an urgent need to transform the system into one that suits the needs of all South Africans (Legodi, 2001). This meant a change from the previously unequal and segregated system to a new democratic one. Furthermore, the South African constitution, considered the highest law of the land and the most progressive worldwide (Melber, 2014), demanded that education be transformed and democratized according to human values (Legodi, 2001). For instance, in terms of administration, this entailed combining formerly separated institutions and moving departments, employees, offices, documents, properties, and over ten million students and teachers to a functional framework (Gumede & Biyase, 2016). Furthermore, 19 education departments were consolidated into a single national department and nine provincial departments along with several legislative changes, to ensure that those who were historically disadvantaged had access to education.

The South African education transformation process has been changing since 1994 in an attempt to deterge the curriculum of its racist elements and redress educational inequalities that existed for several decades (Sayed et al., 2013). A framework policy document called The White Paper on Education was first established in 1995 and it paved the way for further curricula reforms (Sayed et al., 2013). The section below will give an overview of the curriculum transformations that occurred since apartheid ended.

1) Curriculum 2005 (C2005) was introduced on March 24, 1997, as the cornerstone of post-apartheid education (Chisholm, 2005). The Minister of Education, Professor Bengu, announced the introduction of C2005 in Parliament, which not only marked a significant departure from the apartheid curriculum but also a new paradigm from content-based teaching and learning to outcomes-based teaching and learning (Cross et al., 2002). C2005 was supposed to go into effect from Grade 1 at the beginning of 1998 and be introduced in all

of the school's grades until their curricula had been updated (Legodi, 2001). Furthermore, the government's strategy was to implement OBE while phasing out the previous content-based scheme. Professor Kader Asmal was a C2005 sceptic. As a result, he commissioned a Curriculum Review Committee, chaired by Professor Linda Chisholm, to assess C2005 shortly after taking office as Minister of National Education (Gumede & Biyase, 2016; Legodi, 2001). Other offices that were involved in the review include the South African Democratic Teachers Union (SADTU), all the Departments of Education as well as the Cabinet (Chisholm, 2005). This led to the second transformation which occurred three years later in 2000 when C2005 (up to grade 9) was reviewed, streamlined, and updated, paving the way for 2) The Revised National Curriculum Statement (RNCS 2002) in April 2002 (Chisholm, 2005). Furthermore, in 2007 the National Curriculum Statement (NCS) was introduced and eventually the Curriculum and Assessment Policy Statements (CAPS) were established in 2012 (Adu & Ngibe, 2014).

Curriculum 2005 (C2005), which focused on the ideals of Outcomes-Based Education (OBE), was introduced as the basis of the post-apartheid school curriculum in 1997 by the new national Department of Education where content-oriented subjects were replaced with learning areas that had statements as well as learning outcomes (Chisholm, 2003, 2005; Sayed et al., 2013). In this curriculum, teachers were expected to arrange the teaching of learners based on learner-centeredness concepts and postulates, something that contrasted with the pure knowledge transmission, as well as the rote learning that the apartheid system previously used (Cross et al., 2002; Crouch & Hoadley, 2018; Gumede & Biyase, 2016; Muthivhi & Broom, 2008). However, “Teachers schooled and trained through Bantu education under apartheid lacked opportunity to overcome the legacy of a very poor preparation for teaching.” (Crouch & Hoadley, 2018, p.21) in other words, such expectations were confusing to teachers that were coached within the Bantu education confinement

(Thobejane, 2013) because the training and preparation of teachers to implement C2005 did not receive the same amount of focus and attention as did the curriculum change (Crouch & Hoadley, 2018). As a result, the following implementation challenges were incurred 1) Foundation Phase learners could not read, write, or count at the expected levels, 2) there was a lack of training for the teachers and 3) most schools lacked the resources to implement the major expected changes (Badugela, 2012). In the year 2000, a Ministerial Committee was established by the newly appointed Minister of National Education, Professor Kader Asmal to review the curriculum's progress and efficacy (Gumede & Biyase, 2016). The committee was to assess the extent of educators' curriculum knowledge, the effectiveness of OBE instruction, and other related issues (Crouch & Hoadley, 2018). After the review in 2000 for grades R-9, it was recommended that the curriculum be streamlined, which led to the establishment of the RNCS 2002 (Grades R-9) and the NCS 2000 (Grades 10-12) (Chisholm, 2003a; Hewson, 2012; Sayed et al., 2013).

The aim of the RNCS 2002 (Grades R-9) had its roots in the South African Constitution Act 108 of 1996 which supplies the basis for curriculum transformation (Muthivhi & Broom, 2008). Due to mounting pressure from poor student academic performance, ongoing implementation challenges such as content and assessment overload, as well as widespread public criticism of the OBE system (Chisholm, 2005; Crouch & Hoadley, 2018), another review was launched in 2009 to revise the RNCS 2002 (Grade R-9) and the NSC (Grades 10-12) (Hewson, 2012). This resulted in the development of CAPS (Hewson, 2012), of which Gumede and Biyase (2018) contend that CAPS is not a new curriculum, but rather a revision of NCS.

From 2012 the two National Curriculum Statements were combined into a single document known as the NCS Grades R-12. NCS Grades R-12 builds on the previous curriculum but also updates it and aims to provide a clearer specification of what is to be

taught and learned on a term-by-term basis. Furthermore, the NCS Grades R-12 2012 prescribes the policy for assessment within the schooling sector and explains the objectives, outcomes as well as assessments for teaching and learning (Badugela, 2012). When NCS was amended to improve implementation, the result was a single policy document for each subject in the schooling sector called CAPS 2011 (Adu & Ngibe, 2014). CAPS 2011 replaced subject statements, learning program guidelines and assessment guidelines.

The CAPS documents were established in 2011 and came into effect in January 2012 (Jacobs, 2015). CAPS 2011 differ from OBE in that they are more subject-oriented and subject boundaries are clearly addressed with weekly teaching plans (Khupe, 2014). CAPS 2011, just like the previous curriculum documents included valuing Indigenous Knowledge Systems (IKS). The Specific Aim 3 in the Physical Sciences and Life Sciences of the CAPS 2011 documents is based on understanding the applications of sciences in everyday life, as well as understanding the history of scientific discoveries and the relationship between IK(S) and classroom science (Hewson, 2012; Jacobs, 2015). The inclusion of IKS into the curriculum, which was ignored during the colonial days has its basis in social justice and democratic principles (Khupe, 2014). This is to ensure that African learners are offered opportunities in science and which were not available during the apartheid era.

Literature Review

Indigenous Knowledge Systems

IKS is a body of knowledge rooted in the African philosophical thinking that belongs to indigenous people within a certain geographic area and has survived for thousands of years regardless of colonialism (Khupe, 2014; Mapara, 2009). There is no formal definition of indigenous people because there are countless people worldwide that are considered indigenous (Shizha, 2013). Nonetheless, this study adopted the definition of indigenous people from Aikenhead and Ogawa (2007) where they defined indigenous people as descendants of first land occupants who identify as a group and are recognized by other groups of people or government authorities. Writers use the term indigenous to refer to the minority people within local environments, however, when used within the African contexts, the concept of indigeneity refers to the philosophical origins of people and a sense of natural belonging to a place (Mpofu et al., 2014; Shizha, 2013).

The South African Department of Basic Education (Department of Basic Education, 2011) certifies knowledge as indigenous if it has evolved over thousands of years and one can describe it as African. However, in the CAPS 2011 documents, IK is not confined to African beginnings (Khupe, 2014). Furthermore, the Department of Basic Education endorses the changing dynamics of IK over the years by acknowledging that it might not be passed on wholesomely from one generation to the next due to changing societies “As society changes, some of that knowledge is being lost” (Department of Basic Education, 2011, p.8). This statement implies that it is nearly impossible to find the knowledge that is entirely exclusive to a group of people because individuals in each generation interact with other groups, adapt, and add to their knowledge the changing environmental conditions, thereby passing on their own body of knowledge to the next generation (Hoppers, 2009). The South African context is made up of different cultural groups that are in constant interaction, therefore cooking,

dressing, working, and using technology may vary substantially between groups (Keane, 2008) where IK from one group could have been integrated by the indigenous peoples' interactions with other tribal groups which in turn might influence how they conduct their daily activities. Other researchers argue that the opposite might be true.

In contrast to the heterogeneous nature of IK above, Hewson and Ogunniyi (2011) certify knowledge as indigenous and allude to its homogenous nature if it existed before colonial times, where some practices and knowledge are reserved only by certain community members and are selectively passed down in their pure form to the next generation. For instance, deep convictions, faith, and ways of thinking may change somewhat gradually, if at all (Keane, 2008). Bruchac (2014, p.4) illustrates this further by referring to "knowledge keepers" in local communities "who are often carefully trained to link parts of traditional narratives to specific events and locales, and that cultural coherence is ensured by regular repetition.". The Native American communities select and train children to be knowledge keepers from a young age, while within the Maori, only selected group members are entrusted with specialized knowledge that is also passed down to a selected few members of the community (Bruchac, 2014).

From the above definitions, this study will view IK(S) both as conservative and dynamic in nature because as useful traditional knowledge is preserved, such as faith and ways of thinking, knowledge such as cooking, dressing, and using technology is also reconstructed in response to contemporary environmental realities. Furthermore, the term Black learners will be used to refer to indigenous learners. This is not to say Western culture is not indigenous (to the people of western culture), but the concept is in line with the previously oppressed people whose ways of knowing, doing, acting, and dancing have not been valued in the education system.

The Nature of Indigenous Knowledge (NOIK) has some of the following characteristics: 1) IKS embraces testable and non-testable supernatural phenomena, (Zinyeka et al., 2016) 2) IK is orally passed on (Khupe, 2014; Zinyeka et al., 2016), 3) IKS is based on relationships, where Semali and Kincheloe (1999) included physical and spiritual relationships between people and the environment, 4) IKS is a product of daily experiences and is fortified by trial and error (Hunn, 1993; Khupe, 2014). Because the elderly are repositories of knowledge and experiences (Khupe, 2014; Sutherland & Henning, 2009), a large portion of IKS is retained in their cognition (Riffel, 2020). Languages, ideas, beliefs, customs, folk stories, and techniques are all part of IKS, and the knowledge comes in different forms such as values, technology, animal, plants, languages, and environmental knowledge (Mapara, 2009). Furthermore, IK comes in/from day-to-day lived-experiences such as in education, economic, administration and law, as well as experiences, for instance, they include weaving mats, brewing local beer, and producing palm oil from palm kernels (Òtúlàjà et al., 2011).

In countries where knowledge systems were suppressed by colonial powers, such as non-Western learner's culture and language during apartheid in South Africa, there have been calls by science educators to include different knowledge systems into formal education, therefore, curricula have been oriented to acknowledge indigenous peoples' languages and culture (Khupe, 2014; Muza, 2014). Although IK and IKS are terms that are used interchangeably in the literature (Taylor & Cameron, 2016), this study will adopt the distinction between IKS and IK from Òtúlàjà et al., (2011) where IK is a subset of IKS. There have been attempts by African countries such as Kenya, Nigeria, and Tanzania to implement IKS into their formal education. However, this is not a unique African experience; countries across the world such as Canada, the USA, the Middle, and the Far East, Australia and South

American countries have attempted the integration of IK into their curricula (Ogunniyi, 2007). Below I discuss some studies on IKS and science integration.

IKS and Classroom Science Integration

To achieve effective learning in science, there is the need to fill the gap between western knowledge and IK because Naidoo (2010) reported several cases where teachers believed that IK and classroom science are contrary to each other (Nnadozie, 2009). In addition, even science education researchers acknowledge the existence of the conflict between western and indigenous cultures (Mpofu et al., 2014). Different communities have various IKS which in turn makes implementing IK concepts into the science classroom difficult (Khupe, 2014). A point worth mentioning is that it has been described as complex to integrate IKS into classroom science (Mavuru & Ramnarain, 2020; Mpofu et al., 2014) because teachers have been trained with a Eurocentric worldview/framework; therefore, their understanding of IK is considered limited (Khupe, 2014) because it is unexplored. Furthermore, it is not enough to know which teaching strategy to use, but also the type of learners as well as the community they come from to understand the type of IK they might, in turn, possess (De Beer & Mothwa, 2013). This is to allow teachers to anticipate the conflicts and misunderstandings that learners might experience in science classes (Molefe & Sanders, 2009). Several strategies and examples have been suggested for IK integration in the teaching and learning of science.

If teachers do not have material to follow up with when integrating IK, they could draw knowledge from their own IK or research their local communities to find which IK they could bring to the classroom and integrate as per curriculum documents (Nnadozie, 2009). The abundant cultural practices and IK in South Africa including the commercialization of indigenous plants and the use of indigenous materials are enough to give learners a good start to classroom science (De Beer & Mothwa, 2013; Fakoyede & Otulaja, 2019). For instance,

the discovery of medicinal plants that have been in use by communities for decades and eventually become commercialized can provide teachers with opportunities to integrate IK into their classroom science. The medical properties of different types of medicinal plants have been recognized by several pharmaceutical companies (De Beer & Whitlock, 2009). An example of this is of a local district in Giyani where the locals have used the *Lippia javanica* plant (known in Setswana as Musukudu) as a form of insect repellent. After CSIR registered for a patent along with the local community to test the plant as an insect repellent, clinical trials showed a success rate of 40% and an efficacy of 95% of the oil from Musukudu (De Beer & Mothwa, 2013). Using the IK from the local communities and the commercialization of the local plant, teachers could use such opportunities to introduce learners to the world of science that supports IKS. Another example of an indigenous medicinal plant that can be used in the science lessons is *Sutherlandia frutescens* which has medicinal properties that can fight symptoms of influenza and sexually transmitted diseases (Van Wyk & Prinsloo, 2018). Additionally, another strategy that was suggested by Fakoyede and Otulaja (2019) is integration through cultural mediation, where teachers use appropriate materials to instruct Black learners. An example the authors gave was of the use of beadwork in Life Sciences to demonstrate the structures of simple and complex organic sugars in Chemistry (Fakoyede & Otulaja, 2019).

Another way of incorporating IK into the classroom is using argumentation pedagogies (Muza, 2014). Argumentation is a set of declarations compiled to either justify or disprove a claim so that an agreement is reached regarding a contentious subject matter (Ogunniyi, 2007). This method has long been in use since pre-Socratic times including current times by scientists. Even the FET CAPS science documents acknowledge the use of debates and argumentations for scientific ideas to be accepted as valid (Department of Basic Education, 2011). Argumentation is the formation of reasons using inductive methods and

reaching conclusions from those discussions (Muza, 2014). As such, this method can be used in the science classroom by teachers who attempt to incorporate IK into their science classrooms activities. Ogunniyi and Onwu (2007) developed the Contiguity Argumentation Theory (CAT) which elaborates the process by which conflicts arise when faced with conflicting views. Using CAT, Muza (2014, p. 20) elaborated that opposing views can be settled through "accommodation, integrative reconciliation, and adaptation".

Successful argumentation will depend on the teachers' knowledge base of IK and classroom science and how they manage the conflicts brought about due to integrating these two forms of knowledge (Mhakure & Otulaja, 2017). Some of the issues that have been raised regarding this method are about the influence of teachers' behaviour and attitudes toward capabilities demonstrated by the learners from their argumentation tasks (Òtúlàjà et al., 2011). Furthermore, most science education researchers question the method when it comes to teaching learners that are taught in a language that is not their mother tongue (Òtúlàjà et al., 2011). Regardless of these concerns, a study by Hewson and Ogunniyi's in-service student on teachers in 2008, concluded that argumentation is a strategy that could be used for incorporating IK into the science classroom within the South African context (Mhakure & Otulaja, 2017).

According to Ogunniyi and Hewson (2008), the integration of IK concepts in classroom teaching practice is foreign to many White, Coloured and Black teachers because they are trained in a Eurocentric system (Khupe, 2014). As such, science reforms are unsuccessful in providing for classrooms that have a diverse combination of learners with diverse multi-cultural backgrounds (Mavuru & Ramnarain, 2018). According to the authors, one of the leading reasons for the failure is the disregard of teachers' views of IK and the role it plays within the classroom setting. Teachers' awareness and views contribute to their identity as science teachers and influence their teaching strategies as well as the content they

offer in science classrooms (Smith, 2005). Furthermore, for learners to be successful in class, teachers must be able to recognize learners' socio-cultural context and background and the effects these have on the teaching and learning of science (Aikenhead & Jegede, 1999). Being able to understand the NOIK and classroom science is an important goal toward integrating IK into science classrooms (Khupe, 2014). Thus, this study describes teachers' awareness of IKS in a peri-urban school and intends to find out how they may be able to integrate it into teaching and learning science within their classrooms.

Summary of the Chapter

In the background of the study, I discussed the history of the South African education system and how it has impacted the current education system for Black learners. The history of the South African education system has six categories in which it evolved. The first one is the 1) Indigenous education, 2) education by the Dutch settlers, 3) education by the British settlers, 4) the Christian National Education, 5) Bantu education and the current, 6) Democratic education. From the beginning of colonialism, when slave education by the Dutch settlers begun, Black learners' education has been oppressive. For instance, the Dutch settlers educated Black learners so that they could meet their needs of manual, cheap labour, while the British settlers train Black people to have the right attitude to work without any other professional growth. During the Trekker states when the Afrikaner people broke away from the British government, Black learners received little education. Bantu education was introduced after the formalisation of apartheid, where in 1948, the NP separated races for political reasons. History has had a huge impact on the current education system, under the democratic system. The current education system aims to redress the inequalities of the past and integrate Black learners' IK into science teaching to make abstract concepts more relevant to non-western learners lived-experiences. This is because, throughout the development of the education system, Black learners' education was not focused on

developing them professionally, but it was rather preparing them for a subservient life (Legodi, 2001). For instance, Western, non-Western, and Black learners all had different curricula at school with Black learners taught just enough to perform menial tasks and not think critically. However, because such a system neglected the culture and knowledge of Black learners, Black learners, in turn, regarded the education as insignificant and irrelevant to them. This took a different turn at the advent of democracy, in 1994.

Post-apartheid in 1994, curriculum transformation was one of the new government's priorities. The educational transformation began with the introduction of OBE through C2005. Due to implementation challenges such as lack of training time for teachers and unclear guidelines, a ministerial committee set up by the then Minister of Education, Professor Kader Asmal and headed by Professor Chisholm investigated and re-evaluated the curriculum, from which the RNCS 2002 (Grades R-9) were developed. Continued implementation challenges such as content and assessment overload resulted in another review in 2009 to revise the RNCS 2002 (Grade R-9) and the NSC (Grades 10-12), which resulted in the production of a single policy document for Grades R-12, the NCS (Grades R-12)/CAPS 2011.

In the literature review, I introduced IKS as a body of knowledge that is native to indigenous people and has survived for thousands of years regardless of colonialism and apartheid. I also acknowledge that currently, IK may not have been passed down in its purest form because of the interactions that indigenous people may have had with settlers and other nations that they may have interacted with. This is because IKS comes from day-to-day experiences such as weaving mats, brewing local beer and the production of palm oil from palm kernels which can be influenced through interactions/counteraction with other cultures. On the other hand, there is some IK that is still passed on in its purest form because of deep convictions, faith, and ways of thinking. For instance, communities within the Native

Americans and Maori select specific children at a young age to ensure cultural coherence and pass on pure specialized knowledge that is exclusive to them.

There have been numerous studies that suggest how to integrate science in the classrooms such as using local community experiences to bring IK into the class as well as the use of argumentation. The integration of IK concepts in the classroom teaching practice is foreign to many White, Coloured and Black teachers because they are trained in a Eurocentric system. As such, this study describes teachers' awareness of IK in a peri-urban school and how teachers find ways to integrate IK into Grade 10-12 science classrooms.

Chapter Three

Theoretical Frameworks

This study will be grounded by theoretical frameworks. Before discussing them, I will describe how literature defines theoretical frameworks, and why they are needed in a study. Kerlinger (1966, p.9) describes a theory as "a set of interrelated constructs, definitions, and propositions that present a systematic view of phenomena by specifying relations among variables to explain and predict phenomena*"*. Theories are usually abstract representations of ideas that researchers use to understand their research questions (Siseho, 2013), as such, a theory's conclusions, assertions, and forecasts of relationships serve as an analytical basis for studies that seek clarity for their research questions (Kivunja, 2018). On the other hand, a framework is a construct that (Muhumuza, et al., 2013) that a researcher uses to finetune and support research findings (Imenda, 2014), it also provides a direction for data interpretation (Muhumuza et al., 2013; Osanloo & Grant, 2016). Kerlinger (1966, p.9) describes a framework as "a set of ideas that you use when you are forming your decisions and judgements" which lay the groundwork for interpreting the relationships between variables in a phenomenon (Molefe, 2014).

A theoretical framework is a structure that summarizes ideas and hypotheses that researchers build based on prior knowledge that has been tested and written so that when research findings are put into perspective with the theoretical framework, they provide academic rigour (Kivunja, 2018). The primary reason theoretical frameworks are needed for research is to provide a scholarly basis for all data interpretations in the research and articulate a study's theoretical assumptions (Neuman, 2000). Upon collecting data, the results are checked to see if they agree with the framework and if the chosen framework can be used to describe the collected data (Imenda, 2014).

The theoretical frameworks for this study inform the rationale for this study, the significance of this study and how my study fits in with existing research and theories (Heale & Noble, 2019). Theoretical frameworks help researchers to connect how and why events occur in phenomena by identifying the nature and cause of events (Seifert & Sutton, 2009). Therefore, my chosen theoretical frameworks are based on social learning theories and emerge in my findings as well as discussion. They include constructivism, border-crossing, collateral learning, situated learning and culturally relevant pedagogy.

Constructivism

Constructivism is a teaching and learning philosophy founded on the premise that learning is the product of mental construction, where learners build knowledge internally based on their lived-experiences (Bada & Olusegun, 2015; Cobb & Bowers, 1999; David, 2020; Schunk, 2012). As such, learners create subjective realities by linking new information from reality to old knowledge constructed subjectively (Bada & Olusegun, 2015; David, 2020). Theorists that created constructivism are Lev Vygotsky (1896 – 1943) and Jean Piaget (1896 – 1980).

Vygotsky's Social Development Theory

The social development theory emphasizes the role of social interaction in a learner's development (David, 2020). Instead of learning to do something before acting it out, the theory assumes that the learners go through physical activities with the surrounding environment before they learn (Jonassen & Rohrer-Murphy, 1999). In other words, learners will adjust personal interpretations to become socially acceptable by being engaged in new surroundings. The major themes that arise from this theory are the Zone of Proximal Development (ZPD) and the more knowledgeable other (MKO).

Zone of Proximal Development (ZPD)

Vygotsky (1978, p.86) defined ZPD as "the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem-solving under adult guidance or in collaboration with more capable peers″. With this definition, Vygotsky highlighted the importance of socio-cultural learning; that when children interact with MKOs or teachers, they use their cognitive apparatuses to develop constructs within their ZPD (Chaiklin, 2003). As such, learning occurs in the ZPD, the gap or space between what a learner cannot learn on their own and what a learner can learn with assistance from an MKO (David, 2020; Vygotsky (1978) as cited in Yilmaz (2008)). In the context of education, learners learn best when working in collaboration with others who have more knowledge and skills. Therefore, the goal would be to move learners to their next ZPD level by providing learners with culturally relevant tasks that will help learners achieve a level of learning that they would not have otherwise been able to achieve by themselves so that they are motivated to complete the tasks. This theory stresses the importance of socio-cultural experiences as keys to children's learning and development. For instance, Vygotsky agreed that babies are born with fundamental cognitive abilities and that these abilities are enhanced by social interaction, eventually developing into more complex mental processes (Brau, 2020). The development of complex mental processes is aided by assistance from MKOs.

More Knowledgeable Other (MKO)

The social development theory alludes to the fact that learning can take place in the presence of an MKO (David, 2020). An MKO can be a person or other physical tools that learners use (Abtahi et al., 2017) that have more knowledge and skills than the learners (Mcleod, 2020). Vygotsky suggested that with the help of an MKO, learners can accomplish a higher level of learning (Brau, 2020).

Jean Piaget's Theory of Cognitive Development

This theory explains the changes in reasoning levels that learners experience as they develop new ways of understanding reality (Lefa, 2014). Piaget used schemas or schemata as the basic blocks that measure intelligent behaviour (Mcleod, 2020). A schema is a mental representation of newly learned concepts that are stored in learners' minds and used when needed to understand phenomena and respond to situations (Mcleod, 2020; Seifert & Sutton, 2009). Furthermore, schemata are not inert because learners acquire them from their lived-experiences daily (Schunk, 2012).

Piaget (1964) believed that cognitive development is an active process that occurs because of maturation and environmental influences. Therefore, learning is not inert but is stimulated by situations such as teaching (Piaget, 1964). According to Schunk (2014), learning takes place once learners reach a mental conflict and resort to either accommodation or assimilation to make sense of reality. Accommodation is when learners change existing mental constructs and align them with new incoming information (reality) so that they can make sense of reality (Schunk, 2014), while assimilation is the integration of reality into mental constructs. The latter happens when learners change the new incoming (reality) information and align it with existing mental constructs so that they can make sense of reality (Schunk, 2014; Piaget, 1964). For instance, according to Schunk (2014), the act of interpreting events is an illustration of assimilation. The biological drive to align mental constructs with reality is driven by equilibrium (Schunk, 2014). Therefore, equilibrium is a basic element for cognitive development because it keeps cognitive concepts consistent with the realities that learners experience (Schunk, 2014). As such, assimilation and accommodation are complementary to each other in the sense that when cognitive structures are assimilated, new information could be accommodated (Schunk, 2014).

In the context of learning, teachers ought to provide learners with opportunities to construct their own meanings of realities through critical thinking and experiences by exploring the teachings and information for themselves (Lefa, 2014). Piaget also encouraged learners of different cognitive levels to work together (MKOs) so that those with less cognitive levels can advance their learning (Lefa, 2014). When teachers provide learners with such opportunities or context, they provide them with critical tools that can motivate them to discover information on their own (Ojose, 2008).

Cultural Border-Crossing

For Black learners to obtain a culture of classroom science, they should be able to mentally move from their day-to-day life to the world of classroom science (Jegede & Aikenhead, 1999). Sociology scholars have catalogued classroom science or "Western Modern Science" (WMS) (Snively & Corsiglia, 2001) in Western Europe and North America and designated it as a White male, Western middle-class structure of meaning and symbols (Rose, 1994; Simonelli, 1994; Snively & Corsiglia, 2001). As such, in the late 1980s and 1990s researchers' perspectives became aligned with the notion that classroom science is a subculture of western societies or realities. Therefore, Black learners learn classroom science while already in possession of IK cultures that help them make sense of their everyday world (Herbert, 2008; Nnadozie, 2009). To learn classroom science, they go through a process of cognitive border-crossing where they cross boundaries from their indigenous culture to the subculture of classroom science (Herbert, 2008; Nnadozie, 2009).

Cultural border-crossing is a change in belief and expectation that Black learners undergo when they transition from their indigenous cultures to the culture of classroom science (Aikenhead, 1996; Aikenhead & Jegede, 1999; Nnadozie, 2009). Border-crossing is not an easy process, nonetheless, Nnadozie (2009) asserts that it is a necessity if meaningful learning of classroom science is to be achieved.

Science education in the form of modern classroom science has impacted learners from developing countries in a negative way because most of them feel as if classroom science is a foreign concept to their heritage since it alienates their culture (Aikenhead & Jegede, 1999). When learners cross cognitive borders, to understand science, they do not abandon their IK to understand science, but rather they learn science while they retain their IK (Nnadozie, 2009). If they attempt to conceptualize science and they experience a conflict between the two cultures, they might be forced to reconstruct new ways of understanding the new scientific concepts (Aikenhead & Jegede, 1999). The authors (ibid) termed this process assimilation, which can cause social interferences such as avoidance; a natural reaction that may deem border-crossing unfeasible for the learner. Such a cultural conflict has consequences like cultural or symbolic violence for both teachers and their learners. Cultural violence is when a learner is to learn and similarly make sense of content to another group of people using actions that do not make sense to the learner. For example, an Aboriginal science student declined to take geology classes because he did not want the geological descriptions of landscape to contaminate his spiritual belief in nature (Aikenhead, 1998; Nnadozie, 2009). Nevertheless, for effective science learning to take place, both teachers and learners ought to be able to cross these borders (Aikenhead, 1996; Nnadozie, 2009).

According to Nnadozie (2009), the general objective of science education is to eliminate symbolic or cultural violence. As such, moving across cultures depends on the nature of support that learners receive from their teachers (Nnadozie, 2009). If there is no support structure, the learners may reach a phase where they could be expected to excel in something that does not make any sense to them, and this could lead to cultural or symbolic violence. Aikenhead (1996) argued that curriculum developers should consider border-crossing to make science more accessible to Black learners. In so doing, cultural distinctions will be appreciated and valued in teaching and learning (Mulholland & Wallace, 2003). In the

end, aspects such as learners' resilience, playfulness factors that play a role in learning as well as the type of support they receive will determine the type of border-crossing experience they will go through (Jegede & Aikenhead, 1999).

Four types of border-crossings have been identified as smooth, managed, hazardous, and impossible (Aikenhead, 1996). Whenever learner's indigenous culture and knowledge are consistent with those of classroom science, then smooth border-crossing occurs; managed border-crossing is when learners' indigenous culture and knowledge vary from the classroom sciences' while hazardous border-crossing is when both cultures are dispersed, which results in hazardous border-crossing for the learner (Fakudze, 2004). Lastly, impossible border-crossing is when both cultures completely clash, rendering border-crossing from the learner's indigenous culture to the science subculture impossible at that point in time (Fakudze, 2004).

Collateral Learning

Collateral learning is the process that non-western learners undergo when they border-cross from their indigenous culture to that of the classroom science (Jegede & Aikenhead, 1999). Jegede (1995) argued that culture plays a fundamental role in learning science. Learners learn science by combining their indigenous culture with the science culture; when they reach the borders of both cultures, collateral learning theory can be used to explain the various processes they go through to make sense of their learning (Nnadozie, 2009). The ability of learners to engage effectively in classroom science depends on how familiar learners are with both indigenous and classroom science cultures, how well they continuously transition between the cultures and the support that they receive from teachers during such transitions (Aikenhead & Jegede, 1999).

Jegede (1995) presented the collateral learning theory where he argued that learners experience potential cultural conflicts when they enter the science classroom. Furthermore, he argued that the belligerent way that science curricula are structured within non-western

classrooms gives the perception that knowing and understanding classroom science is through understanding the western culture only, which in turn exacerbates the conflicts that Black learners go through. When indigenous cultures interact with western cultures, they complicate the cognitive processes such as knowledge acquisition for Black learners (Jegede, 1995). Knowledge acquisition is a gradual process, therefore Black learners should have processed pertinent information over a long period before storing the knowledge in their long-term memories; this process that takes longer for Black learners that come across classroom science concepts for the first time (Jegede, 1995).

Learners can retain two different cultures and knowledge in their memory for a long time (Nnadozie, 2009), where the ability to reflect on divergent cultures and reconcile contrasting beliefs is a basic human attribute (Aikenhead & Jegede, 1999). Therefore, learners strive to resolve the cultural conflicts through the process of asking certain questions like “how “and “why” while looking for evidence until the conflicts reach a commonality, which is eventually stored in the long-term memory (Jegede, 1995). Tang and Yang (2017) argued that learners construct their own explanations regarding conflicting cultures based on cultural and environmental influences that are tested by the conflicting phenomena.

Aikenhead and Jegede (1999) provided an example of how the explanations may be constructed through the process of collateral learning by giving an illustration of a rainbow. In the science culture, learners are taught that the bending of light rays by water droplets through refraction causes the existence of a rainbow, while some Black cultures appreciate the presence of the rainbow as a sign of a python crossing the river or the death of a supreme chief (Aikenhead & Jegede, 1999). As such, for Black learners to engage effectively with classroom science regarding the rainbow, they would have to construct explanations for the epistemologically conflicting concepts in their long-term memory (Aikenhead & Jegede,

1999). In doing this, the conflicts between scientific cause versus African significance will be resolved.

Jegede (1995) presented the Collateral Learning Theory to explain how learners coordinate the conflict between indigenous culture and science culture. Three types of collateral learnings, which exist in a continuum, were named by Aikenhead and Jegede (1999) as parallel, secured, and dependent collateral learning. Parallel and secured collateral learning are on opposite ends of the continuum where parallel collateral learning represents conflicting cultures that do not interact at all. In this case, learners would have to access any of the two cultures to understand phenomena, depending on the milieu they are in (Aikenhead & Jegede, 1999). Learners do this by modifying their cognition so that they can accommodate new concepts; in turn, the existence of both cultures is not obstructive to a learner's lived experiences because the two cultures and ways of knowing never interact (Jegede, 1995). On the other hand, secured collateral learning occurs when the western and indigenous cultures interact, conflict, and are ultimately resolved (Aikenhead & Jegede 1999). Dependent collateral learning lies in between the continuum and occurs when learners modify one of the conflicting cultures without changing their existing worldview (Aikenhead & Jegede, 1999). The fourth type of collateral learning was called simultaneous collateral learning, as named by Jegede (1995). Simultaneous collateral learning is when a learner attempts to learn about phenomena from different cultures at the same time, to do this, they assess the phenomena, available problem-solving approaches from both cultures as well as similarities and differences regarding the two ideas (Jegede, 1995). Fakudze (2004) elaborated further that simultaneous collateral learning lies in between parallel and dependent learning in that phenomena in one culture allows the learning of the other opposing culture. When familiar with the collateral learning theory, teachers become better collateral brokers because effective collateral learning depends on successful border-crossing into the classroom by both learners

and teachers (Aikenhead & Jegede, 1999; Nnadozie, 2009). Furthermore, to avoid conceptual conflicts, the strategies used by teachers in class should consider pre-existing knowledge of learners and where it comes from (Muza, 2014).

Situated Learning

Brown et al. (1989) first established the situated learning theory, which was later expanded upon by Lave and Wenger (1991). This theory describes how people, as members of a community of practice (CoP), learn professional skills, and it provides education and training studies into how legitimate peripheral engagement progresses to full membership by developing habits that allow them to become full participants (Fuller et al., 2005; Wenger,1999). Therefore, the situated learning theory's primary emphasis is on learning as social participation by both teachers and learners, where the focus is on how much of what is learned is unique to the context in which it is practised (Anderson et al., 1996; Wenger,1999). In this instance, participation refers to an all-encompassing phase of active participation by learners and teachers in their social groups, and the construction of identities that shape who they are (Wenger, 2011). Traditional learning involves activities such as internalizing abstract concepts from classroom notes and books, whereas situated learning can be informal and include relationships between people who informally connect pre-existing knowledge through interaction, collaboration, participation, and gaining access to various contexts (Fuller et al., 2005; Patton & Parker, 2017; Tularam, 2008). This type of learning occurs through participating in CoPs (Eberle et al., 2014).

The process of learning for newcomers who do not possess the knowledge and skills of the CoP to which they are entering is called Legitimate Peripheral Participation (LPP) while the newcomers are referred to as Legitimate Peripheral Practitioners (LPPs) (Eberle et al., 2014; Floding & Swier, 2012). As LPPs gain skills and knowledge, communicate in a community-specific way and take on more complex roles, they become full active members

(Eberle et al., 2014). Teachers who learn together in a common area, form a CoP, similarly, learners who in the same class who learn together, also form a CoP (Wenger, 2011). Members of a CoP increase their knowledge by continuously interacting with each other to find solutions to their challenges (Floding & Swier, 2012). Furthermore, a CoP shares information and ideas thereby helping each other out; and in so doing, building relationships that allow members to learn from each other and to solve problems.

Members of a CoP are called practitioners because they belong to groups of people who share an interest or a passion for what they do, and they learn to do something better by interacting with one another regularly (Wenger, 2011). Furthermore, a CoP takes time to develop and does not include instantaneous meetings. For instance, when teachers meet regularly for lunch in an unplanned way, they are a community that gets to talk about how to teach learners and in turn, learn from one another's knowledge and experiences. As such, this theory is based on a socio-cultural interaction in a context where people construct knowledge through active participation with other cultural practices within their social communities (Jimenez-Silva et al., 2012). People can become part of a CoP through engaging, imagining and aligning (Wenger, 1998). CoPs have domain, community, and practice as attributes (Floding & Swier, 2012). Shared interests are the domain and identity of the community, while the community is people who participate in similar activities by sharing information and building relationships.

By participating in cultural activities, members of the CoP can see themselves in the future as they move from the periphery to full practice (Jimenez-Silva & Olson, 2012). This participation is legitimate and peripheral; and as newcomers gain knowledge and skills, the process becomes more complex as teachers and learners are drawn centripetally (from the outer circle in the periphery to the centre of knowledge and skills) and become much more engaged (Floding & Swier, 2012). They move from being LPPs to becoming full legitimate

practitioners. The more they practice in the community, the more they can align who they are with what they practice (Jimenez-Silva & Olson, 2012). It is therefore essential for teachers and learners that aspire to become full practitioners to be active in their CoPs. In so doing, teachers and learners gain community traditions and discover their own traditions that they can use to transform the community because their actions represent the members' own perceptions of what matters (Wenger, 1998; Zaffini, 2018).

Culturally Responsive Teaching

Culturally relevant pedagogy/teaching (CRP) is a multicultural, social justice-based approach that focuses on using school contents to empower learners intellectually, politically, and socially (Brown et al., 2019; Silva-Peña & Peña-Sandoval, 2019). This theory was first named by Ladson-Billings (1995) when she stated that successful pedagogical practice, is a theoretical model that not only explores student achievement but also helps students embrace and validate their cultural identities while gaining analytical insights that address social inequalities that schools (and other institutions) maintain, it acknowledges learners' cultural backgrounds and experiences in all aspects of teaching (Gay, 2002; Samuels, 2018). Additionally, this theory links learners' indigenous backgrounds with new scientific concepts thereby facilitating effective learning (Rychly & Graves, 2012). The rationale behind this approach is to and foster more academic achievement and engagement by all learners through embracing diversity and establishing their cultural attributes. It includes teachers that are committed to cultural accomplishments and can identify as being both cultural brokers and change agents (Samuels, 2018).

Academic achievement, cultural competence and critical consciousness serve as guiding principles for CRP (Ladson-Billings, 1995, 2006). On the part of academic success, Ladson-Billings (1995) asserted that regardless of the socio-economic pressures that affect the academic performance of previously disadvantaged learners negatively, a teacher should

always encourage learners to focus on excelling in academics, thereby ensuring academic success. However, academic success is multifaceted and is influenced by a lot of factors and not just the teachers' encouragement to excel.

Cultural competence is when teachers use the learners' cultural differences to ensure that they achieve academic success (Ladson-Billings, 1995). Thus, allowing learners to express who they are culturally (either through their music, the clothes they wear or the way they speak), can give them the confidence to focus on academics and excel. Ladson-Billings (1995) believed that it was not enough to only be culturally competent without having the ability to question society.

Critical consciousness has its basis in Paulo Freire's work in the Pedagogy of the Oppressed (Cree, 2013; Freire, 1996). Freire argued that the solution to social emancipation is through the arousal of an individual's thinking processes. He argued that to achieve liberation, it is critical to view learners as conscious beings and to replace education with real-world challenges to promote critical consciousness (Freire, 1972). This can be achieved with an education that helps to create a partnership between the teacher and learner instead of the teacher imparting (banking) information on the learner without empowering them to think critically (Cree, 2013). Therefore, the skills and knowledge acquired from the classroom should also enable learners to question themselves and the society they are in so that they can become active (intelligent) citizens.

The diversity of multicultural classes is on the rise (Roman & Ortega, 2019). This diversity is in the form of race, language, and economic status. As such, instead of creating barricades based on such learner diversity, classrooms should instead be able to create unifying environments (Roman & Ortega, 2019). Flory and McCaughtry (2011) developed the cultural relevance cycle, that included teachers' awareness and understanding of the community they are practising in, understanding the gap between the teachers' beliefs and the

learner's reality, and using IK to develop approaches that would close the gaps (Flory & McCaughtry, 2011; Roman & Ortega, 2019).

Summary of the Chapter

Theoretical frameworks help to support and ground studies. Researchers can use them to support their discussions and data analysis. The chosen theoretical frameworks for this study were based on social learning theories and include constructivism, border-crossing, collateral learning, situated learning and culturally relevant pedagogy.

Constructivists believe that people develop their realities (meanings) based on their lived-experiences. As such, the social development theory by Vygotsky theorizes that learners learn from the social interactions that they experience with more knowledgeable others (MKOs) such as teachers, parents, their peers, and even physical tools in society. Learners establish mental constructs after interacting with MKOs. Piaget's cognitive theory of development explains the changes that learners go through when they construct their mental realities. Assimilation is when learners align new information to their pre-existing knowledge while accommodation is when they change their mental constructs to accommodate the new information. Assimilation and accommodation are complementary processes that are kept consistent by equilibrium.

When Black learners go through the process of learning science, a subculture of western society, they cross cultural borders; a process that can be smooth, managed, hazardous, or impossible, depending on the type of support that they receive from teachers. Smooth border-crossing is when an indigenous learner's culture (knowledge) is consistent with the classroom science culture, while managed border-crossing is when the indigenous learner's culture varies from the classroom culture, and impossible border-crossing is when the learner's indigenous culture varies with classroom science to the point that it renders the process of border-crossing impossible. The collateral learning theory explains how

indigenous learners go through the border-crossing process, in other words, the conflicting cultural processes between classroom science and their IK culture when learning science. These processes exist in a continuum and include secure, parallel, and independent collateral learning.

Culturally responsive teaching is when teachers validate learner's cultural identities and in the process of teaching and learning, empower learners to be active citizens who question social inequalities. Instead of learning passively and taking in what the teacher teaches, they learn to use their skills to question certain attitudes and phenomena in society. Moreover, teachers can use indigenous learners' identities to affirm it so that learners are encouraged to excel academically.

Chapter Four

Research Method and Findings

In this Chapter, I discuss the research method I used in this study, the advantages and disadvantages, the research design and the instruments that were used for this study. Toward the end of the chapter, I discuss the data collection and research participants, data analysis and interpretation, the trustworthiness of the study, delimitations, ethical considerations for this study and end the section by providing a summary of the research method. In the section that follows after that, I discuss the research findings, where I present findings to the research questions mentioned in Chapter one. Thereafter, I present the challenges faced by teachers when integrating IKS into science classrooms and end the chapter with an integrated discussion. I then provide a summary of the research findings.

A research method is a comprehensive approach to a study; it includes the methods, design, data collection and analysis that the researcher used (Creswell & Creswell, 2017; Muza, 2014).

Research Methods

All research conducted has systematic approaches that aid researchers in answering questions through intensive in-depth investigations (Queirós et al., 2016). The type of data collected is dependent on the method that is used (Hancock et al., 2001). There are three types of methods that researchers can choose from when conducting studies: namely, quantitative, qualitative, and mixed methods (Creswell & Creswell, 2017).

Quantitative

Quantitative method is used to measure variations and predict relationships, (Mack et al., 2015), which allows a researcher to make generalized claims about a study population (Creswell, 2009). This method tests for objective theories by predicting relationships among variables through an experimental design (Creswell, 2009). Additionally, the goal of

quantitative research is to determine the effect of a treatment or intervention on a specific outcome while adjusting for all other variables that can affect the outcome (Creswell, 2009). The variables for this method are numerical and are measured using statistical processes (Mack et al., 2015; Neville, 2007). Researchers' approaches are hard to adapt since they sequentially collect data using identical closed-ended questions (Neville, 2007). Advantages of using similar close-ended questions include that participants give consistent responses from which meaningful comparisons can be established (Mack et al., 2015). Furthermore, the data collection process can be quick because researchers do not need to spend time in the study context before collecting data (Choy, 2014; Johnson & Onwuegbuzie, 2004). The disadvantage is that this method requires a large sample size and some factors that influence the research problem may not be meaningfully reducible to numerical data, these include beliefs, perceptions, and identities, therefore this method was not suitable for this study.

Mixed Method

Mixed method is a combination of qualitative and quantitative methods where the researcher believes that simultaneously using both methods yield more comprehensive results than when either method is used on its own (Creswell & Creswell, 2017). Johnson and Onwuegbuzie (2004) argued that the purpose of this approach is not to replace either of the qualitative or quantitative methods but rather to magnify the strengths of each and to decrease their weaknesses. In so doing, the method might yield more genuine findings (Cropley, 2015). Advantages of using this method include that the method might yield strong findings due to the convergence of the methods while disadvantages include that these methods could be expensive, time-consuming and might cause challenges to a researcher who attempts to undertake both methods simultaneously (Johnson & Onwuegbuzie, 2004). As such, this method was also not suitable for this study.

Qualitative

The main goal of qualitative research is to understand people's lived experiences because it focuses on the interpretation of social dynamics that cannot be quantified (Mack, 2005; Queirós et al.,2017). Consequently, qualitative research assesses social behaviour variables like beliefs and attitudes to fully comprehend what motivates people in society (Choy, 2014).

For this study, I engaged the qualitative method to be able to provide a thick description of the teachers' experiences of their awareness of IK and discuss what emanated from the follow-up interviews. I collected textual data from questionnaires, audio recordings and field notes to understand teachers' attitudes and believes towards the integration of IK(S) and classroom science. Advantages of the qualitative method are it enables researchers to look for hidden values and beliefs in peoples' lived experiences in the form of textual data (Choy, 2014; Mack et al., 2015) while allowing the researcher to ask probing questions (Creswell & Creswell, 2017). The disadvantage of this method is that data collection can be time-consuming (Choy, 2014). To overcome this challenge, meaningful relationships were formed with the participants after obtaining ethical clearance, to familiarise me with the study participants, who in turn were able to partake in the data collection process.

Research Design

Research design is a type of inquiry that provides specifications and directions of the procedures to be taken in a research process (Creswell & Creswell, 2017). There are several research designs that qualitative researchers can choose from when conducting a study. The common ones are narrative, phenomenological, grounded theory, ethnography, self-study, and case study (Creswell & Creswell, 2017). The next section presents the commonly used research designs in qualitative methods after which I describe the design that I believed was suitable for this study.

Narrative research is a design that examines the experiences of participants so that a story regarding their lives can be told (Creswell & Creswell, 2017; Polkinghorne, 2007). The main purpose of such a study design is to identify occurrences based on personal knowledge and subjective paradigms (Lester, 1999). Clandinin and Connelly (2000) defined a narrative design as a way of interpreting an experience through the formation of an alliance between the researcher and participant. The authors described temporality, sociality, and place as factors that distinguish this design from others because when using this design, these factors must all be inspected at the same time. Temporality is when the researcher is directed into the past, present, and future of the study participants while sociality is a combination of the participants' emotions and context that together form cultural, social, and linguistic accounts. The researcher is also involved in the study when exploring the social aspect of narrative inquiry. Lastly, place grounds the actual context where the study is taking place (Clandinin & Connelly, 2000). Narrative design is commonly associated with autobiographies and biographies (Moen, 2006); therefore, it was not suitable for this study.

Grounded theory is a design inquiry where the researcher develops theories grounded in the study participants' perspectives found in the data that is collected (Creswell & Creswell, 2017). Ethnographic design studies are when the researcher studies patterns of behaviour, actions, and languages of a cultural group over a long period in their natural setting (Creswell & Creswell, 2017; Reeves et al., 2008). This design was not suitable for this study because theories were not developed from the data collected. Furthermore, the current study did not take place over a long period.

A case study is a design where the researcher analyses events, programs, or processes (Creswell & Creswell, 2017). Such studies are conducted in their natural settings and are bound by time because they centre on a single representative of a group (Hancock & Algozzine, 2016). Case studies are classified as intrinsic, instrumental, or collective. An

intrinsic case study is when the researcher does not intend on generalizing findings while instrumental case studies are used to provide general explanations of phenomena based on a sequence of events (Harling, 2012). A collective case study attempts to convey an issue using several case studies (Hancock & Algozzine, 2016; Harling, 2012).

This study used the intrinsic case study design to investigate teachers' awareness of IKS and how teachers use this knowledge in teaching and learning sciences in their classrooms. The purpose of a case study is not to investigate a complete organization, but it narrows the study down to a feature or a group (Muza, 2014). Therefore, this study focused on a group of Physical Sciences as well as Life Sciences teachers who teach at the FET level. The advantage of a case study is that it enables readers to learn more about the phenomenon as opposed to presenting abstract concepts from literature (Cohen et al., 2002), therefore the present case study design was able to get in-depth data from the study participants.

Research Instruments

Research instruments are tools that researchers use to collect data so that they can answer research questions. To find the appropriate instruments to use for research, a researcher must read relevant materials regarding similar studies that have been done to find out the instruments used by other researchers (Hagan, 2014). The instruments that were used for this study were questionnaires and interviews.

Questionnaires

A survey is a research tool used to gather data on current phenomena to determine people's lived-experiences, values and beliefs (Janes, 2001; Jankowicz, 2000). Commonly used surveys are in the form of questionnaires, interviews, postal and telephone surveys (Leong & Austin, 2006). There are two forms of surveys: cross-sectional and longitudinal surveys (Mathers & Hunn, 2000). These authors (ibid) defined cross-sectional surveys as

those that are executed at one point in time while longitudinal surveys are carried out over some time.

Advantages of using surveys include the following: it is a method of collecting a large amount of data, surveys are cost-effective and easy to administer, they can be used to collect various types of data at the same time, such as attitudes and behaviours (Mathers & Hunn, 2000).

Questionnaires are written surveys that contain questions related to the study objectives. They can be self-administered or be administered by a trained administrator who will explain the study to participants and answer any questions the participants may have (Mathers & Hunn, 2000). This study used cross-sectional questionnaires that were administered to the participants by the researcher. Two different sets of questionnaires for the Life Sciences and Physical Sciences teachers were developed in line with the NCS/CAPS documents to gain an understanding of FET science teachers' IKS awareness and how they use it in teaching and learning (see Appendix G). These were validated by my supervisors

A limitation to the use of the survey instrument is that the questions asked are pre-determined; therefore, the participants cannot fully express their opinions as they can only answer questions that they are asked (Leong & Austin, 2006; Mathers & Hunn, 2000). To minimize this limitation, I followed up on the questionnaire responses from my study participants by using face-face and at a later stage, telephonic conversations with selected participants to ensure that they expressed the views that they were unable to express in the questionnaires. Additionally, extra space was provided on the questionnaire for the participants to elaborate their responses further.

Semi-structured interviews

Cohen et al. (2002) described an interview as a conversation between two people where the researcher asks the participants some questions that are related to the research

questions (Warren, 2002). The main aim is to obtain explanations and interpretations from the participants (Kvale, 1996). Researchers can extract meanings from what the participants say depending on the type of interview they choose.

There are unstructured, structured, and semi-structured interviews that a qualitative researcher can choose from depending on the research objectives of the study (Chilisa, 2011; Whiting, 2008). Unstructured interviews may begin with general questions related to the research questions then later topics listed in the interview guide are raised (Chilisa, 2011). Furthermore, interviewers are free to ask their questions in any order that is dependent on the responses they get from the participants. Structured interviews utilize the format of the questionnaire and may have close-ended questions and are mainly used for quantitative studies and participants with speech or language impairments. Semi-structured interviews involve open-ended, questions that are usually followed by other questions when clarity and further explanation is needed (Whiting, 2008).

Advantages of interviews include that they give the study participants opportunities to express themselves. They allow the researcher to observe the study participants and be able to write down field notes on information provided and any other observations that might contribute to answering the research questions. They also allow the researcher to ask for further explanations (Leong & Austin, 2006; Owens, 2002). Furthermore, Sanders and Mokuku (1994) asserted that the need for clarity is so that there are no mistakes regarding what is being asked.

Data Collection and Research Participants

The first home languages of the schools that participated in this study were isiZulu, Sesotho, and Setswana, while the language of learning and teaching (LOLT) was English. Five FET band teachers from three schools took part in this study. Pseudonyms of their choices were used to protect their identity: 1) Faith, 2) Anna, 3)Mbo, 4)Joe and 5) Lerato.

Later, three teachers Joe, Anna and Mbo took part in the interview session. However, Mbo was unable to have a follow-up discussion. Textual and audio data were collected. Textual data were collected using questionnaires. Questionnaires were reviewed with the participants before they are administered. Upon administering the questionnaires, I discussed a convenient time with the participants for me to collect them. During this time, data was also collected in my field notes.

Audio data were collected using audio recorders during the interviews (conversations). This took place after collecting the questionnaires back from the participants. Sample interview schedules were drawn to guide the face-to-face conversations as well as the responses from the questionnaires to guide the interview questions.

Audio data were collected through face-to-face conversations, as well as telephonic interviews. Follow up discussions took place during the Covid 19 pandemic after the Department of Education issued letters to stop face-to-face data collection (see Appendix B). As such, follow up conversations with the participants were done telephonically and recorded. Audio recordings of responses to both face-to-face and telephonic conversations were transcribed verbatim and sent back to participants through email for member-checking. The audio files and transcribed transcripts were also cross-checked with experts (my supervisors) for accuracy.

Data Analysis and Interpretation

Data from questionnaires, transcripts, as well as field notes, were analyzed using content analysis. Content analysis is the process of summarizing and organizing textual data as well as uncovering themes that represent appropriate interpretations used to answer research questions (Cohen et al., 2002; Flick, 2013). Hsieh and Shannon (2005) highlighted similarities and differences between three types of content analysis 1) conventional, 2) direct and 3) summative content analysis. The major difference between the approaches is the

method of code establishment (Hsieh & Shannon, 2005). Codes can be participants' thoughts, strategy codes, social structure codes, and event codes. They connect interesting attributes from data that can be examined concerning the research questions (Braun & Clarke, 2006; Cohen et al., 2002).

During conventional analysis, codes are extracted from the whole data set whereas with the direct approach analysis, codes are created beforehand using existing theories. When using the summative approach, codes are derived during data analysis using only part of the data set instead of the whole data set (Hsieh & Shannon, 2005). The advantage of the conventional analysis is that the researcher can gain a deeper understanding of the study phenomena (Hsieh & Shannon, 2005). A researcher can use direct analysis to validate and expand on existing theories (Hsieh & Shannon, 2005). Existing theories enable the researcher to focus on research questions; and they assist in predicting relationships between variables (Hsieh & Shannon, 2005). The summative analysis quantifies words to understand the context in which they are used by the participants (Hsieh & Shannon, 2005). This study used the conventional data analysis, where codes were extracted from the whole data that were collected.

There are six steps involved in the content analysis of data as described by Maguire and Delahunt (2017). (1) becoming familiar with data; (2) generating codes; (3) searching for themes in data; (4) reviewing and (5) defining themes and (6) final write up of the thesis. The first step entails going through the results a few times whilst taking down notes of any impressions that may arise. The second step involves generating the initial codes in a meaningful way. Zhang and Wildemuth, (2009) and Braun and Clarke (2006) defined themes as articulations of ideas that are in the forms of single words, phrases or paragraphs that exhibit patterns related to the research question. Developing themes in the third step involves arranging the codes into themes. Reviewing themes in the fourth step means arranging them

according to what they mean and their relevance to research questions. Defining themes involves identifying what the themes are about and how they relate to one another.

Content Analysis of the Questionnaire

This study used the software program MAXQDA to code the data. The reason for analysing participants' responses is to try to understand the underlying meaning of the words as used by the participants (Hsieh & Shannon, 2005).

Content analysis is a flexible method that analyses textual data by allocating consecutive parts of the raw data to categories using coding frames (Flick, 2013; Hsieh & Shannon, 2005). As such, the researcher needs to focus on aspects of the raw data that are relevant to the research question when building the coding frames (Flick, 2013). I created coding frames using data from the questionnaires. This process included selecting the appropriate material, producing, defining, and organizing codes into categories (Schreier, 2012). After generating the coding frames, I revised and augmented the results, went through the same steps again to remove irrelevant codes that did not apply to the research questions and finally generated themes that I used for data interpretation, discussion and write up (Schreier, 2012).

Content analysis of the Semi-Structured Interviews

Data analysis of the semi-structured interviews coincided with data collection because analysis started while I began conducting my interviews (Braun & Clarke, 2006; Sandelowski, 1995). Additionally, I took note of any evident patterns in my field notes that emerged from the interviews. This happened in between interviews.

As part of the initial analysis phase, data were transcribed verbatim from the audio recorder into written texts. I am a first language Setswana speaker, therefore translating some of the work was part of the transcription process. Although transcription is taxing (Braun & Clarke, 2006), it helped me become familiar with the data, which is part of the process of

analysis. I scrutinized the transcribed data set for plausible patterns before initializing the coding phase using MAXQDA (Braun & Clarke, 2006), as well as manually to cross-reference the results I was getting.

Following the coding phase, we discussed the results that I received from the process with my supervisors for validation. Thereafter I created themes by sorting and linking the various codes (Braun & Clarke, 2006). The themes I created are supported by direct excerpts from interview scripts (Flick, 2013). I fine-tuned the themes by re-analyzing the codes and the complete data set with my supervisors to ensure validity. During this process, a challenge that might have risen was the potential misunderstanding of codes which might have led to failure to create proper categories and themes (Hsieh & Shannon, 2005). To minimize these potential effects, I cross-checked the results with my supervisors and went through the process of creating the codes twice (Hsieh & Shannon, 2005; Lincoln & Guba, 1985). Additionally, after transcribing audio data, the scripts were given to the participants for them to go through as part of member-checking. For the discussion section, emerging themes from the questionnaires, interviews as well as field notes were compiled and used to answer the research questions.

Due to the large amount of data that researchers have when conducting interviews, one of the challenges they may face is its data management in terms of location and retrieval especially when folders contain hard and electronic copies (Flick, 2013). I minimized this by carefully naming, dating, and labelling data stored on hard copy files, field notes and questionnaires while storing the electronic files, audio-recorded interviews, and interview transcripts in password-protected files which only me and my supervisors have access to at the University of Witwatersrand.

Trustworthiness of the Study

Each study implements various evaluation criteria to warrant the rigour of the study; therefore, Anney (2014) contended that qualitative researchers can review credibility, dependability, and transferability as indicators for trustworthiness. For this study, I consider credibility as proposed by Lincoln and Guba (1985).

Credibility

Credibility is defined as confidence that is put in the results of a study as a representation of the social world establishment being investigated. It interrogates how well researchers' findings correspond with the participant's interpretations (Anney, 2014; Mertens, 2005; Zhang & Wildemuth, 2009). Anney (2014) proposed numerous credibility strategies such as member-checking and triangulation.

Triangulation is when the researcher uses more than one method to obtain study results (Anney, 2014). There are different ways one can triangulate; (a) investigator triangulation in which one uses different researchers to investigate the same problem, (b) data triangulation where one makes use of different research instruments to enhance the quality of data and lastly (c) methods triangulation where the investigator applies various research methods (Anney, 2014; Lincoln & Guba, 1985). These are the strategies that I considered in this study. I used data triangulation where data from questionnaires, transcribed scripts and field notes were triangulated in the process of data analysis. Also, I discussed my findings with my supervisors and triangulated data from the questionnaires, transcripts, as well as my field notes to ensure credibility.

Delimitations of the Study

The time that teachers took to return the filled questionnaires to me resulted in extension periods. I expected to receive the questionnaires back from teachers within a period of a week, however, some of them had not yet filled them by the time I had to collect them. This

resulted in more time allocated for data collection. For instance, the participants took an average of four weeks to complete the questionnaires. The original expected turn-around time was one week, however, I provided more extended time for the participants to complete their questionnaires and return them.

Some of the participants postponed the times we had agreed on for me to fetch the questionnaires. Because of the Covid-19 pandemic, I was no longer able to have face-to-face conversations with the participants, which influenced the available times they had for us to have follow up telephonic interviews. Since the study was conducted voluntarily, one of the participants pulled away during the final phases of data collection.

Ethical Considerations for this Study

Before the data collection process began, I sought the necessary permissions and approval to research the people in authority (Creswell, 2015). Permission to conduct the study was obtained from the Gauteng Department of Education (GDE) (see Appendix A) as well as the University of Witwatersrand Human Research Ethics Committee (non-medical) (see Appendix C). Full disclosure regarding the participants' anonymity and confidentiality was communicated to them (see Appendix E). before they signed a consent form (see Appendix F) and partaking in the study. Signed consent was also obtained from the principals in the various schools, permitting me to work with teachers in the schools (see Appendix C).

I ensured not to make unreasonable demands from the participants, as such their participation was based on informed consent that is free from pressure and where the potential risks, as well as benefits, which were communicated to them (Ritchie, Nicholls & Ormston, 2013). I also provided an information sheet for the participants to read before they completed their questionnaires. The purpose of the information sheet for the participants was to avoid deceit. Also, the consent form they signed had information of the person they can contact besides me and my supervisors in case of any concern.

The data that I collected using my instruments were kept safe in my supervisors' office until 2022. Thereafter the data will be destroyed.

Summary of the Research Method

In this chapter, I discussed research methods, research designs and how I gathered and analysed my data. Research methods are systematic approaches that researchers use to gather data and answer research questions. Three methods that I discussed in this chapter are qualitative, quantitative, and mixed methods. Qualitative methods enable researchers to gather textual data, the quantitative method gathers numerical data and are analysed using statistical programs while the mixed method gathers both qualitative and quantitative data. Research designs provide specifications of the procedures that take place during research. In this chapter, I have described narrative, grounded theory, ethnography and case studies as the commonly used designs in qualitative studies. This study used an instrumental case study approach to investigate teachers' IKS awareness because it provides general explanations of phenomena.

Research instruments are tools that researchers used to collect data. This study used a questionnaire and semi-structured interviews to gather textual and audio data respectively. Audio data was later transcribed verbatim. Furthermore, in between interviews I wrote down some field notes of my observations to add to my data. Questionnaires are surveys, which contain questions that relate to research questions. This study used a questionnaire based on the NCS/CAPS specifications to seek teachers' awareness of IKS. Five teachers participated in the first phase of data collection using questionnaires, while three participants partook in the semi-structured face-to-face conversations.

Semi-structured interviews are conversations between a researcher and study participants. They allow for questions to be asked in case more clarity is needed regarding the questions asked. Unstructured interviews may begin with general questions while questions

from structured interviews have an order that is followed. Semi-structured interviews have open-ended questions that are usually followed by other questions that might not be in the interview guide. This study used semi-structured interviews to obtain audio data from the participants.

Content analysis was used to analyse data. This involves going through data several times to become familiar with it, developing codes and themes from the data and using the developed themes to discuss findings. Data from the interviews were first transcribed from audio to text before codes could be developed, as well as themes, which were supported with excerpts from the interviews.

I have discussed how I ensured the trustworthiness of the study through credibility. This was done through member-checking and the help of my supervisors as well as the triangulation of data from field notes, interviews and questionnaire transcripts. Delimitations to this study included time extensions for collecting the questionnaires as well as a possible low participant number as the data was collected during the third term and follow up conversations were held during the Covid-19 Pandemic.

For this study, permission to conduct this research was sought from the Gauteng Department of Education (GDE) as well as the University of Witwatersrand Human Research Ethics Committee (non-medical).

Research Findings and Discussion

This section provides details on the results of this study. To provide a logical flow for the chapter, findings for the first research question are presented, followed by findings for the second research question. Given the opportunity to implore triangulation for the data, the results include responses generated from all methods of data collection. The responses are from questionnaires, interviews as well as field notes that were integrated and grouped into themes. Also, the results are integrated with some literature in the form of a discussion which answers the research questions that are outlined in chapter 1. The differences and similarities in these themes were analysed, with the help of the theoretical frameworks mentioned in chapter 3 where applicable, to answer and make sense of the research questions as described in the data analysis section in Chapter four.

Regarding the first research question about FET teachers' IK awareness (What awareness of IKS do FET science teachers have and how do they intend to use IKS in teaching and learning of Life and Physical sciences in peri-urban schools?), three themes emerged, namely that: 1) IKS has a cultural aspect and is context specific, 2) IKS has significant cultural practices and lastly, 3) the value of IKS. The third theme was an umbrella theme (Vaismoradi et al., 2016) that was divided further into subthemes as follows: 1) the bilateral validation of IK and classroom science, 2) the dialectical relationship between IKS and behaviour and lastly 3) IKS builds a sense of identity and belonging. The reason for subdividing an umbrella theme is that the subthemes reflect and share the central idea of the umbrella theme, however, each subtheme is focused on a unique aspect of the research question (Vaismoradi et al., 2016). Similarly, for the second research question (To what extent do FET science teachers integrate IKS into their teaching and learning?), three themes emerged from this. The first one was 1) Teachers' attitudes toward IKS integration in the science classrooms, 2) Teachers draw examples from their own IK for teaching in science

classrooms, and the last one was 3) How FET teachers integrate IKS into their teaching and learning of sciences in peri-urban schools. To analyse teachers attitudes toward integration, the first theme was further divided into three subthemes because it was also an umbrella theme: 1) How can IKS be used to alleviate poverty, 2) Teachers' understanding of the CAPS documents and finally, 3) Teachers' views toward IK integration.

After interpreting the results and discussion as well as the themes which emerged, the section goes on to present the challenges faced by teachers when integrating IKS into the science classrooms. They include 1) How to explain mechanisms of indigenous concepts as well as the secrecy associated with IKS, 2) Time management issues as well as 3) The lack of parental engagement. The chapter concludes with an integrated discussion of the results and a summary of the research findings. conclusion,

Research Question 1: What IKS Awareness and Understanding do FET Science Teachers Have?

Theme 1: IKS has a Cultural Aspect and is Context Specific

The theory of situated learning was used to analyse this theme. It posits that as knowledge is socially constructed within a particular community, over time, a collective mind which connects individual members of the group to the cognitive level develops (Boer et al., 2002). To put it another way, learning occurs most effectively within social cultures because it includes interactions between people who informally connect their prior experience (Fuller et al., 2005).

IK was described by Anna as knowledge that entails culture and traditional structures, while Mbo and Joe described it as knowledge that has developed in a specific context over time and is gained from the experience of members that belong to certain cultural groups. Similarly, Abah et al. (2015) described IK as knowledge gained through experiences and is limited to a specific community of people. Furthermore, Snively (2018b) added that because

of some communities' deep-rooted occupation, which has existed for thousands of years, indigenous people have profound attachments and identify with their ancestral land. They are connected by complex, socially formed webs of beliefs and values within their communities. These principles and values are important because they underpin indigenous peoples' social activities which shape worldviews (Brown et al., 2019). Because of this, Anna stated in her definition that IK can be used in the modern-day to understand how, during the early days, ancestors carried out some of their social activities.

According to Taylor and Cameron (2016), IK is currently used by communities because it has been passed down through generations for decades. These study participants defined IK as context-specific because it is influenced by the geographic and social factors that surround communities (Gupta, 2012; McInerney et al., 2011), however, in both his questionnaire and face to face responses, Mbo limited IK's presence to rural areas only. "That is my personal opinion, on people who are still living in a more rural area where they still have, they see these things and they see their elders still doing it." This statement contrasts with what Mafiri (2017), a North-West University IKS graduate who believes that IKS is everywhere, that we carry IKS with us regardless of our geographic location.

There are some common practices among cultural groups as well as differences in the way that they perform practices, depending on the environment in which they are located. An example was given by Joe of how different cultural groups have various ways of preparing vegetables referred to as *morogo*. He said that even though morogo is consumed by most indigenous communities in South Africa, due to the different geographical contexts, the methods of its preparations are not the same. For instance, the Northern Cape is hot and dry, while Limpopo has hot and wet seasons, these two regions have different climates, which in turn affect how local people prepare their morogo. This resonates with what Snively and

Williams (2016) put forward, that nature-related IK concepts and traditional ways of doing things should not be generalized because they are specific to geographic locations.

The teachers predominantly attributed IK to culture and tradition. Similarly, Nnadozie (2009) and Onwu and Mosimege (2004) argued that cultural and traditional practices are means of acquiring IK. The participants further regarded IKS as culturally specific knowledge that, because of customs, developed from a certain location. Also, this knowledge requires common practices that rely on the geographical position of a group, however, such knowledge cannot always be generalized, even though there are common practices within groups. From the situated learning theory, teachers gained their IKS as they participated, practised, and became closely involved in their cultural environment, where they appreciated its history, cultural values, as well as the laws that governed them as a community (Fenwick, 2000; Lave & Wenger, 1991).

Theme 2: IK has Significant Cultural Practices

In this theme, teachers attributed IK to cultural practices. The significance of cultural practices that form part of IKS was mentioned by Mbo. He said that he appreciates certain traditional ceremonies because they form part of his identity, even though he no longer lives in a rural region. He gave an example of *ho phahla* that is performed by members of his community to ask his ancestors to protect their children when they go to school, and when there are other significant occasions in the community such as a child going to university for the first time.

Anna, on the other hand, said that IKS is significant because it provides a sense of identity and belonging because of certain cultural practices such as the use of medicinal plants that exist in modern times. “Yes, it is. I do believe that it is important. Because as a person, you need to understand what tradition is, where it comes from because some of these things are still being practised today. We are still using *abomhlonyane* and these other home

remedies even today". Teachers who participated in a study by Jacob (2015) echoed similar concepts about the essence of cultural practices in IK. Some of the cultural practices such as ho phahla and the use of traditional medicine such as mhlonyane have a significant meaning to local communities because they are still being practised. Culture influences learners' academic achievements (Biescheuvel 1992; Jegede 1995), therefore academic performance is inseparable from its cultural milieu (in school and outside). Joe noted the value of indigenous learners' culture. He said that it is important to remember that teaching involves transferring western culture to Black learners who have their pre-existing knowledge and culture, something that should be taken into consideration.

> I think it is very very important because, at the end of the day, you must not forget that, in us trying to enculturate the western system of knowledge, we are doing that to the cultural people who have got their own way of doing things. So, knowing their background and indigenous knowledge system is very important in that sense. (Joe)

For teaching and learning science, the link between culture and cognition has been increasingly recognized by teachers and has clarified how cultural orientations and behaviours can be valuable tools for school learning (Seiler, 2018). Furthermore, an increasing body of work suggests that integrating cultural practices into learning contexts can contribute to greater involvement and enhanced learning for learners.

Theme 3: The Value of IK

The teachers stated that IK had, and still has value. The value of IK was divided into three subthemes: the bilateral validation of IK and classroom science, the dialectical relationship between IK and behaviour, as well as IK builds a sense of identity and belonging. These subthemes are discussed below.

Subtheme 1: The Bilateral Validation of IK and Classroom Science

In this sub-theme, Jegede (1995)'s collateral learning theory helps to explain how the concept of bilaterally validating IK using western methods can aid with the reduction of bias toward IK due to how western science is currently presented in classrooms. The belligerent manner in which science teaching and learning is applied in African classrooms gives the impression that the only credible way to learn science and the natural world is by using the Western worldview of nature, thus demonizing the IK worldview of indigenous learners as inferior and non-scientific (Jegede, 1995). As such, collateral learning describes how Black learners find a way to deal with science learning in an environment that is often vitriolic and not very accommodating to their IK.

From the interviews, Joe reiterated that IK is scientific and that western science methods can be used to validate IK and eventually minimize bias toward it. When bias toward indigenous learners' IK and their worldview diminishes, then both western ways of knowing as well as IK(S) might find a place in classroom science and make the process of collateral learning easier for indigenous learners to understand abstract scientific concepts. In line with this, Joe gave an example of how we can test soils that certain groups of indigenous people consume to supplement their diet, and further mentioned that these can be used as examples for the learners in class.

> That is science. If you look at that soil, it has got lots of minerals, consists of many many, your iron, we talk about vitamin B, B-plus, complex, and so forth. And that will help if you are in a classroom talking about homogenous and heterogeneous substances.
>
> We can also go and test it in the laboratory. And you will find out that it does consist of those irons. (Joe)

Ogunniyi (2015) supported what Joe stated above at a conference when he acknowledged the rich knowledge that indigenous people have about the importance of soil, thereby illustrating the depth of wisdom they possess. This supporting statement by Ogunniyi was irrespective of whether the latter wisdom had undergone rigorous scientific methods for validation or not. The validation of IK will ease the process of collateral learning for Black learners in the science classrooms because of the reduced conflict between the two knowledge systems, where IK will be accommodated.

On one hand, many scholars, such as Mosimege (2005), Mwadime (1999), and Ntsoane (2005), claim that it would be a mistake to subject IK to the same validation procedures as one normally does in western science. They also said that one should not look at IK through the same judgment lens as one does in classroom science because they are different knowledge systems and therefore require different validation processes. On the other hand, during the (National Research Foundation and Department: Briefings | PMG, 2004) Mr Nefolovhodwe concurred that the validation of IK ought to be a bilateral process, where IKS can be used to validate other knowledge systems and vice versa because he was concerned about only one method being validated in schools. In this case, by using western science processes such as laboratories to validate IKS, the expectation becomes reduced criticism toward IK and more acceptance so that broader focus may shift toward technological advancement using IK. For instance, targeted interventions such as in the field of technological advancement (Tharakan, 2015) using IK methods have produced positive outcomes. In Ghana, IKS has diverse impacts, where farming practices are influenced by local agricultural traditions that lead to high food productivity. Furthermore, Tharakan (ibid) stated that the production of indigenous vegetable cultivation in Uganda results in a high level of household food security as well as improved effective public health initiatives for

both Ghana and Uganda because of IKS integration into health practices like HIV treatment and management.

The implication is that if the two knowledge systems are held in the same regard, then there would be less criticism toward IK integration in the science classroom that already exists. Scholars such as Jegede have already affirmed the presence of wisdom and knowledge that exists in indigenous communities such as their knowledge of soils. Collateral learning is the process that African learners undergo in a classroom setting that is not quite responsive to their IK when trying to learn science through border-crossing. From this theme, if IKS could be validated using the rigorous processes found in western science, then perhaps collateral learning could be easier for the learners. Although other scholars such as Mosimege (2005), Mwadime (1999), and Ntsoane (2005) have argued that IK cannot undergo the same methods of validation because they are different knowledge systems, the Department of Science and Technology agreed that validation ought to be a bilateral process to try and minimize the bias toward IK in schools.

Perhaps IK should not be validated through the same western processes, nevertheless, there have been successful practical programmes where the incorporation of IK into certain practices has led to positive outcomes outside of schools. Examples include incorporating IK into farming practices in Ghana to increase food production as well as into public health practices like HIV treatment and management. Either way, incorporating IKS into procedures and practices does tend to have outcomes, as discussed below, and similar, if not better outcomes might be achieved in the teaching and learning of science classrooms.

Subtheme 2: The dialectical relationship between IKS and behaviour

The theory of social constructivism was used in this subtheme to show how society has an impact on learned behaviour. Cultural practices as tools can shape how a person behaves. These cultural tools include language, belief, and traditions to name a few (Vygotsky, 1978).

As one of their definitions of IK, the teachers mentioned that IK is valuable in terms of the cultural practices in certain communities because the practices impact how people in communities behave. For Piaget, knowledge building by an individual takes place when information is deliberately assimilated and incorporated into prior knowledge (Jones & Araje, 2002). However, as the founder of the social constructivist learning theory, Vygotsky puts more emphasis on the social environment (Tudge & Scrimsher, 2003 cited by Schunk, 2012). He claims that without the intermediary of tools, humans cannot function in the physical world. In this context, these tools are cultural practices such as virginity testing which allow the Zulu communities to teach sex education, thereby impacting their youth's sexual behaviour. During our discussion, Joe remarked that IKS has societal value, in which it enhances cultural awareness by influencing behaviours in given communities. He said that there are cultural practices that help to shape peoples' behaviours positively, such as virginity testing (*ukuhlola ubuntombi*) for young women in the Zulu culture.

> If we were to stick to our common cultural practices, where the younger ones will respect the older ones, where the younger ones will not indulge in sexual activity until they have reached this age, you know, where maybe like the Zulus are doing. They go to this Zulu dance where they are being checked if they have broken their virginity or they are still virgins, and so forth. (Joe)

Such traditions have been reported as part of Zulu traditional sex education and solutions to the spread of the Human Immune Deficiency Syndrome/Acquired Immuno Deficiency Syndrome (HIV/AIDS) infections, premature death, and reducing pregnancy rates within the Zulu youth communities (Nyawose, 2013). Furthermore, because spirituality is part of IKS (Cameron, 2007; Dei, 2011; Khupe, 2014), during such ceremonies, traditional healers were recorded to petition ancestors to protect the young girls against HIV/AIDS infections, Gender-Based Violence (GBV) and teenage pregnancy (Ntuli, 2018; Phiri, 2001).

IKS holds value to Joe, knowledge like this is crucial to the unveiling of which concepts learners are familiar with that can be used in the science classroom. These are the tools Vygotsky mentioned that govern the cognitive process of learning (Shabani et al., 2010). Vygotsky (1987) emphasized that the most significant aspect of a learner's psychological growth is social contact with cultural objects, where language, customs, values, arts, and science are all examples of cultural tools or artefacts (Cole, 1997; Vygotsky, 1987).

Based on Vygotsky's theory if we can understand such tools, that mediate cultural practices, then we can understand the mental processes which govern them (Adam, 2017). What is still a matter of debate is how to make prior knowledge such as this, educationally profitable (Haenen et al., 2003) and how to access this knowledge base from the teachers, for the teaching and learning of science concepts.

Subtheme 3: IKS builds a sense of identity and belonging

The theory of Culturally Responsive Pedagogy (CRP) is used to explain this theme, where teachers stated that identity is part of IK and that it enhances a sense of belonging. CRP is defined as teaching practices that address the different cultural characteristics which distinguish learners from each other and the teacher (Rychly & Graves, 2012). When teachers are cognizant of their cultural identity and can acknowledge their learners' cultural backgrounds as they engage in teaching and learning sciences, they become culturally responsive teachers. This is because they can empower learners intellectually, politically, and socially (Brown et al., 2019; Silva-Peña & Peña-Sandoval, 2019).

Identity is defined in a particular sense by who we have been in the past, who we are now at any given moment, and the possibilities of who we might become (Tschida, 2009). Also, a significant part of identity formation includes putting into action the thoughts, values, and feelings that one has. Mbo mentioned that since his cultural identity is embedded in IK, he cannot separate himself from IK. "Ya, I think it is very important to me. In a sense that it

is how I, how my identity is embedded there. I can't separate myself from there." Sherperd et al. (2018) asserted that when one is comfortable with their cultural identity, they have a sense of community, purpose, and self-worth, which is often a product of being attached to a cultural group through sharing culture and belief systems.

The concept of identity goes beyond beliefs or knowledge because it involves emotional and psychological aspects that derive from being attached to a group (Berry,1994). This means that once culturally secure, then indigenous people will appreciate their practices and be able to take part in indigenous technologic advancement (Mawere, 2015) that are passed on from generation to generation. In line with this, Anna said that the probability of continuing with practices that ancestors performed increases once people have grasped their cultural identity and traditional practices. This is because this knowledge is indigenous to that group of people, which contributes to their identity. She gave an example of medicinal plants such as umhlonyane currently used by indigenous people to treat a variety of illnesses that range from menstrual cramps, gastrointestinal and respiratory disorders, as well as asthma (Health-e News, 2020).

> Yes, it is. I do believe [that] it is important. Because as a person you need to understand what tradition is, where it comes from because some of these things are still being practised today. We are still using abomhlonyane and these other home remedies even today. Only because our grandparents and all these other people understand their uses, they understand where they are coming from, and that is why they are still being used today. So, you can also continue using it with your family because you understand its' origin, you understand how to use it. As opposed to them now continuing a tradition where no one knows why it was done, the reason behind it and how it was supposed to be carried out. (Anna)

Similarly, Joe also implied that in certain instances, because cultural identity is not well-founded among indigenous groups, it follows those indigenous practices are not well understood and as such, are not being used to advance our ancestral technology such as for medicinal purposes.

> You see, if you go to China, the Chinese, stick to their own ways of doing things. I am one person who has realized that oh! It is because we tend to look down upon our own ways of doing things. That is the reason why we are underdeveloped. That is the reason why even our own medicine is not working for us is that we have to wait for the western authorities to approve any medicinal developments that we might have. Look at amid this Covid19, we have got a country that came up with a solution that is within the rest of Africa, but what are we doing…(Joe)

This would make sense because Maunganidze (2016) opined that throughout many regions of the world, the transmission of IK and practices to the next generation is at risk given that new knowledge is constantly introduced, adapted, and altered IKS are becoming more complex (Marie, 2019). In addition to the lack of IK documentation, the IK located with the elderly is slowly fading with them as they die off (Riffel, 2020). For instance, according to Joe, his children do not speak their traditional dialect as fluently as he does because they were brought up in a city "The Tsonga that they talk speak is not the exact Tsonga language that I grew up speaking because they grew up in a city." This statement supports the assumption that as IK evolves, some traditional practices will not be well understood by the younger generations.

Knowing and understanding one's identity helps to build a sense of belonging. Therefore, teachers need to provide opportunities that will help students build and understand their cultural structure and make sure that they feel like part of the community in the

classroom (Brockway, 2005). Furthermore, as cultural mediators, teachers provide students with opportunities to participate in constructive discourse about intercultural differences and to explore contradictions between conventional cultural values and experiences in various cultural systems (Gay, 2018).

Joe suggested that if western science methodologies can be used to validate the IK science that learners bring, then learners will feel that their cultures are validated and respected. Teachers who are cognisant of learners' cultural backgrounds are culturally responsive, provided that they use this knowledge to empower their learners beyond the walls of the classrooms. Bilateral validation of IK using western processes might help harness culturally responsive teachers by tapping into the IK they already have and helping them to recognize and saddle it in their learners.

Indigenous cultural practices can influence peoples' behaviour positively, such as virginity testing in the Zulu community which is part of the solutions for reducing the spread of HIV/AIDS infections, teenage pregnancy as well as GBV. Also, IKS helps to build a sense of identity and belonging because one's identity is embedded in one's culture and belief systems.

Research Question 2: To What Extent Do FET Teachers Integrate IKS In their Teaching and Learning of Life and Physical Sciences Within Peri-Urban Schools?

To understand the extent to which FET teachers integrate IKS in their science teaching and learning, their attitudes, thereafter their sources of IK were analysed. Three themes emerged from this. 1) Teachers' attitudes toward IKS integration in the science classrooms, 2) Teachers draw from their own IK for teaching models and examples in science classrooms and 3) How FET teachers integrate IKS into their teaching and learning of sciences in peri-urban schools. In an attempt to analyse teachers attitudes toward integration, the first theme was an umbrella theme that was further divided into three subthemes: 1) How

can IKS be used to alleviate poverty, 2) Teachers' understanding of the CAPS documents and finally 3) Their views toward IK integration.

Because CAPS recommends the integration of IK concepts into sciences, their understanding of CAPS, as well as their views toward IK integration were looked at to further understand the extent to which they use IK in teaching and learning sciences.

Theme 1: Teachers' attitudes toward IKS integration in the science classrooms

To understand the extent to which FET teachers integrate IK into their teaching and learning, it was important to understand their attitude towards 1) the IK-related statement from the policy document which recommends the use of IK in science classrooms, and 2) the use of IK beyond the classroom, such as to alleviate societal issues.

Subtheme 1: Teachers' understanding of the CAPS document

The participants were probed about their knowledge of the CAPS documents and IKS-related statements from the documents. Mbo mentioned that the statement is better understood from an indigenous perspective provided that the relevant IK is available to explain relevant scientific topics "This curriculum can be profoundly understood if it acknowledges and proceed from native's IKS version of the subject under discussion [if this IKS version is available]". Other teachers like Joe said that it is a revised policy document that assists teachers with weekly teaching plans:

> The Curriculum and Assessment Policy Statement is a revisor of the previous NCS if gives us educators detailed guidelines of what to teach and assess on each grade and each subject. It gives detailed weekly planning for us educators to follow. (Joe)

Lastly, Faith stated that IK is relevant for Physics and Chemistry and can be linked to the South African heritage. Faith illustrated this with the use of cabbage that is used by indigenous people for making tea. She said that this can be linked to classroom science to

demonstrate indicators when teaching.

> IKS is mostly relevant in Chemistry and in Physical Science. It can be linked to SA heritage. It can be recognised in the food we eat and the household chemicals we use. For example, we look at red cabbage, indicators, for example, red cabbage, creation of green tea, it can be made in big factories where they mix ingredients, while in the rural areas they still make their own tea by collecting certain leaves (from different trees)- the result is herbal tea. Both green tea and homemade herbal tea fulfil the same purpose... (Faith)

Lerato and Anna gave different explanations for their understanding of the statement. Anna mentioned the use of history when teaching but did not elaborate further on the kind of history, while Lerato mentioned culture as part of IK that should be used in her learners' teaching and learning experiences. "I should integrate indigenous knowledge during my teaching. And it should form part of the basic learning and teaching experience. Therefore, as South Africans, we should value each other's culture. "Anna went further and said that "What I understand is that history is important and that it should be considered in the teaching and learning of Life Sciences. The African history should be acknowledged."

From their responses, teachers gave different explanations of their understanding of the IK-related statement in the CAPS documents. They understood it to be a teaching plan that should be used in their classrooms while incorporating their learners' IK. With this, another question regarding the importance of IK in alleviating some of the challenges facing society was asked to the teachers because according to the science CAPS documents, "…globally organizations struggle to find solutions to important issues such as hunger, poverty and underdevelopment.". The teacher's responses were analysed in the section that follows.

Subtheme 2: How IKS can be used to alleviate challenges facing society

The use of IK by indigenous communities to generate income is not a new one. For instance, poor," unskilled" elderly women in South Africa depend on IK-based technologies for the development of crafts that form a key part of household cash income (Mudemba et al., 2020). Their manufacture of baskets, mats, strainers, brushes, and decorative pieces made for tourist markets are examples of these (Adam & Shackleton, 2016). Furthermore, rural women in the Eastern Cape Province have relied on IK to overcome livelihood problems over the years (Garutsa & Nekhwevha 2018; Mudemba et al., 2020). Even though poverty has multi-dimensional patterns, poverty levels are mostly calculated using income and consumption-based economic dimensions. As such, the handicraft industry is estimated to contribute approximately R3 billion to South Africa's Gross Domestic Product (GDP) and the sector employs close to 3,00,000 people (The Department of Trade and Industry, 2013).

One of the questions asked to the participants was about the CAPS documents regarding how IKS is used to address challenges facing society such as hunger, poverty, and underdevelopment (Department of Basic Education, 2011, pg.8). Faith, Mbo and Joe agreed that IK can be used to help alleviate such issues, and Joe and Anna further gave examples of how this could be achieved. Joe said that if IK-based solutions can be integrated into society, then issues such as poverty could be alleviated. He gave an example of how dried crops could be used as fertilizers to contribute to food production instead of being burnt.

Faith mentioned that incorporating IK into teaching and learning can trigger learners' curiosity and innovation such as creating alternative solar systems or using cattle dung as alternatives in the absence of electricity. Mwantimwa (2008) agreed that incorporating IK principles into science classrooms would make students feel in charge of the skills they bring to learning environments, leading to yet more innovation. In Pedagogy of the Oppressed

(Friere, 1970), Friere suggested that enabling learners to have control of their knowledge is equal to respecting their culture, tradition, and identity.

If the teachers acknowledged the importance and relevance of IK in their learners' daily experiences as well as in the CAPS documents, it follows that they have a positive attitude toward the integration of IK into science teaching and learning, which meant that the likelihood of them integrating IK into their science classrooms would be high. As such, their views toward IK integration were analysed in the section that follows.

Subtheme 3: Teachers' views toward IK Integration

Teachers' views about integrating IK concepts into science learning are important because they will help to know if teachers are open to using IK when teaching in their science classrooms. When asked about their views on the integration of IK into science teaching and learning, Lerato said that IK can help learners understand science better because it is evidence-based and therefore more practical. Furthermore, from the interviews, all the FET teachers acknowledged the existence of IKS and the value that the integration of IK concepts might have on their teaching and learning in science classrooms. Joe said that he uses IK concepts to make learning more accessible to his learners and gave an illustration of how he does this on a typical day of teaching. He said he first introduces a topic, then allows learners to explain and discuss their understanding of it, thereafter he proceeds to build on what they said.

> That one will come after I have introduced that particular topic. For most of the learners, I will just draw into most of the learners' main understanding of a scientific concept; then, each one will bring forward their own understanding. (Joe)

Shizha (2008) is of the view that teachers' attitudes, beliefs, or the lack of the Nature of Indigenous Knowledge (NOIKS) will influence their teaching and learning practices in

science classrooms. This holds for both Anna and Mbo's cases. Anna and Mbo appreciated the value that the integration of IK concepts in teaching and learning can bring, however, their attitudes toward integration varied. Even after Anna admitted her lack of the NOIK, this "belief" affects her attitude toward IK integration into science teaching and learning positively, which was the opposite case for Mbo.

Anna mentioned that although integrating IK into her teaching and learning gives her extra work on top of what she already has, she continues to do research on IK related to the topics in her Life Sciences class. This is because she realized that all her Life Sciences subjects have topics with elements of IK. In her initial responses, she said that IK might help learners learn science better because learners would be more involved in discovering and building their knowledge base. "It can potentially help learners learn science better. Learners will have an interest in learning science as they will be more involved in discovering knowledge and building knowledge". She further said that "Learners need to be made aware of the different worldviews by including African history and the philosophy of science and the development of the worldview in each of the topics in Life Science.", however, she also pointed out her reservations regarding her limited IK which made her less confident about integrating IK concepts in her class but does not stop her from attempting to. She simultaneously appreciated that learners bring knowledge from home, which she uses to explain classroom science concepts to them. Inevitably, meaningful teaching and learning in the science classroom depend on the teacher's ability to supplement teaching materials (Snively, 2018a) as well as their creativity in using IK to make science meaningful to their learners.

> I am not so confident, to be honest. It is only some things that I have recently looked into to say ok, there is this IKS thing because I am supposed to tackle it when I go into the classroom. So, I started looking into it

> now to say how do I then tackle this IKS because honestly if you look at it, it is throughout everything that we do in Biology.
>
> But I feel like mina [me] it is nicer to give learners information, interesting information about the origins of where that particular thing came from. They come with some level of knowledge from home. They know what they know from home. So how can we use what they already know to try and explain certain scientific concepts, which is what you have been saying to me, you spoke about cloning, you spoke about fermentation, you spoke about umhlonyane as well to say ok fine, this is how you understand it, this is the very same thing is what I am trying to explain to you scientifically. (Anna)

Finally, Mbo who has more than 10 years of teaching experience, made it clear that he has always taught classroom science in a western manner because he has never been exposed to the possibility of integrating IKS into his teaching and learning until he did his postgraduate studies. Nevertheless, he believes that IK only exists in the rural areas and that there is no space for it to be incorporated in the township school that he teaches in. “I was born, bred and experienced an urban way of life in a South African township known as [township name]. Given my urban life background, I am not conversant with my folk’s IK”. This resonates with what Taylor and Cameron (2016) said that some educators are of the view that there is no space for IK in science teaching and learning. Moreover, it is extremely challenging for some teachers with many years of teaching experience to teach IK because it is considered 'taboo' (De Beer & Mothwa, 2013).

> On an issue *ya* (of) how have I been teaching; I have always taught according to Western ways and knowledge. I never, I only met the issues *tsa* (of) indigenous knowledge when I was doing post-graduate *mo di* (in) honours

> and all of that because you have to be aware that I started taking teachers' diploma certificate first, er, advanced certificate, and then part-time I did my honours, and then my masters. I only got the awareness of indigenous knowledge when I was doing my postgraduate degrees.
>
> So, I will say I don't know much about indigenous knowledge, even if when I try to imagine incorporating it into my teaching, I find that I will be found wanting quite a lot. Because I am also born here in [this township] in an urban area, I have never encountered any rural kind of life and cultural way of living here in [this township]. (Mbo)

Mbo mentioned that he is not conversant with his parents' IK. This could be because he either is not aware of the NOIKS, (Jacobs, 2015) due to the exposure he got from his basic schooling days. However, he mentioned that he got exposure to IK during his postgraduate studies, although he did not make any further mention on this, he continued to emphasise that he would not be able to integrate IK into his teaching and learning.

Seehawer (2018) stated that teachers' attitudes toward integrating IK into their teaching and learning are influenced by their exposure from early school days as well as at higher learning institutions. Ogunniyi (2007) is of the same view, that teachers who are against IK integration into science teaching and learning might be because they are more familiar with the Eurocentric worldview in which they were schooled. Barcelos (2013) added that the belief that western science is absolute and superior to all other forms of knowledge is a form of colonial persuasion, even if it is not as intentional as privilege, which everything else is measured against, has been normalized. Finally, this might be influenced by the "faulty" positivist methods of intelligence measurements, where teachers that hold and value Western worldviews above as more intelligent than others (Kincheloe & Steinberg, 2008).

The teachers had positive views about the integration of IK into science classrooms. Lerato said that IK is evidence-based, while Joe, although not explicitly, does integrate IK concepts into his teaching and learning, simultaneously helping his learners to border-cross into the culture of science by using their prior knowledge to explain abstract scientific concepts to them. Anna and Mbo acknowledged their lack of NOIKS, while Anna embraced the presence of IK in the topics that she teaches in her science class. On the other hand, Mbo continues to teach exclusively in western ways without integrating IK concepts because of his views toward IK integration. Mbo had the most teaching experience in teaching and only recently got exposure to IK integration in classroom science in his postgraduate studies. The following themes will describe the IK examples that teachers use in their science classrooms to teach their learners.

Theme 2: Teachers draw examples from their own IK knowledge for teaching in science classrooms.

The NCS/CAPS 2011 documents recommend the use of IKS in teaching and learning science but do not give specific examples of what is to be taught and how it is to be used to explain abstract scientific concepts to learners. This theme, as well as the next one, will explore the IK ideas and examples that FET science teachers use in their classrooms, as well as how they integrate them for their learners. This section will start by exploring some IK concepts that are used in Alaska, where IK curricula have been set by the government in learning institutions. After this, the section will identify which examples and concepts the study participants use in their classroom science teaching and learning. The theories of border-crossing and situated learning will be used as lenses to analyse this theme.

Outside South Africa, there are some examples of how government institutions have incorporated IKS into their school curricula. For instance, to ensure the integration of IKS into the science curriculum, the Alaskan government sponsored the “Alaska Native Science

Camps and Fairs" whereby learners worked hand in hand with the local community elders to search for topics that could be used to develop projects that exhibit science in the everyday lives of learners (Barnhardt, 2007). This is echoed by Zidny et al. (2020) that the process of learning science should be based on situations from the daily lives of learners and their situations so that they can value the relevance of science in their daily lives. Elders in Minto helped identify 72 applications of the birch tree, which aided learners to test scientific principles rooted in local knowledge. Furthermore, the Handbook for Culturally Responsive Science Curriculum, among the plethora of available materials provides practical information and examples of how to integrate indigenous knowledge into science teaching, learning and assessment (Barnhardt, 2007).

Back home in South Africa, similar attempts have been initiated, where education policies direct teachers to use IKS in their teaching and learning. For instance, although not the same as the Alaskan topics, according to Taylor and Cameron (2016), the physics section of the Grade 10–12 CAPS have the following IK as examples that science teachers can use in their classroom: the making of fire using friction and the use of clay pots to preserve food and water through the process of cooling. Using the illustration of clay pots, in this study, Joe mentioned that he can/uses an example of how clay pots minimize the bacterial activity of foods like milk to keep it fresh for longer. He mentioned that because the mud was used by indigenous communities to cool down fluids like milk, this was a concept that he used to help his learners border-cross and teach them the concept of conductivity. Also, the grass on thatched huts can be used to explain the concept of conductivity to his learners. In this example, he said that the huts remain cooler inside than outside because the grass used for roofing does not conduct electricity.

> Conductivity! Like mud, *akere* (is not it) in those days. What they would do, Uhm is, they would keep things like milk, say milk, uhm, they will

> dig it underground, in a pot, like that to keep it for a long period. It would stay fresh for a long time. Remember that bacterial activity is minimized when the temperature is very, very low. So, they will keep, that milk will be fresh for a very long period.
>
> Traditional huts could be used in explaining concepts like conductivity. On hot summer days, these huts are always cold inside because the grass does not conduct heat. So, during summer this our parents find comfort shelter inside the huts than in modern houses. (Joe)

The process of smooth border-crossing occurs when a learners' indigenous culture is consistent with that of the science classroom (Aikenhead, 1996; Fakudze, 2004). The implication is that when learners perceive similarities in their prior knowledge with what is being taught in class, the likelihood of them understanding the science concepts and constructing their own knowledge increases.

Joe gave other examples that learners are familiar with and make use of in their daily lives such as *amasonja* and morogo that are consumed across most cultures, and mentioned *Bovu*, used for sunscreen.

> The food, they carry to school include traditional vegetables like morogo and some of them even carry amasonja which is a delicacy for many people in Botswana and Limpopo. It is very nutritious in protein. The use of Bovu which is used to keep skin light and act as sunscreen is another way of the importance of IK. (Joe)

Taylor and Cameron (2016) noted that the IK examples mentioned in CAPS are guidelines and not necessarily science content. This is turn makes it challenging for teachers to position IK with classroom science. Also, Mbo said that because IKS is not included as

part of the Grade 12 Physical Sciences examinations, it makes it more difficult for the teachers to integrate into the class. “In Grade 12 we are not doing that. So, you see that can only be done as research by the learners to come and present in class. And then we look into how they present the facts, and we use a rubric to grade them. But we will always emphasise that this is not for examination purposes”.

From the interviews, Anna and Joe made an example of how they use the process of making *umqombothi* related to fermentation more accessible to learners. Anna mentioned that the way the South African Breweries (SAB) make beer is an advanced process of making traditional umqombothi. The Life Sciences textbook refers to the process of making umqombothi as “traditional biotechnology” and mentions how indigenous methods are still of interest in the scientific community (Beckett, 2012).

Anna also mentioned that she would use the topic of cloning to incorporate IK into her teaching and learning because it is a topic that she teaches in her Life Sciences classes that raises numerous questions from her learners. The reason for this might be because it involves the spiritual dimension of IK. After all, her learners felt that their ancestors were able to provide food without “playing God”.

> So, when we teach about cloning, it goes back to IKS in the sense that there are people who believe in God, there are people who believe in ancestors, and you need to tackle all of that with your learners and tell them *ukuthi* (that) when we look into genetically modified things, we are not trying to play God or trying to play our ancestors, but we are looking at it from a point of science and how this science has helped to keep a lot of people to have food, to ensure that when there is drought, there is enough food. (Anna)

Ogunniyi (1988) found in the study involving Nigerian junior secondary school learners that the way learners perceive biological concepts is highly influenced by their

religious beliefs (Mavuru & Ramnarain, 2020). Moreover, even if the spiritual aspect included in explanations for IKS conflicts with the scientific form of knowledge (Zinyeka et al., 2016), it cannot be ignored in the science classroom (Mavuru & Ramnarain, 2020). A study by Fleming (2004) found similar objections by indigenous communities toward Genetically Modified Organisms (GMOs) as the ones stated by Anna's learners. From the study, a wide range of adversaries expressed their discontent saying that during genetic modifications, when scientists mixed genes, they were playing God and interfering with nature. As such, when integrating IK into such topics, a teacher would have to ensure that learners engage effectively with the science regarding cloning in such a way that they construct knowledge from these epistemologically conflicting concepts into their long-term memory (Aikenhead & Jegede, 1999). In this case, for learners to have a meaningful learning experience, these conflicts would have to be resolved.

Joe said that he would use knowledge regarding the *Mvuba* tree when discussing acids and bases in his classroom.

> You know during the olden days, uhm, when this; what is this one, the African people suffer from; excess acid, which causes the heartburn? Ya! They will just take a leaf of a certain tree called Mvuba, in Tsonga. They would boil it and cook it. And then drink the water.
>
> And in that tree, when you investigate further; you will find that, somehow, it's [it is] rich in compounds like bo ma [the] Magnesium hydroxide. You see, now, it starts to neutralize the excessive [excess] acid in the body. (Joe)

The concept of using naturally occurring acids and bases is echoed in the Grade 11 Physical Sciences textbook where learners are encouraged to research acids and bases that are found mostly in plants; they are further encouraged to include where the plant occurs as well

as the indigenous uses of the plant and their chemical composition thereof (Horner & Williams, 2012).

Furthermore, Joe said that he uses IK to explain the concept of work in his class. The definition of work on page 220 of the Grade 12 Physical Sciences textbook is "When a force acts in or against the direction of motion of an object, work is done on the object". It goes further to give an example of weightlifting, which is similar to how Joe made use of it to identify any misinterpretations that are introduced by the daily use of the word "work".

> For example, say I am introducing the concept of work, *kwa* [in] grade 12. Work, as they know it, most learners will tell you *work ke mosebetsi* [it is work]. Work, ke *mobereko* [it is work]. Do you understand that? Ya, ke mobereko [it is work]. Once these learners have brought up one or two things, based on their own cultural knowledge, learning becomes a lot easier because each of them has given me how each one understands the concept of work according to their own belief. Many of them then, become interested in the topic. (Joe*)*

Another teacher, Mbo mentioned the brewing of African beer as well as the causes of lightning as examples that he could use in his science classroom. He further said that the definition/description of lightning versus his learners' understanding of the concept is one of the topics that comes up when he teaches. In such an instance, Keane (2008) explained that science teachers can explain how lightning works, but not why a particular person would get struck by it and not the person next to him. This adds to the notion of teachers' reluctance to use IK concepts because school textbooks do not present IK knowledge enough for teachers to incorporate and make science more accessible to their learners. Also, that teacher training has not been given as much attention as the curriculum change.

This does not mean that examples of IK that can be used by teachers in science class

do not exist. For instance, the oral tradition of lightning protection has been followed by indigenous people living in areas vulnerable to lightning. Cameron (2019) published a study that provided a scientific justification for the indigenous belief that Lavender trees are associated with lightning. She said that the air would be saturated with electricity on hot summer days in Nelspruit, which would induce a zigzag glow before lighting struck on the leaves of the Lavender trees. These motions led the indigenous people in that region to equate lightning with a serpent moving through the sky. Such an example can be used by teachers to offer an alternative way for the epistemological conflicts that may arise in class regarding the concept of lighting.

This theme illustrated that teachers have IK examples that they can use to explain abstract science concepts to their learners. The Alaskan government managed to integrate IK into their learning institutions by involving local elders to give their knowledge about situations and examples that are relevant to learners' lived-experiences. This in turn has made learning a meaningful experience for learners.

In South Africa, given that teachers have not been given a model to follow when incorporating IK (Semali, 1999) into their teaching and learning, it is clear from the above that they use their experiential IK to help explain certain western science concepts to their learners. Examples such as using mud and grass to explain the concept of conductivity, cabbage leaves to illustrate how indicators work when making herbal tea, food such as Masonja, bovu for sunscreen, the brewing of umqombothi to illustrate the process of fermentation, the alignment of conflicting concepts such as cloning for food production, mvuba to illustrate acids and bases, work and lightning have been discussed by the teachers in this study. The teachers have not only shown that they have numerous IK concepts and examples, but they also gave topics in science into which these examples can be integrated into.

Theme 3: How FET teachers integrate IKS into their teaching and learning of sciences in peri-urban schools.

Teaching methods include activities and processes that describe instructional techniques that teachers use to enable learning in their classrooms (Mnkandla 1996; Mudzamiri 2019). Mudzamiri (2019) is of the view that teaching and learning should make use of IK to ease the process of learning sciences for learners with different cultural backgrounds. As such, the teachers interviewed in this study all agreed that effective worthwhile teaching involves tapping into learners' previous knowledge and using it to facilitate their learning processes. For instance, prior knowledge might be in the form of ideas, concepts, and evidence from their lived-experiences, as well as traditional artefacts (Holliday, 2000; Fakoyede & Otulaja, 2019; Mudzamiri, 2019). However, such demonstrations and teaching materials should be context-based and should fit within the local community because there is little value in teaching while using knowledge and artefacts found in America or the United Kingdom which are foreign to the learners' environments (Jacobs, 2015; Mudzamiri, 2019).

Faith and Lerato stated the importance of practicals when incorporating IK into teaching and learning science, however, their methods varied. Faith said that she could perform practicals in class through demonstrations to explore the boiling of herbs for classroom concepts such as acids and bases. "We can make sure we engage learners in practicals …" and "We can allow different herbs to be boiled by the learners to test whether the results (products) are acidic or basic. Allowing the learners to link this application to all the products they use at home daily." Perhaps one of the interesting findings from this is that Faith later mentioned that she could demonstrate IK concepts in her science classroom by taking her learners to the cradle of humankind when teaching the topic of evolution. "I can use practical teaching method most of my lesson is presented with evidence of ancient

inventions…For human evolution, I can take them to the cradle of humankind." What Faith said contrasts with Henning and De Beer (2010)'s finding that teachers avoid integrating IK into evolution topics and IK. "The learners shall be provided with a background understanding of science and how it said to have its roots in African cultures. Both science and indigenous knowledge is based/rooted in evidence." Faith based her statement on her belief that science has roots in African culture and is evidence-based.

When asked how they integrate IK into his classroom, Joe and Anna mentioned that they would first introduce a topic and then listen to how learners interpret the topic, then later explain the topic using knowledge and explanations that learners presented to the class; this is a form of classroom discussion. Joe stated "That one will come after I have introduced that particular topic. I will just draw into most of the learners' main understanding of a scientific concept is; then, each one will bring forward their understanding." because "The use of analogies that relate to African practices could be of great help in knowledge impacting to our learners." Joe believed that IK can be used to further reinforce a topic and make it clear to his learners, thus enhancing their learning experience.

Anna, on the other hand, mentioned that "One way is to consider the experiences of learners what they know and what they have learned from home about culture and heritage. Once learners have made that clear, then I as a teacher can then use that information and integrate it into my lessons." Ogunniyi and Ogawa (2008) stated that beginning a class session by exploring learners' prior knowledge before introducing topics to them adheres to the constructivist method and is considered as part of a holistic approach that aids learners in the process of border-crossing. Nsamenang and Tchombé (2012) pointed out that one strength of using classroom discussions is the ability to stock up ideas and experiences from the whole group of learners and that it is an active process that allows everyone to participate. Contrary to this, classroom discussions can have domineering learners who might not allow

others to participate, and they can be time-consuming.

Other methods which have been proposed to integrate IK into teaching and learning sciences include taking learners on field trips, going to museums, and visiting the elderly in local communities (Ogunniyi & Ogawa, 2008). Mbo suggested using argumentation if he were to incorporate IK into his teaching and learning. "To allow learners [who are well vested in a particular IKS topic] to engage in an argument of how IKS [if it is pertinent to the curriculum] can be utilized to enhance their understanding of relevant school curricular topic(s)." He explained that he would allow learners to listen to alternative views from other learners concerning a certain topic, present evidence to support those views and finally reach a conclusion with them on the matter.

> I think the centre tenet of argumentation is to allow a learner to listen to the other's alternative view, how the evidence of that supports the conclusion. To then show that it's a better account of what is being debated. (Mbo)

He mentioned that this would include active and self-directed learning from the learner's perspective because they would have to go out and look for evidence to support their arguments in class.

> Argumentation in the classroom brings forth multiple versions of the same topic. It helps learners to re-think or revise their versions of their arguments in light of [considering] alternative versions or evidence presented by their fellow learners…
>
> They will then say that mine will be a better account of nature because I have evidence in front of me. You only have hearsay in front of you. And then how do you convince the next learner? And in that way, a person who does not have sufficient evidence will be prompted to go and search and therefore self-learning takes place. (Mbo)

In tandem, Nsameng and Tchombé (2012) mentioned that for learners to reach conclusions during self-directed learning, they must put into practice deeper skills such as problem-solving and critical thinking skills. Also, Hewson and Ogunniyi (2011) postulate that one way of integrating IK into science classrooms is through discussions in the form of argumentation to help learners with the claims they make regarding phenomena they are studying (Riffel, 2020). This is done when they provide evidence, statements, and data to support the claims they make in class. Given IK, the CAT model includes the cultural aspect of IK to help learners reach equilibrium between scientific and traditional competing ideologies in class (Hewson & Ogunniyi, 2011).

Anna went further and said that we could make use of the digital technologies, research, and guided practice to integrate IK into teaching and learning sciences. “Research together with guided practice would really help learners learn. Engaging learners in projects where they go out and research certain topics in LS from community individuals”. She gave an example of traditional methods that exist and can be found on the internet that could lend a visual representation to the learners in her classroom. This is because according to her, nowadays, learners and new incoming teachers from colleges and universities are technologically inclined, therefore they can all relate easily to this type of teaching method.

> I just feel like another way to access the IKS is through these digital platforms because you can just pull up a video on fermentation and show them how it is done in a village (of which you can get that video) and show them fermentation and how it is done in these big companies (of which you can still get a video of it). The learners can then have some form of a way to relate to say that the knowledge of fermentation came from our old ancestors who brewed beer on their own. (Anna)

Nsameng and Tchombé (2012) echoed similar sentiments that because learners can

learn more due to increased internet access if teachers focus too much on the prescribed curriculum, it limits the range of classroom discussions that a teacher can have with learners. Anna also pointed that due to lack of experience, new teachers do not know when or not to engage learners in classroom discussions. This could cause a challenge in terms of time management, given that such discussions are time-consuming. “I can say that with the new teachers the challenges are knowing when to engage in a discussion with learners and knowing when not to engage in a discussion with learners.”

Teachers use classroom discussions, where learners give their version of how they understand topics, followed by the teachers’ explanations using this knowledge. When teachers use learners’ IK as prior knowledge in their teaching and learning for multicultural learners, it helps to ease the process of learning sciences for them. The prior knowledge that learners bring into the science classroom must be context-based so that it is familiar to learners’ lived-experiences to make science learning more meaningful. A point to ponder on is from Khupe (2014) who noted that the demonstrations are methods for the transmission and acquisition of IK.

When integrating IK into their teaching and learning, the teachers mentioned various methods of how this can be achieved. Faith and Lerato gave examples of demonstrations in class or the science laboratories, presentations of artefacts in the classrooms and field trips to the cradle of humankind when using IK examples to illustrate abstract scientific concepts to their learners.

Joe uses classroom discussions to integrate IK into his teaching and learning. Classroom discussions are an active way of learning, that allows every learner to participate. These discussions can be in the form of debates, presented through argumentation, as Mbo described his method of integrating IK concepts in his science classroom. In this, learners are encouraged to seek evidence, present data to the class to support claims that are made and

conclude. The CAT model developed by Hewson and Ogunniyi (2011) includes the cultural aspect of IK in argumentation, which gives learners a sense of recognition and respect. The use of digital technologies was put forward by Anna, that learners' interests can be tapped by the media they use every day to help them relate to the IK content that is taught in science classrooms. However, argumentation methods can be time-consuming, as such a balance should be reached when engaging in classroom discussions with learners, especially for new teachers from universities and colleges.

Challenges Faced by Teachers When Integrating IKS into the Science Classrooms

Although not the focus of this study, it was important to look at what teachers perceive to be potential hindrances to them using IK concepts when teaching abstract science concepts. This was done to aid with the recommendations and get a clearer picture of how the challenges can be addressed.

The teachers who were interviewed identified some challenges to integrating IK into their teaching and learning as follows: the inability to explain mechanisms of IK concepts attributed to the secrecy associated with IK knowledge, lack of time to include IK concepts into their lesson plans, and the lack of parental engagement in learners' education. Hewson and Ogunniyi (2011) also noted similar challenges as well as a lack of resources that teachers are faced with when integrating IK concepts into their teaching and learning.

How to explain mechanisms of indigenous concepts as well as the secrecy associated with IKS

Mbo mentioned that most of the IK were used when indigenous people needed to survive, however, the mechanisms which informed that knowledge is not well understood.

> Quite a lot of indigenous knowledge was initially for survival, but the problem is how do I explain the mechanism of how it works? So, scientific knowledge

> has been proven and it can be repeated, the modern one, can be repeated by anyone anywhere. Our science in the classroom can be repeated but with IK, one can't explain... there is no way of saying, the results *di tlile jwang* (how they came about), how did the results come about. (Mbo)

He compared this to how western science can explain the mechanisms behind some of its theories and how they can be repeated and proved. Therefore, he mentioned this as one of the challenges that he might face if he were to attempt to use IK concepts in his teaching and learning. He attributed this lack of methodology to the secrecy surrounding IK and gave an example of medicine and that medicinal healing practices were passed on to only a selected few and not to the whole community, which in turn has left a gap in the "how" aspect.

> But on how this medication works, there is a secret. He doesn't tell you. And then given the secrecy behind it, inevitably, there won't be evidence coming up. So, you see, this indigenous knowledge is shrouded in secrecy in that the methodology was for those selected few and who would then use it to make a living like becoming *ke eng*, *dingaka* [what is this, healers] and cure. So yeah, how to integrate it into this new knowledge, how to integrate it with this scientific knowledge I will find it very much difficult. (Mbo)

Nonetheless, in the NCS/CAPS 2011 documents, the major emphasis is on valuing IK and acknowledging IK as a contributor to the values contained in the constitution, as well as showing the relationship between IK and science. Therefore perhaps, harnessing the IK that learners have using the knowledge to make abstract scientific concepts in class could be the first step in overcoming this challenge. Moreover, IK is holistic and indigenous people have had and have their own formal and informal education programs and their pedagogies focused on their philosophies of education (Morcom, 2017). Therefore, both knowledge systems allow the same use of reasoning to transcend the narrow vision offered by the

rationality of natural causes (Horton, 1967; Jegede, 1995); in other words, they both have the same reasoning patterns.

Mbo might be a representation of the many teachers that have been described by De Beer and Mothwa (2013) as those who believe that IK is pseudo-science because it cannot be proven scientifically and laboriously, even if there seems to be no 'scientific' justification for regarding non-Western thinking as unscientific, antiscientific, or any less superior (Jegede,1995). To add to this, Òtúlàjà et al. (2011) asserted that IK cannot always readily be put through the simplistic techniques of western laboratories. Also, the NCS/CAPS 2011 (Grades 10-12) curriculum acknowledges that some IK concepts lend themselves to scientific methods explanations while others will not (Department of Basic Education, 2011). As such, there might not be a need to try and justify the mechanisms of IK to the learners, but to merely use the knowledge that learners have to explain abstract scientific concepts to them. Teachers might not have IK readily available to them because IK is orally transmitted, and most are not recorded Naidoo (2010).

Time Management Issues

Mbo also stated a lack of time as a potential challenge to integrating IK into his classroom teaching and learning. He said that if he has a concept to explain to his learners, he will rather adhere to the explanation prescribed to him in the curriculum so that classroom discussions would reach an end on time. Also, he mentioned that due to the multiculturalism that exists in his class, for him to use IK to explain physics concepts to his learners, it would mean that he would have to be conversant with the knowledge that the learners would bring into the classroom, which would require time for research on his part. Naidoo (2010) echoed similar sentiments that teachers that have been trained in Eurocentric settings would be more familiar with that worldview when teaching and may not readily possess IK that learners have. This creates a gap on which IK to use when teaching and learning science in the classroom.

In this regard, Òtúlàjà et al. (2011) said that any IK can be used in class so that a focal point is created in which both teachers and learners' IK can be expanded where they learn about other peoples' IK and will also enhance respect for all learners (Snively & Williams, 2016). With this, opportunities for using multiple angles, and utilise argumentation in the science classroom come into play.

Lack of parental engagement

Anna stated that there is a lack of parental involvement because they (parents) are not interested in their children's education.

> Because now you might have an issue with the learner at school and try to get their parents to come and engage in a discussion that would be good for the learner, but parents are not interested in such discussions. (Anna)

From her research, Seehawer (2018) suggested giving learners take-home assignments to investigate IK practices from their families as part of a strategy for IK integration. However, given what Anna said, this would pose a challenge if the parents were not willing to participate in their children's education. De Beer and Mothwa (2013) found that there is a positive outcome for the learners' when parents are involved in their education. They further stated that parents are community members and have a wealth of IK, therefore when learners are given take-home projects, it would be easier for them (parents) to direct them to the relevant people in the community.

Integrated discussion

The theory of collateral learning captures the psychological experience of border-crossings (Aikenhead, 1996; Jegede, 1995). Given the findings that Jegede and Aikenhead (1999) had regarding how learners feel isolated from classroom science due to the variations between its culture (classroom science) and their culture, it follows that teachers as cultural brokers, also undergo the process of border-crossing when teaching and learning science. In

general, collateral learning requires two or more opposing schemas retained in long-term memory at the same time because it is a declarative understanding of a concept that a learner stores in long-term memory with a strategic capacity to use in either the western or traditional environment. There are variations in the degree to which the opposing principles communicate with each other and the degree to which the conflicts are resolved to help one to make sense of the world (Aikenhead, 1996). In the case of Mbo's statement, it can be recognized that for him to be able to teach the necessary concepts in his Physical Sciences class over the years using his Eurocentric training, he might have undergone a process of assimilation. In this case, when teaching, he has consciously abandoned his traditional ways of knowing in the science class and has adopted a Eurocentric way of making sense of the world (Aikenhead,1996). However, as part of their IK definition, all teachers acknowledged the presence of culture as part of IK.

Culture coupled with indigenous practices helps build a sense of identity, which, according to Vygotsky, is an important part of psychological development. Through its artefacts, which are the main attribute of any community, culture affects cognitive development (Verenikina, 2003a). However, in practice, Zinyeka et al. (2016) assert that IK is manifested and orally conveyed through imitation, demonstration, drawings, literature, and other artefacts. The teachers mentioned practical experiments and field trips as methods that they can use to integrate IK. Perhaps aligning teaching methods with how IK is transmitted within societies is something that can be studied further, however, teachers would need to have an idea of what IK to use for their learners.

One of the reasons Mbo is reluctant to integrate IK in his science class is because he said he does not know the NOIKS, which might stem from the general notion of the bias toward IK. Joe suggested that if IK can be validated using western processes, then perhaps this can help improve and increase the value that it has within society because even from the

study, Mbo was of the view that IK does not have space in the science classroom. This leads to the assumption that if IK in science curricula were to be made more personal and inclusive, where teachers can identify with their own IK and in a sense “be validated”, perhaps this would help them tap into their knowledge and afford it an opportunity to be used to make abstract scientific concepts more accessible to learners.

It is worrying to hear an indigenous teacher say that they do not have IK because one of Vygotsky's lenses is the cultural influence, which he claims has a huge impact on how learning occurs. Mbo’s view can be attributed to the fact that he might have little knowledge about the NOIK and its place in science. However, this is a potential study that can be investigated, and if conducted, might contribute to the ongoing literature of IKS in South Africa. Costa (1995) noted that progress in the science classroom depends on a teacher’s ability to help learners cross their cultural boundaries, which in turn requires the teacher to have cultural capital. For instance, in their study, Chang and Le (2010) noted that there is a positive correlation between cultural identity and academic success where Mexican American teenagers reported that a stronger cultural identity displayed more favourable attitudes toward schooling. Cultural capital is therefore needed by teachers in the teaching and learning of science for the process of mediation, which is one of the theories developed by Vygotsky as part of the border-crossing process.

According to Vygotsky (1978), mediation refers to the role played by MKOs in the lives of learners. These are individuals who improve learners’ teaching and learning experiences by choosing and positively influencing the learning experiences offered to learners (Turuk, 2008). Vygotsky (1978) further argued that the secret to successful learning lies in the social interaction between two or more individuals with different levels of skills and experience. Therefore, if the teacher is not aware of the IK capital to be invested in the class, it creates a possible challenge for the integration of IK in the science classroom because

the teacher will not be able to use IK to help learners progress into and beyond the next layer of comprehension within learners' ZPD.

In this theory, several internal developmental processes are awakened by learning in the ZPD when learners communicate with MKOs. Following the example of Chang and Lee (2010), the impact of integrating IK in the science classroom will have a dialectical relationship on learner behaviour. Learners will move from assisted learning to independent learning because they will reconcile conflicting abstract scientific concepts in the classroom with their IK after a smooth border-crossing process. For instance, the use of clay pots to preserve food and water is a common indigenous practice, as well as the process of brewing traditional beer. These examples can be used to explain scientific topics such as conductivity and fermentation, respectively. Once these concepts from classroom science and IK have been resolved by the learner through the process of collateral learning, only then can they move from assisted learning to independent learning at a deeper level. However, given the nature of the multicultural classrooms that exist in South Africa, does this mean that a teacher would have to know the IK that all their learners bring into the classroom? To aid with this, the concept of multicultural school science will be explored next.

Multicultural education aims to meet the demands of culturally diverse learners while considering their diverse cultural backgrounds (Lemmer & Squelch, 1993). The promotion of multicultural education, which fosters the decolonization of science, was suggested by Aikenhead and Elliott (2010). With this, in their process of collateral learning, learners will master and use science without sacrificing their traditional ways of knowing. In this case, a teacher would have to have knowledge and understanding of their own culture, be mindful of the culture of their learners, and know which cultural factors impact the processes of teaching and learning. This does not mean teachers would have to know and be familiar with all the IK their learners bring to class, but they can use this as an opportunity to learn and respect their

learners' IK. Furthermore, the teacher would have to recognize school science as transformative and student-centred. The concept of education as a transformative and student-centric experience was strongly advocated for by Paulo Freire. Freire (1978) mentioned that education should include one's culture and prior knowledge so that the learners could understand how educationally and traditionally their society is viewed, he called this critical consciousness (Mathieson, 2014). A teacher who engages pedagogies of critical consciousness has attributes of a critical relevant teacher.

The cultural characteristics, experiences and perspectives of multicultural learners are used by teachers who engage with CRP as conduits to teach learners more effectively in class. CRP assumes that when academic abilities and knowledge are found inside learners' perceptions and frames of reference, they are more intimate, have a higher interest appeal, and are easily and thoroughly learned (Gay 2002; Mathieson 2014). This implies that if these learners are taught with their culture considered, their academic performance will improve. Joe is an example of a teacher who uses CRP to engage with his learners in the science classroom because he not only uses the knowledge his learners bring to the classroom to explain science concepts to them but also reflects on the status quo of the political and social structures within education, as well as the topics that he teaches (field notes). This is an example of transformative education that places learners at the centre.

The quest for quality education remains an elusive dream for the black child in the South African community as they are burdened with a past that involves the denial of education, separate and unequal education, and relegation to insecure, substandard schools (Mathieson, 2014). Despite this, Ladson-Billings (1995) has confidence that academic success is still achievable for the black child, something that can be accomplished through CRP. In her writing, she maintained that the idea behind CRP is to get students to "select" academic excellence and she gave three criteria for this. The criteria are that (a) students must be

academically successful, (b) students must develop and/or retain cultural skills, and (c) students must develop critical awareness through which they challenge the social order in the current status quo. In this study, the teachers not only understood and explained what the NCS/CAPS 2011 documents recommended and expected from them, but also narrated how the integration of IK into science can help alleviate some challenges that society is faced with, something which goes beyond the walls of a science classroom. Furthermore, like many others, these teachers want their learners to academically excel.

Two of the teachers believe that learners should have cultural awareness, however, only one teacher, Joe, voiced his concerns regarding the social issues around the current status quo of education. In his follow up interview, he mentioned that despite the good quality of education that exists in South Africa, we were unable to participate in the development of a vaccine against Covid 19, given the existence of extensive knowledge about medicinal plants and Joe further questioned the political motive reason behind all of this. Gay (2002) built on the idea of CRP and focused a bit on the curriculum. She explained that 75 % - 95 % of all classroom instruction is made up of textbooks and that learners are inclined to believe that a textbook's authority is clear and that the information within it is accurate. It is therefore up to a teacher to challenge such norms, using IK and encourage learners to do the same.

Gay (2002) states that the content of the science curriculum should be selected and presented to the learners for whom it was designed in ways that are specifically applicable to them. However, Khepera (2007) contends that teachers cannot teach what they do not know. Annah mentioned from the interviews that their professional development programs, which she termed teacher subject information sharing sessions were offered only once a month and were highly dependent on the facilitator. Also, she said that the IK workshops that they are offered are not productive because of the lack of engagement from the session, that they are

more of instructional sessions, where teachers are told what and how to teach. As such, she hardly gained anything from them. In this case, teacher learning is affected and does not contribute much to their communities of practice (CoPs).

An effective way for teachers to learn from one another and develop is to engage in CoPs; the learning process can be defined as legitimate peripheral participation (LPP) for newcomers in such communities (Eberle et al., 2014). According to Vygotsky (1978), the way learners take part in their tradition and social environment contributes to their cognition. As such given that teaching and learning is a two-way process, teachers can also learn and engage with one another within their CoPs about how to improve their teaching strategies on certain topics. However, this does not have to take place in a formal setting. From my notes, all the teachers that I engaged with had a common staff room where they take their tea and lunch breaks and have an opportunity to engage with one another. A place where new and incoming teachers from other schools as well as those from colleges can meet socially.

Although Lave and Wenger (1991) did not account for newcomers who already have experience and might be new due to a transfer, in this context, this learning theory also applies to them. This is because as peripheral members of a CoP, beginners typically learn about a community and society from the beginning. After all, they lack the requisite community-specific expertise that would allow them to engage in a more central way within the school. Therefore, peripheral involvement is the second key aspect of participative learning (Lave & Wenger, 1991), which means a change in the way in which newcomers are involved in the CoP. This begins with somewhat passive behaviours such as studying the ways senior teachers speak, interpreting new circumstances, responding to them, and coping with problems. Teachers of common practice groups share the perspectives, community knowledge and skills that form their expertise with each other (White, 2006). As a result, a shared CoP is an ideal platform for disseminating information such as best practices, tips, and feedback

among teachers (Wenger, 1998). This means that when teachers share with and learn from each other in their common staff rooms, kitchens and during their development workshops, they strengthen the professionalism of teaching. However, this teaching and learning do not have to be one-sided, that is from the old-timers to the younger, incoming teachers.

Anna mentioned that the younger, newcomers in her school are well versed with technology and the digital era, therefore she recommended that the newcomers also teach the old-timers about the digital age to help enhance learners' learning experiences in science classrooms more meaningful. Given the current pandemic of Covid 19, some schools are using non-contact teaching, as such, the use of technology in integrating IK into teaching and learning is also something that can be investigated further.

Chapter Five

Conclusion, Recommendations and Further Studies

Conclusion

This chapter will summarise the results and discussion of this study. I start by presenting the theoretical frameworks that guided this study, then present a summary of the findings for the themes that emerged from the investigation. This is followed by a summary of the challenges faced by FET teachers when integrating IK into teaching and learning, as well as a conclusion. While presenting the conclusion, I will also give my final thoughts.

This study aimed to investigate FET science teachers IKS in South African schools. The theoretical frameworks that were used to guide the investigation included the learning theories such as constructivism 1) Vygotsky's social development that comprises of the ZPD and MKO, 2) Piaget's theory of cognitive development, Jegede and Aikenhead's cultural border-crossing as well as collateral learning, situated learning, and Ladson-Billing's culturally responsive teaching.

The first research question analysed teachers' IK awareness and understandings. Three themes emerged from this, teachers reported that IK has a cultural aspect, it has significant cultural practices and they also commented on the value that IK has. The last theme was divided into three subthemes, the bilateral validation of IK and classroom science, the dialectical relationship between IK and classroom science, as well as IK builds a sense of identity and belonging.

The teachers defined IK as knowledge that has a cultural aspect that evolved from communities that have occupied certain geographic areas over a long period. This knowledge includes languages, beliefs and practices that are exclusive to indigenous people that form culture. In turn, peoples' culture shape how they make sense of the world through their worldviews. The theory of situated learning posits that people socially learn about culture, by

building relationships with each other and between people who connect pre-existing knowledge in an informal manner (Fuller et al., 2014). Within their teaching profession, teachers are members of their indigenous communities who have gained their IK through participating in indigenous CoP.

Teaching is a form of cultural practice. Cultural practices form part of IK, however, because of the bias that exists toward IK and the lack of knowledge of what and how to implement, the teaching practice has not yet translated the integration of IK in classroom science into what the curriculum intends. Therefore, the bilateral validation of IK using western practices might influence this and have a practical impact. For instance, the example of the Lavender tree by Cameron (2017) is a good example of IK knowledge that has been validated using rigorous scientific methods that teachers can use in class. Cameron (2017) provided evidence for the indigenous peoples' beliefs and validated their knowledge concerning the Lavender tree and lighting. There is a dialectical relationship between IKS and behaviour, where knowing about the tree influenced indigenous people's behaviour to not go near it during the lightning seasons.

Most of the teachers in this study understand and have a positive attitude towards the NCS/CAPS mandate to integrate IK into their science teaching and learning. They also believe that integrating IK into their science classrooms can help alleviate societal challenges such as poverty and hunger. Teachers also gave IK examples that can be used to explain abstract science concepts and the scientific topics into which IK can be integrated into. Furthermore, the methods of integration display border-crossing and collateral learning characteristics for the learners in a way that learners might be able to resolve conflicts and make sense of what they are learning. The teaching methods included argumentation during classroom discussions, field trips and practical experiments.

One teacher had a justice-based approach, focused on empowering their learners when they mentioned the methods of teaching. They acknowledged that their learners have various cultural backgrounds and noted that the prior experience they bring into the classroom is important for teaching and learning science. One teacher implicitly questioned the value of the education system, given that South Africa was unable to be at the forefront in the search for the Covid19 vaccination, challenging the status quo, as well as the politics that are involved. This teacher displayed the qualities of a culturally responsive teacher.

The challenges mentioned by the teachers toward the integration of IK include the lack of time to research on IK for them to integrate it into their teaching and learning, the lack of parental involvement in their children's education as well the mechanisms involved behind IKS. Clearer instructions and methods are needed in the form of policies, which must be enacted. Incentives in the form of teaching materials, school equipment and textbooks could perhaps also serve as motivation for the teachers to implement IK. For instance, Mbo mentioned that the Department of Education sends out models for them to use when teaching so that their learners have tangible materials when learning science.

Although the participants in this study display a positive attitude towards IKS, this does not translate into an implemented practice in the classroom that would accomplish the intended curriculum set out for IKS. This optimistic attitude can only be seen in the minimal attempt of the participants to include IKS into their teaching and learning of science.

Recommendations

This section will discuss recommendations for teachers as well as policymakers that might help in the quest to integrate IK into the teaching and learning of sciences at the FET level.

Recommendation for teachers

Research in South Africa suggests that teachers are willing to use IK to make western science concepts meaningful to their learners. In this study, the teachers indicated their need for appropriate support from the Department of Education. Anna suggested the need to involve teachers when assessments are reviewed because they are the ones who facilitate and ensure the learning process in the classrooms.

Teachers must know that successful IK integration in science depends on their ability to incorporate IK into their classrooms because Black learners have difficulties border-crossing between their familial lives and schools, which will, in turn, have a negative influence on their academic performance (Abah et al., 2015; Aikenhead & Jegede, 1999). As such, teachers must work for an awareness of their learners' cultural ideas and values and assemble a tool kit of teaching strategies that are sensitive to the perspectives of all learners and respect them (Snively, 2018).

Recommendation for curriculum developers

Although Mbo and Anna became exposed to IK in science through pursuing further education as well as university training, they were not trained on how to translate IK into practice, therefore higher learning institutions that train pre-service teachers also have a responsibility toward IK incorporation in science classrooms. As such, curriculum developers should look into forming a meaningful relationship between teachers, community elders, parents and professional associations to form clear policy documents because just valuing IK in policies will not guarantee that teachers will incorporate it into their teaching and learning.

A review of current policies which should be enforced through gazettes, informing teachers of the need to include IK in their science classrooms can also be looked into because Joe felt that although the value of IK has been highlighted in the curriculum, the policy documents need to be more explicit through the inclusion of instructional techniques so that policy

can be implemented in the classroom. In turn, a relationship between the Department of Education, IK stakeholders and scientists should be fostered to see where linkages exist that are of mutual benefit for teaching science in the classroom.

Furthermore, one of the reasons mentioned for the failure of C2005 implementation was due to the negligence of the teacher's role in the classroom as the gatekeeper of information (Jansen & Christie, 1999; Jansen & Taylor 2003; Nnadozie, 2009) because they were not involved in the planning and implementation phases. It remains imperative that teachers' roles in the development of science curricula and decision-making policies be revisited and adjusted accordingly.

Subjects are regarded as relevant because they have topics of their own and stand alone. Given the existing inferior status towards IKS, it will gain more relevance if it is made to stand alone. Furthermore, topics related to IKS from these subjects may be grouped to form a separate IKS curriculum. It would enable teacher training institutions to create modules from the above topics with a separate IKS curriculum.

Lastly, education policymakers concerned with the assessment of FET science subjects need to include IKS in the evaluation strategies, because the non-examination of IKS justifies teachers not to integrate it into their classroom teaching and learning.

Further studies

A significant finding in this study is that although teachers know the NCS/CAPS documents, they rely on their annual teaching plans to conduct their class lessons. Further studies into how the teaching plans can incorporate IK and help teachers deliver their lessons will be important.

Also, teacher's awareness, beliefs and training strongly influence if they incorporate IK into their teaching and learning. If teachers do not recognise the significance and influence of IK in their daily lives, they will not see the influence it has on their learners' lived-

experiences, thus not incorporate them into their teaching and learning. Further studies on learners' lived-experiences and their views on IKS in science could help pave the way for the possibility of its (IK) integration in the science classroom.

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Appendices

Appendix A

GAUTENG PROVINCE
Department: Education
REPUBLIC OF SOUTH AFRICA

8/4/4/1/2

GDE AMENDED RESEARCH APPROVAL LETTER

Date:	**14 October 2019**
Validity of Research Approval:	**10 February 2020 – 30 September 2020** **2019/219A**
Name of Researcher:	**Kigozi F.N**
Address of Researcher:	**1 Jan Smuts Avenue, Braamfontein**
	Private Bag 3
	Wits, 2050
Telephone Number:	**084 352 2073**
Email address:	**flavour28@gmail.com**
Research Topic:	**Teachers' Indigenous Knowledge Awareness and how to implement it in teaching and learning in a South African school.**
Type of qualification	**MSc in Science Education**
Number and type of schools:	**Three Secondary Schools**
District/s/HO	**Johannesburg West**

Re: Approval in Respect of Request to Conduct Research

This letter serves to indicate that approval is hereby granted to the above-mentioned researcher to proceed with research in respect of the study indicated above. The onus rests with the researcher to negotiate appropriate and relevant time schedules with the school/s and/or offices involved to conduct the research. A separate copy of this letter must be presented to both the School (both Principal and SGB) and the District/Head Office Senior Manager confirming that permission has been granted for the research to be conducted.

15/10/2019

The following conditions apply to GDE research. The researcher may proceed with the above study subject to the conditions listed below being met. Approval may be withdrawn should any of the conditions listed below be flouted:

Office of the Director: Education Research and Knowledge Management
7th Floor, 17 Simmonds Street, Johannesburg, 2001
Tel: (011) 355 0488
Email: Faith.Tshabalala@gauteng.gov.za
Website: www.education.gpg.gov.za

1. *Letter that would indicate that the said researcher/s has/have been granted permission from the Gauteng Department of Education to conduct the research study.*
2. *The District/Head Office Senior Manager/s must be approached separately, and in writing, for permission to involve District/Head Office Officials in the project.*
3. *A copy of this letter must be forwarded to the school principal and the chairperson of the School Governing Body (SGB) that would indicate that the researcher/s have been granted permission from the Gauteng Department of Education to conduct the research study.*
4. *A letter / document that outline the purpose of the research and the anticipated outcomes of such research must be made available to the principals, SGBs and District/Head Office Senior Managers of the schools and districts/offices concerned, respectively.*
5. *The Researcher will make every effort obtain the goodwill and co-operation of all the GDE officials, principals, and chairpersons of the SGBs, teachers and learners involved. Persons who offer their co-operation will not receive additional remuneration from the Department while those that opt not to participate will not be penalised in any way.*
6. *Research may only be conducted after school hours so that the normal school programme is not interrupted. The Principal (if at a school) and/or Director (if at a district/head office) must be consulted about an appropriate time when the researcher/s may carry out their research at the sites that they manage.*
7. *Research may only commence from the second week of February and must be concluded before the beginning of the last quarter of the academic year. If incomplete, an amended Research Approval letter may be requested to conduct research in the following year.*
8. *Items 6 and 7 will not apply to any research effort being undertaken on behalf of the GDE. Such research will have been commissioned and be paid for by the Gauteng Department of Education.*
9. *It is the researcher's responsibility to obtain written parental consent of all learners that are expected to participate in the study.*
10. *The researcher is responsible for supplying and utilising his/her own research resources, such as stationery, photocopies, transport, faxes and telephones and should not depend on the goodwill of the institutions and/or the offices visited for supplying such resources.*
11. *The names of the GDE officials, schools, principals, parents, teachers and learners that participate in the study may not appear in the research report without the written consent of each of these individuals and/or organisations.*
12. *On completion of the study the researcher/s must supply the Director: Knowledge Management & Research with one Hard Cover bound and an electronic copy of the research.*
13. *The researcher may be expected to provide short presentations on the purpose, findings and recommendations of his/her research to both GDE officials and the schools concerned.*
14. *Should the researcher have been involved with research at a school and/or a district/head office level, the Director concerned must also be supplied with a brief summary of the purpose, findings and recommendations of the research study.*

The Gauteng Department of Education wishes you well in this important undertaking and looks forward to examining the findings of your research study.

Kind regards

.....

Mr Gumani Mukatuni
Acting CES: Education Research and Knowledge Management

DATE: ..15/10/2019.....

Office of the Director: Education Research and Knowledge Management
7th Floor, 17 Simmonds Street, Johannesburg, 2001
Tel: (011) 355 0488
Email: Faith.Tshabalala@gauteng.gov.za
Website: www.education.gpg.gov.za

Appendix B

GAUTENG PROVINCE
REPUBLIC OF SOUTH AFRICA

Enquiries: Gumani Mukatuni
Directorate: ER & KM
Tel: (011) 355 0775/ 082 515 5412
Gumani.Mukatuni@gateng.gov.za

MEMO

TO: **Head of the Department, DDGs, Chief Directors, Directors, Districts, Principals, Universities and Research organisations**
FROM: **Faith Tshabalala**
Acting Director: Education Research and Knowledge Management
SUBJECT: **Regulations on access to schools by Researchers due to COVID 19 pandemic**
DATE: 10/06/2020

Dear Sir/madam

Kindly note that visitors are currently NOT permitted into the GDE school premises because of the pandemic (Covid 19) challenges, as the Department is not certain of the status of the learners or teachers; this includes Researchers.

Researchers may, however collect data online, telephonically or may make arrangements for Zoom with the school Principal. Requests for such arrangements should be submitted to the GDE Education Research and Knowledge Management directorate. The approval letter will then indicate the type of arrangements that have been made with the school.

The Researchers are advised to make arrangements with the schools via Fax, email or telephonically with the Principal.

Yours sincerely

.....

Ms Faith Tshabalala
Acting Director: Education Research and Knowledge Management
Date: 10/06/2020

Appendix C

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

Research Office

HUMAN RESEARCH ETHICS COMMITTEE (NON-MEDICAL)
R14/49 Kigozi

CLEARANCE CERTIFICATE	**PROTOCOL NUMBER: H19/09/15**
PROJECT TITLE	Teachers' indigenous knowledge awareness and how to implement it in teaching and learning sciences in South African schools
INVESTIGATOR(S)	Miss F Kigozi
SCHOOL/DEPARTMENT	Animal, Plant and Environmental Science/
DATE CONSIDERED	13 September 2019
DECISION OF THE COMMITTEE	Approved Permission letters from schools are required before data collection can commence
EXPIRY DATE	07 November 2022

DATE 08 November 2019 **CHAIRPERSON** (Professor J Knight)

cc: Supervisor : Dr F Otulaja

DECLARATION OF INVESTIGATOR(S)

To be completed in duplicate and **ONE COPY** returned to the Secretary at Room 10004, 10th Floor, Senate House, University. Unreported changes to the application may invalidate the clearance given by the HREC (Non-Medical)

I/We fully understand the conditions under which I am/we are authorized to carry out the abovementioned research and I/we guarantee to ensure compliance with these conditions. Should any departure to be contemplated from the research procedure as approved I/we undertake to resubmit the protocol to the Committee. **I agree to completion of a yearly progress report.**

_____ **Signature**

_____/_____/_____ **Date**

PLEASE QUOTE THE PROTOCOL NUMBER ON ALL ENQUIRIES

Appendix D

Researcher: Ms. Flavia Kigozi
Phone: 0843522073
e-mail: 0701690r@Students.wits.ac.za
24/07/2019

[School address]

Dear [Principal name]

Permission to Conduct Research in Your School

My name is Ms. Flavia Kigozi. I am a Master's degree student at the School of Animal, Plant and Environmental Sciences in the Faculty of Science at the University of the Witwatersrand. I am seeking your permission to conduct research titled **"**Teachers' Indigenous Knowledge awareness and how to implement it in teaching and learning sciences in South African schools" for my degree**.** I am inviting your school as well as one teacher for Life and Physical Sciences to participate with me in this study.

The aim of the study is to find out science teachers views of indigenous knowledge (IK) and how they can use those views in enabling the teaching and learning of Physical and Life Sciences. I am interested in finding out if teachers are aware of indigenous knowledge, and how to use it in their sciences classrooms. Teachers will be supplied with a questionnaire to complete at their convenience. A follow up 40-minute interview/conversation will be arranged at their convenience to probe their questionnaire responses further. The questionnaire and interviews will not affect school time.

Participation in this study is voluntary. The participants in this study will not be advantaged or disadvantaged in any way, except that they may become aware of their IK and how it can be used in the teaching and learning in their classroom settings. Participants are free to withdraw their permission/participation at any time during the project without any prejudice or penalty against them. There are no foreseeable risks in participating in this study. Participants will not be paid for participating in the study.

The names and identities of participants and the location of the study will always be kept confidential and in all academic writings about the study. Pseudonyms will be used instead of actual names. Individual privacy of participants in this study will be maintained in all publications resulting from this study. All research data collected will be kept in locked cabinets in my supervisor's office and in a password-protected computer. Only the researcher and her supervisor will have access to the data. Data will be destroyed between 3 - 5 years after completion of this study.

Should you have any further questions about this study, please feel free to contact the Wits University Ethics Committee, via Ms Shaun Schoeman by e-mail at:

<Shaun.Schoeman@wits.ac.za> or by telephone at 0117171408 or my supervisor, Dr. Femi Otulaja, via email at <Femi.Otulaja@wits.ac.za> or by telephone at 011 717 6075.

Name of Principal	Signature of Principal	Date
Ms. Flavia Kigozi		
Name of Investigator	Signature of Investigator	Date

Name: Flavia Kigozi
Email address: 0701690r@students.wits.ac.za
Cell phone #: 0843522073

Appendix E

Researcher: Ms. Flavia Kigozi
Phone: 0843522073
e-mail: 0701690r@Students.wits.ac.za
24/07/2019

Participant's Information Sheet

Dear Sir/Madam

My name is Ms. Flavia Kigozi. I am a Master's degree student at the School of Animal, Plant and Environmental Sciences in the Faculty of Science at the University of the Witwatersrand. I am conducting a research titled "Teachers' Indigenous Knowledge awareness and how to implement it in teaching and learning sciences in a South African school" for my degree. I am inviting you as a science teacher to participate with me in this study. The aim of the study is to find out science teachers' awareness of indigenous knowledge (IK) and how teachers could use their awareness in teaching and learning sciences in their classrooms.

Participation in this study is voluntary. Participants will not be advantaged or disadvantaged in any way, except that they may become aware of their indigenous knowledge and how that awareness can be used in teaching and learning sciences in the classroom. Participants are free to withdraw their permission/participation at any time during this study without any prejudice or penalty against the participant. There are no foreseeable risks involved in participating in this study. Participants will not be paid or compensated in any way for taking part in this study.

The names and identities of participants and location of the study will always be kept confidential and in all academic writing about this study. Pseudonyms will be used instead of actual names of participants. Individual privacy of participants will be maintained in all publications resulting from this study. All data collected in this study will be kept in locked cabinets in my supervisor's office and in a password-protected computer. Only the researcher and her supervisor will have access to the data. These data will be destroyed between 3 - 5 years after the completion of this project.

Should you have any further questions about this study please feel free to contact the University Ethics Committee, via Ms. Shaun Schoeman by e-mail at <Shaun.Schoeman@wits.ac.za> or by telephone at 0117171408, or my supervisor, Dr. Femi Otulaja, by email at <Femi.Otulaja@wits.ac.za> or by telephone at 011 717 6075. Thank you.

Yours sincerely,

Signature

Name: Flavia Kigozi

Email: 0701690r@students.wits.ac.za
Cellphone: 0843522073

Appendix F

Teachers' Indigenous Knowledge awareness and how to implement it in teaching and learning sciences in South African schools.

Ms. Flavia Kigozi

I, _____agree to participate in this research project. The research has been explained to me and I understand what my participation will involve. Please circle the relevant options below.

I agree that my participation will remain anonymous	YES	NO
I agree that the researcher may use anonymous quotes in his / her research report	YES	NO
I agree that the interview may be audio recorded	YES	NO

…… (participant signature)
…… (name of participant)
…… (date)

Appendix G

Life Sciences Teacher's Questionnaire

Life Science Teachers' Questionnaire

Kindly answer the following questions truthfully to the best of your knowledge. Your participation in this survey is gratefully appreciated. Thank you.

Gender: _____ Grade(s): ____Years of teaching: _____

Preferred pseudonym: _____

The CAPS document for Life Sciences states:

1. On page 5, that teachers should teach in ways that demonstrate the "**Valuing [of] indigenous knowledge systems [IKS]: acknowledging the rich history and heritage of this country [South Africa] as important contributors to nurturing the values contained in the Constitution**;"

a) What do you, as a Life Science teacher, understand by this policy statement in the CAPS?

_____
_____
_____
_____
_____

b) In your own view, do you think that in your teaching you can be able to bring out this rich heritage (mentioned above) in your learners? How can you make that possible?

_____
_____
_____
_____
_____

2. In the CAPS documents on page 17, teachers are informed that: "**Learners must be exposed to the history of science and indigenous knowledge systems from other times and other cultures.**" and also "**science should be taught in an integrated way in order to enhance the subject and clarify the relationship between subject and indigenous knowledge systems that relate to a specific topic, related history and scientific discoveries and the applications of science in everyday life**"

Knowing the above and more importantly that "**Science as we know it today has roots in African ... culture"** amongst other cultures",

c) What "**variety of approaches"** can you use for integrating in teaching and learning Life Science (s) in your classroom(s)? Kindly give examples.

_____

_____
_____
_____
_____

d) How would you, as a Life Science teacher, use "**variety of approaches to**" engage with and use this knowledge (**science has roots in African culture**) in teaching Life Science in your classrooms to African learners?

_____
_____
_____
_____
_____

e) Explain how you think the integration of Life Sciences (teaching and learning), using variety of approaches mentioned above in (c) and (d) , with Indigenous Knowledge can or cannot help learners learn science better.

_____
_____
_____
_____
_____

Also, on page 17, concerning **Specific Aim 3: Understanding the uses of Science**, CAPS say "**The third aim of Life Sciences is to enable learners to understand that school science can be relevant to their lives outside of the school and that it enriches their lives",** however, **"All knowledge stems from views on how the world works. One of the differences between modern science (and technology) and traditional, indigenous knowledge systems is that they have their origins in different world views. Learners should understand the different cultural contexts in which indigenous knowledge systems were developed**".

f) How could this be accomplished in your lessons?

_____
_____
_____
_____

3) How do you think indigenous knowledge is expressed (shown) in the everyday living of your Life Science learners?

_____
_____
_____
_____
_____

General Comments:

_____
_____
_____
_____
_____
_____

Physical Sciences Teacher's Questionnaire

Physical Science Teachers' Questionnaire

Kindly answer the following questions truthfully to the best of your knowledge. Your participation in this survey is gratefully appreciated. Thank you.

Gender: _____ Grade(s): _____Years of teaching: _____

Preferred pseudonym:_____

The CAPS document for Physical Sciences states:

1. On page 5, that teachers should teach in ways that demonstrate the "**Valuing [of] indigenous knowledge systems [IKS]: acknowledging the rich history and heritage of this country [South Africa] as important contributors to nurturing the values contained in the Constitution**;"

a) What do you, as a Physical Science teacher, understand by this policy statement in the CAPS?

_____
_____
_____
_____
_____

b) In your teaching, how can you bring out this rich heritage (mentioned above) in your learners?

_____
_____
_____
_____
_____

2. On page 8 , teachers are informed that: "**Some concepts found in Indigenous Knowledge Systems lend themselves to explanation using the scientific method while other concepts do not…**"

c) Which "**concepts"** in Indigenous Knowledge that "**lend themselves to explanation using the scientific method**" can you use for teaching and learning Physical Science in your classroom(s)? Kindly give examples._____

_____
_____
_____

_____
_____

d) How would you, as a Physical Sciences teacher, use "**variety of approaches to**" engage with indigenous knowledge in teaching Physical Sciences in your classroom (s) to African learners?

_____
_____
_____
_____
_____

e) Explain how you think the integration of Physical Sciences (teaching and learning), using variety of approaches mentioned above in (d), with Indigenous Knowledge can or cannot help learners learn science better.

_____
_____
_____
_____
_____

3) On page 8 CAPS says that "**all scientific and technological knowledge including Indigenous Knowledge Systems (IKS) is used to address challenges facing society**", and that "**this knowledge has been a source of may innovations and developments including scientific developments"** however, globally organizations struggle to find solutions to important issues such as hunger, poverty and underdevelopment**.**

f) Do you think that IK can be used to alleviate some of these issues?

_____
_____
_____
_____

g) How could this be accomplished in your lessons?

_____
_____
_____
_____

4) How do you think indigenous knowledge is expressed (shown) in everyday living of your Physical Sciences learners?

_____
_____
_____
_____
_____
_____

General Comments:

_____
_____
_____
_____
_____
_____

Appendix H

Sample Interview Schedule for Physical Sciences Teachers

Researcher: Ms. Flavia Kigozi
Phone: 0843522073
e-mail: 0701690r@Students.wits.ac.za
24/07/2019

Sample Interview Questions for Physical Science Teachers

1. From your own point of view and as a Physical Science teacher what is indigenous knowledge?

2. Why do you think IK could be useful in teaching Physical Science to FET phase learners?

3. Physical Science is a subject that comprises of the science content, how could you use IK to teach science in Physical Science in such a way that helps develop learners' interest in science?

4. What knowledge and skills are required to able to implement IK in a classroom?

5. Is it possible to engage IK in teaching Physical Science in early grades? If so, kindly elaborate.

6. How will you use IK in Physical Science lessons to help learners develop in their cognitive skills?

Sample Interview Schedule for Life Sciences Teachers

Researcher: Ms. Flavia Kigozi
Phone: 0843522073
e-mail: 0701690r@Students.wits.ac.za
24/07/2019

Sample Interview Questions for Life Science Teachers

1. From your own point of view and as a Life Sciences teacher what is indigenous knowledge?

2. Why do you think IK could be useful in teaching and learning Life Sciences to learners?

3. How could you use IK to teach Life Sciences in ways that help develop learners' interests in sciences?

4. What knowledge and skills are required to integrate IK and westernized sciences in the classroom?

5. What aspects of IK can be used in Life Sciences lessons?