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Teachers' Indigenous Knowledge and the Possibilities of Integrating it With Life Sciences Teaching and Learning

by

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University of the Witwatersrand, Johannesburg

A thesis submitted to the Faculty of Science, in fulfilment of the requirements of the degree of Doctor of Philosophy.

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April 23, 2021

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Abstract

The teaching and learning of Sciences in schools in South Africa can be challenging for teachers and learners. Therefore, the focus of Science education is to make Science accessible and attractive to all learners in the classroom. This study explores teachers' Indigenous Knowledge (IK) and the possibilities of integrating it with Life Sciences teaching and learning in the classroom context. However, in South Africa, teachers are struggling with how IK should be integrated with science for a culturally relevant science classroom. Therefore the following research questions were posed: How is IK represented in the grade 10, 11 and 12 Life Sciences curricula in South Africa classroom? What perception do teachers have of Indigenous Knowledge? What are teachers' experience and the possibilities of integrating IK and Life Sciences' concepts to promote Science in the classroom? A qualitative case study research approach was adopted for this study. A purposive sampling strategy was used to select the participants of this study. Grades 10, 11 and 12 Life Sciences teachers in four peri-urban high schools (13 teachers) in South Africa were involved in this study. This study adopted the constructivist theory as the suitable theoretical framework to unpack the research questions. Interviews, questionnaire as well as content analysis of the NCS and CAPS document were used to collect rich qualitative data in this study. The questionnaires were piloted, and several changes made before it was administered for the main study. Findings from this study revealed that; although the curriculum called for inclusion of IK in the teaching and learning of Science in the classroom, how teachers should integrate both worldviews were not explicitly provided; teacher's view of IK and Westernized Science is that both worldviews are ways of knowing and they both share common grounds as to their scientific nature; teachers' view of IK indicated that teachers are aware of their IK and the possibilities of integrating such knowledge in their Life

Sciences classrooms were emphasized. From the findings, it was recommended that the curriculum need to be explicit with the information on how teachers should integrate IK and Westernized Science in their teaching practice. Also, cultural artefacts should be made available for teachers to effectively integrate IK and Westernized Science. The implication of this study to Science education is that the integration of IK and Westernized Science in the Science classroom influences the need for a more culturally relevant classroom to make Science more meaningful to learners.

Keywords: Indigenous knowledge, Westernized Science, integration, culturally relevant Science classroom, teaching and learning.

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Dedication

This thesis is dedicated to God almighty, my strength and pillar, who saw me through this journey from the beginning till the end. The study is also dedicated to my late parents Mr Emmanuel and Mrs Anastacia Ahanonye. Finally, this thesis is also dedicated to my lovely husband Mr Ughaghare Precious Iteke and to my Angel Samuel Oghenerume Chimdiebube Iteke.

Acknowledgment

I acknowledge the Almighty God for his grace all through the writing of this research work.

To my supervisors, Dr Femi Otulaja, Dr Shalini and Dr Ida Risenga, for their constructive supervision and support and guidance during the writing of this thesis.

My acknowledgement goes to all the people who supported me both financially, morally, emotionally, from the beginning of this research work to the end, especially, Mr. Emmanuel (Awesome daddy) & Mrs. Vera Aniemeke. Thank you for your support. I appreciate it a lot. A special thanks is given to my dearest husband, Mr Ughaghare Iteke for his patience, love, support, and encouragement throughout the period of writing this thesis, God bless you immensely for me. You are indeed my precious.

I want to also appreciate my little angel, Oghenerume Samuel Chimdiebube Iteke for his patience as I write my thesis, God bless you my son.

I want to say a big thank you to my elder sister Natachi Ahanonye (Natie) for caring for me as I put my work together, I really do appreciate you.

My appreciation goes to my dear girl Ijeoma Joy Oguledo as she assisted me with the care of my son and for her patience.

A very big thanks to all my siblings (the Ahans) for their support and moral boosting, I LOVE YOU ALL.

A special thanks to the National Research Foundation (NRF) for sponsoring this project financially. Also, to all the teachers who found time to complete the questionnaire and the principals who permitted me to undertake this research in their various schools. I appreciate the

school ethics committee for granting me clearance to undertake this research. My appreciation also goes to the GDE for granting me permission to conduct this research in the Gauteng province.

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LIST OF ABBREVIATION

ANC	African National Congress
C2005	Curriculum 2005
CAPS	Curriculum Assessment Policy Statement
DoE	Department of Education
FET	Further Education and Training
GET	General Education and Training
IK	Indigenous Knowledge
IKS	Indigenous Knowledge Systems
LO3	Learning Outcome 3
NCS	National Curriculum Statement
NOIKQ	Nature of Indigenous Knowledge Questionnaire
OBE	Outcomes-Based Education
RNCS	Revised National Curriculum Statement
WS	Westernized Science
GDE	Gauteng Department of Education
DBE	Department of Basic Education
NOS	Nature of Science

Chapter One
Introduction to the Study

This study explores teachers' Indigenous Knowledge (IK) and the possibilities of integrating such knowledge with Life Sciences teaching and learning in the classroom context. The teaching and learning of Sciences in schools in South Africa can be challenging for teachers and their learners (Scott, 2008); therefore, the focus of Science education is to make Science accessible and attractive to study for learners in the classroom (George, 2013). In most South African schools where Eurocentric Science worldview is taught, integrating IK in the curriculum is an imperative component in modern Science teaching and learning (Department of Education, 2002, 2005), because "integration of IK into the Science classroom might make Science more relevant to learners in culturally diverse classrooms" (Cronje et al., 2015, p. 319). In this chapter, I provide the background, rationale, significance, and problem statement to this study. I also provide the forms of knowledge and the curriculum in relation to teachers' IK.

IK is the local knowledge of the indigenous people (Dei, 1993; Ogunniyi, 2011). Some researchers use the term Indigenous Knowledge (IK) and/or Indigenous Knowledge System (IKS) (Kaya & Seleti, 2013; Odora Hoppers, 2001; 2002), traditional knowledge (Ogunniyi, 2011; Senanayake, 2006), local knowledge and aboriginal Science (Barnhardt & Kawagley, 2005) interchangeably to describe concepts that are closely related. This makes it difficult to provide a common definition of IK considering the diverse culture of the indigenous people, hence giving IK a fixed definition could create confusions and problems due to the various cultural groups involved (Abrams et al., 2013). IK is local knowledge (Hewson & Ogunniyi, 2011). IKS is a particular type of knowledge and skills that is possessed by certain kinds of

people in a particular area/location. This knowledge (IK) enables the dwellers of that location to relate and get the most out of their environment (De Beer & Whitlock, 2009).

Although IK has been in existence for a long period of time, it has only started to emerge in Science education domains about three decades ago in the African context (Anwar, 2011). Currently, much focus has been placed on the values of IK as a result of its importance in relation to preserving the cultural heritage, environmental sustainability and development and challenging marginalization by colonial hegemony. In addition, the curriculum emphasized the importance of IK in post independent South African curriculum particularly in relation to the Learning Outcome 3 for National Curriculum Statement (NCS 2003) and Subject-Specific Aim 3 of the Curriculum and Assessment Policy Statement (CAPS 2011). For example in the NCS (2003) document policy, the LO3 (Life Sciences, Technology, Environment and Society) indicates that "The learner is able to demonstrate an understanding of the nature of Science, the influence of ethics and biases in the Life Sciences, and the interrelationship of Science, technology, indigenous knowledge, the environment and society" (DoE, 2003, p. 16). However, in the CAPS policy document, it states that "the applications of Life Sciences in everyday life, as well as understanding the history of scientific discoveries and the relationship between indigenous knowledge and Science" (Department of Basic Education, 2011, p.13). As Nakashima et al. (2000) posited, integrating IK with the school curriculum will help to sustain IK in indigenous communities in Africa. From the period of colonialism (Racial segregation and white supremacy) and then apartheid in 1948 (which maintained the law of white supremacy by maintaining colonial British educational system) in South Africa, African learners were marginalized of their IK (Kallaway, 1984; Shizha, 2005), such that Science was taught to the learners in a Eurocentric way in schools to serve the interest of the colonialist (Abdi, 2005).

Colonial Education in South Africa

During the colonial era in South Africa, in the late 17th century, the first European schools were situated and established in the Cape Colony by 'Dutch Reformed Church elders' who were missionaries. In the rural areas, basic maths and literacy skills were taught to the people by the missionary teachers (meesters) but were not taught as school subjects. However, the British schools flourished in 1799 during the arrival of the 'London Missionary Society' in Cape Colony (Byrnes, 1996).

In 1820, the British established their presence fully in the Cape Colony by encouraging families to relocate to the Cape Colony from Britain and by selecting families that were educated beginning of segregation. After their (British) arrival, the British placed a high priority on education. During the 19th century, many religious schools situated in the Eastern Cape admitted the South African (Xhosa) learners seeking for admission. But after the mid-19th century, most parents from the other Nguni-speaking parts of Natal sent their children to the mission schools. Teacher training classes were also funded by the government for Africans who were interested during this era (Byrnes, 1996).

By 1827, the use of English language as a means to acquire education was prominent and it became an educational issue among Afrikaners. By educational issues, I meant that the Afrikaners believed that English language and the curriculum were irrelevant to their people and their rural lifestyles and values. Therefore, they resisted the policies laid down by the government throughout the 19th century because it promoted the British values and English language, and the Afrikaners educated their children in the church and at home (Byrnes, 1996).

Byrnes (1996) posited that due to this resistance by the Afrikaners to British education, enrolment in public schools became poor. In 1829, a multiracial South African College was established by the government which eventually became a university (University of Cape Town). In early 1841, few Africans who applied to the religious seminaries were accepted into the institution. The British in 1852 gave Afrikaners the right to establish their own higher learning institutions which was funded by the incoming governor (George Grey) as at that time. In 1877, the schools in Natal already enrolled 60% of learners who are of age, while the Cape Colony had 49% learners who enrolled into the school. But within the Afrikaners republic, enrolment rate in the Orange Free State remained 12%, while the Transvaal had 8% enrolment rate (Byrnes, 1996; Kallaway, 1984).

According to Byrnes (1996), towards the end of the 19th century, the British government decided to give the Afrikaner parents control over schools (primary and secondary) and included Afrikaans as a language in the schools, then enrolment increased in the public schools (Transvaal and Orange Free State). Towards the late 19th century, there were already three different types of schools; the district schools (primary level), rural/ward schools and the secondary schools situated in the large cities. During this time (19th century), African children were later prohibited from enrolling into government schools in all the four provinces (Natal, Cape Colony, Orange Free State & Transvaal). Therefore, the African learners attended the mission schools where they were taught by the clergies, while the government funds were used to educate the white people in all the provinces, which were a form of marginalization by the government (Byrnes, 1996).

Apartheid Education in South Africa

After the Afrikaners won the election in 1948, new recognition was given to Afrikaans by the National Party (NP), therefore graduates from the high school were required to have proficiency in both English and Afrikaans. In 1953, there was a gap in the educational opportunities because of the Bantu Education Act, and the educational opportunities given to the black people limited them to work in the labour market (Kallaway, 1984). The control over the missionary high schools by the government tightened, and the financial aid that was given to the missionary schools were reduced (Fataar, 1997). The missionary schools that the black people had access to were forced to close, leaving them with no education and inadequate funding (Ocampo, 2004). Furthermore, as a form of marginalization, some established universities such as University of Cape Town and University of the Orange Free State, were prohibited from accepting Black learners into the institution by the 'University Education Act' (UEA) in 1959, even though the institution was meant for Coloured, Black, and Indian learners.

The "Afrikaans medium decree" established in 1974 by the Bantu Education and Development minister stated that all the black secondary schools must use English and Afrikaans as a language of instruction (Alistair, 1976). It was decreed that English should be the language of instruction for practical subjects and Physical Sciences, Afrikaans for Social Science subjects and Mathematics, and the learners' mother tongue should be used in teaching cultural subjects and music in schools. The reason given for this decree by the minister was that the use of English and Afrikaans in schools was to make sure that the black learners could effectively communicate with Afrikaans and English-speaking white people (Byrnes, 1996). Teachers and learners in township schools such as Soweto where Afrikaans was not spoken were further disadvantaged by this decree. Issues about this language use in education arose which lead to student uprising

on the streets of Soweto and other towns on the 16th of June 1976 in South Africa (Alistair, 1976). Learners demanded that they would prefer to be taught in their native language, therefore, due to this uprising, 575 people including children lost their lives, while some were severely injured as the police tried to intervene with violence. Schools were destroyed and learners and teachers were unable to attend schools due to attacks from protesters (Alistair, 1976).

In 1984, there was an improvement in the education for the black people in the "national policy for general affairs", but the call for separate education, which led to Bantu Education System was still maintained. The Bantu Education Act was created in 1953 to ensure that most blacks who were left out of education received education, especially for cheap labour (informal education). As a result of this act, the 'minister of national education authority' had the power to control the general policy for examinations, syllabuses as well as certification qualifications in both formal and informal educational institutions. Various government offices and departments were given the responsibility of implementing the policies, which was divided among them. This caused disarray in the arrangement of the educational authorities. During this time, education for the blacks outside the homelands was the responsibility of the Department of Education and Training, while one education department was responsible for the three houses of parliament (for the Whites, Indians & Coloured), as one racial group.

According to Ocampo (2004) education was made compulsory by the government for all the racial groups, although the laws were made differently at different ages. For example, the law mandated the black learners to attend school from seven years of age until grade seven or the age of sixteen, the white people were mandated to attend school from age seven to sixteen, while the coloured and Asian learners were mandated to attend school from age seven to fifteen. The inequality in education was obvious among these racial groups. The population of pupils in each

primary school differed in the sense that, the pupils in the White schools were 18 per class, 24 in Asian schools, and 27 in Coloured schools and 39 in Black schools. Also, 96% of White school teachers were certified, while only 15% of the teachers in the Black schools were certified, which influenced the quality of teaching at these schools (Ocampo, 2004).

The South African president, P.W. Botha (1984-1989) in 1986 made a statement that stated that “the concept of apartheid was "outdated," and behind-the-scenes negotiations had begun between government officials and imprisoned ANC leader Nelson Mandela. The gap between government spending on education for different racial groups slowly began to narrow, and penalties for defying apartheid rules in education began to ease” (Byrnes, 1996). While preparing for independence in 1993, educational experts were gathered by the president to “formulate a policy framework for restructuring education” for the post-apartheid era. After independence, during the post-apartheid era, all public primary and secondary schools for Whites, Blacks and Coloureds were officially integrated as the new school year began in 1995. Without violence, the first stage of transformation in education began. By mid-1990s (post-apartheid) the number of South African major universities rose to twenty-one and were all financed by the government and opened to all racial groups (Black, White and Coloured (Indians) (Byrnes, 1996).

Post-apartheid Education System in South Africa

In South Africa, after independence in 1994, there were radical changes in the educational system, which caused a great shift in the curriculum, from content-based to an outcome-based curriculum. The apartheid curriculum was termed as a content-based, teacher-centred curriculum which encouraged rote learning as the teachers played the role of a

knowledge transmitter rather than a facilitator (Jansen & Taylor, 2003). Jansen (2001) posited that in late 1994, the process of the curriculum revision,

> Was presented as an attempt to alter in the short term the most glaring racist, sexist and outdated content inherited from the apartheid syllabi, which were still widely used in the aftermath of the first post-apartheid elections in April of the same year (p. 43).

Therefore, three national initiatives which focused on schools were introduced by the South African Department of Education in 1994. The department made the first attempt at eliminating the racist and outdated content of the apartheid curriculum. Secondly, a continuous assessment was introduced into the curriculum. Thirdly, an outcome-based curriculum policy (OBE) emerged. The apartheid curriculum was replaced with Curriculum 2005 (C2005), an outcome-based education policy document. In 1997, the C2005 was launched by the minister of education in Cape Town and was later reviewed in 2000 by the committee that was set up by the minister of education.

The Department of Education (DoE, 2003) posited that for the demands of the multicultural context of the school to be met as well as the needs to change its curriculum, the Revised National Curriculum Statements for R-9 (RNCS 2002) was provided. Also, the national Curriculum Statements (NCS 2002) (DoE, 2003; DBE, 2011) and the new Curriculum and Assessment Policy Statements (CAPS 2012) were provided as well (more information will be provided in the next section). In the Learning Outcomes (LO) outlined in the South African curriculum (NCS 2002) for Life Sciences, the value of IKS was emphasized. For example, the LO3 in the curriculum emphasized on the learner being able to "demonstrate an understanding of the nature of Science, the influence of ethics and biases in the Life Sciences, and the

interrelationship of Science, technology, indigenous knowledge, the environment and society" (DoE, 2003, p. 12).

The Subject Specific Aims of the curriculum relate to understanding the content and making connections, doing practical works and investigations in biology, understanding the history and nature of Science (NOS) and being able to apply the acquired knowledge of Life Sciences in everyday life (DBE, 2011). However, the Subject Specific Aim 3 of the CAPS policy document "relates to understanding the applications of Life Sciences in everyday life, as well as understanding the history of scientific discoveries and the relationship between indigenous knowledge and Science" (DBE, 2011, p. 13). This can be related with the general aim of the CAPS document. In relation to the learning outcomes and subject specific aims, the curriculum calls for the inclusion of IK into the Science classroom to promote "knowledge in local contexts, while being sensitive to global imperatives" (DBE, 2011, p. 4). More information will be provided in the next section.

Identifying Indigenous Knowledge

In the rural communities, most African learners already have scientific and engineering skills, either by going to the farm, playing on the fields or streams in their daily lived experience (Avery, 2013). Ogunniyi (2011) posited that:

> It is common experience that even before studying school Science most African learners particularly in the rural areas have accumulated a wealth of holistic knowledge about their environment (e.g. classification of plants and animals, weather conditions, soil types, seasonal changes, tracking games, various methods of conservation, finding water sources, cures of a congeries of diseases, etc.)

> which school Science with its compartmentalized disciplines have tended to displace rather than accommodate (p. 106).

What Ogunniyi (2011) was trying to say was that every African including the teachers is embodiments of IK, which has been marginalized by the ways in which Science is taught in the classroom. Most Science teachers were trained using the Eurocentric methods of learning Science which could limit the ability of Africans to incorporate Indigenous Knowledge into the teaching and learning of Science in the classroom for African learners (Garroutte, 1999). Also, according to Schallert (2002) the background knowledge of an individual, known as prior knowledge "is a collection of "abstracted residue" that has been formed from all of [his/her] life's experience'' (p. 557). However, every individual has different indigenous experiences; therefore, not all of these individuals identify and interprets knowledge the same way. People who originate from the same culture or different indigenous cultures do not produce the same knowledge (Kincheloe & Steinberg, 2008) due to their diverse cultural background and individual differences. According to Le Grange (2007) how effective learning is will depend on the understanding a teacher has on how to integrate Science and IK, as well as being able to manage concepts related to both knowledge. My goal is to explore teachers' IK, heighten teachers' awareness of IK and elicit from them the possibilities of integrating such knowledge with their Science teaching just like the NCS 2005 and CAPS 2011 mandated them to do.

Background to the Study

The background of this study is based on understanding teachers' IK and the possibilities of integrating such knowledge with Life Sciences teaching in alignment with the curriculum redress. I review various literatures on the integration of IK and Westernized Science, and how this knowledge integration affects individuals from different cultural background in the Science

classroom. I explore the stated policies (NCS 2005 & CAPS 2011) on what, why and how teachers should incorporate IK into Westernized Science teaching and learning. I examine the equity issues of redressing the implementation of IK in the curriculum.

The South African curriculum

The C2005 (post-apartheid curriculum) was the first initiative as an outcome-based approach, which was meant to unify subjects into various learning areas. The intention behind this new initiative was for a new South Africa whose citizenry could create advocacy for democracy, social unity, and a dedication to growing the economy. For this reason, Maodzwa-Taruvinga and Cross (2012) viewed C2005 (OBE) as a curriculum that was compromised, as it captured and reflected elements of traditional essentialism (teaching the basic and essential academic knowledge), progressivism (focusing on learners' needs) and constructivism (learner-centred teaching approach). The authors posited that "in its intent, C2005 was a dramatic departure from the authorization subject and teacher-centred apartheid curriculum and pedagogy, as it marked a paradigm shift from a subject-dominated to an integrated curriculum with an active learner and a facilitating teacher" (p. 128).

Then, C2005 was developed to "offer equal educational opportunity for all" and "establish the socially-valued knowledge to be transmitted to following generations" (Dada et al., 2009, p. 11). However, the implementation of this policy was not achievable because of the flaws in the curriculum criticisms made regarding the policy. As at early 2000, it was discovered that C2005 had significant flaws which was obvious. From the report review assembled by Dada et al. (2009) the flaws found with this curriculum was learners' inability to write, read and count numbers at the right grade level. Also, it was realized that C2005 lacked general knowledge and it shifted away from "explicit teaching and learning to facilitation and group work" (p. 12). The

authors reported that with C2005 “teachers did not know what to teach”; therefore, a review of the curriculum was called for by the media and academics. A review committee was setup by Professor K. Asmal in 2000, who was then the minister of education to inspect the criticisms made by academics and give recommendations on how it can be resolved. The committee was mandated by the minister to implement whatever recommendation given for C2005 review. C2005 was revised and then the Revised National Curriculum Statement (RNCS, 2002) and National Curriculum Statement (NCS 2002), specific to a particular subject were launched (DoE, 2003; 2009).

The RNCS and NCS (2002) curriculum were not new per se, they were a product of the revised C2005, the difference was that they had fewer implementation guidelines, outcomes and curriculum features compared to C2005. The cabinet in 2004 adopted the policy of the South African Indigenous Knowledge Systems (IKS) with the view of recognizing, developing, sustaining, promoting and protecting the Indigenous Knowledge Systems in the country (Department of Science & Technology, 2004; Department of Education, 2002).

After the launch of the two curriculums (RNCS & NCS 2002), issues of implementation emanated, and there were challenges and weaknesses found with the curriculum, teachers critiqued and complained, and then the policy was reviewed in 2009. For the implementation of the new curriculum to be improved, the NCS was revised; the content of both RNCS and NCS (2002) for grades R-9 and 10-12 were merged into a single document known as the Curriculum and Assessment Policy Statements (CAPS) for individual subjects (Department of Education, 2002; 2009), and the revision became effective in January 2012. The aim of the CAPS (2012) document was to support all teachers and to help them in addressing the complex nature of the

curriculum and assessment policy ambiguity (DoE, 2003). Instead of the learning outcome as stated in the NCS, it was replaced with 'Broad Subject Specific Aims' in the CAPS document.

Outcome Based Curriculum (OBE). South African educational system adopted an outcome-based education (OBE) in the late 1990s from Australia to ensure quality and inclusive educational experience for all learners of different socio-cultural backgrounds. "Outcome-Based Education means clearly focusing and organizing everything in an educational system around what is essential for all students to be able to do successfully at the end of their learning experiences" (Spady, 1994, p. 12). The outcome-based curriculum encouraged activity-based and learner-centred approach to education. The OBE has 3 outcomes and the third outcome known as Learning Outcome 3 (LO3) for Sciences mandated the integration of IK with Science teaching in the classroom to make Science more meaningful and relevant to learners from different socio-cultural background (DoE, 2003). While the Specific Aim 3, "relates to understanding the applications of Life Sciences in everyday life, as well as understanding the history of scientific discoveries and the relationship between indigenous knowledge and Science" (DBE, 2011, p. 13).

Learning Outcome 3 (LO3) was replaced by Specific Aim 3 in the CAPS document, Grades 10-12 Life Sciences and it was a problem for teachers. And the problem related to understanding "the applications of Life Sciences in everyday life, as well as understanding the history of scientific discoveries and the relationship between Indigenous Knowledge and Science" (Department of Education, 2011, p.13). Ogunniyi (2007a) is of the opinion that for the life of the South Africans to be improved, there is need to revive and utilized the lost value and wisdom of the indigenous people through Indigenous Knowledge.

The Knowledge Gap for This Study

To achieve the idea of integrating IKS and Westernized Science, several studies have been conducted on Science teachers' IK and its integration with classroom Sciences. For example, Ogunniyi (2006) in his goal to know how teachers understand the Nature of Science (NOS) and Nature of Indigenous Knowledge Systems (NOIKS), developed "a history, philosophy and sociology of Science course" to enhance teachers' understanding of the NOS and NOIKS (p. 120). An instructional approach that is reflective, dialogic, critical and discursive was used to enhance teachers' ability to incorporate Science and IKS. The study was based on argumentation theories (evidence-based argumentation theory, the agential realism theory and the contiguity theory). Ogunniyi (2006) interpreted the contiguity theory as "a dialogical framework for resolving the incongruities that normally arise when two (and sometimes more) competing ideas or schemata e.g. Science, IKS, religious beliefs or cultural norms clash" (p. 118). Ogunniyi (2006) posits that an internal argument arises when there is a clash in schemata (Science and IKS) at the "micro neuro-psychical level" and macro level "between competing ideas in the working memory where consciousness is assumed to be most active" (p. 118). He constructed an instrument which he used to understand teachers' IKS and NOS and to find out whether the participating teachers hold on to a worldview of the NOIK or the scientific view. Ogunniyi and Hewson (2008) conducted similar study on teachers' integration of Indigenous Knowledge and Science using the "Contiguity Argumentation Theory (CAT)" and "Toulmin's Argumentation Pattern (TAP)" (p. 161). The CAT and TAP were introduced into an interactive lecture. The CAT was useful for interrogating the conceptions teachers had of IKS and NOS, while their views of NOS were explored using TAP. This study was carried out to understand how the participants' views of IKS could affect the integration of IKS and Westernized Science

through argumentation. Also, in the study conducted by Dziva et al. (2011) on the teachers' conception of IK in Science curriculum, their concepts illuminated the views teachers have of IKS, why they have such views and the role they think IKS could play in their teaching.

However, there have been deliberations about how the content of the South African curriculum incorporates the impacts of both IKS and Westernized Science in the classroom teaching and learning of Sciences. According to Shizha (2008) the negation of alternative ways of explaining the world is a form of cognitive colonization that denigrates some forms of knowledge. The author indicates that the IKS and Westernized Science are incorporated in the Science teaching and learning, they align themselves with the learners' experiences that are characterised by their sociocultural worldviews. Aikenhead (2001) posited that to ensure effective teaching and learning of Science in a culturally diverse classroom, it is important that a teacher provide learners who are from the indigenous context with the opportunity to learn Science from their culturally diverse worldviews.

In spite of the call that the colonized curriculum be changed, it still remained unchanged even after independence (Abdi, 2003), that is, the shift from Eurocentric explanations of Science and the school pedagogy was little, and the nature of the curriculum remained similar to that of the Eurocentric curriculum (Shizha, 2005). South Africa is not the only country calling for the inclusion of Indigenous Knowledge in their curricular. According to Aikenhead (2001) and Mckinley and Stewart (2012) so many other countries whose traditional knowledge system have been subdued by the western knowledge also calls for the integration of IK and other knowledge systems in the curriculum, for example, India, Nigeria, Zimbabwe, Canada, etc. In the South African curriculum, 'why' IK should be incorporated with Science in the classroom is elaborated on, 'what' IK should be taught in the classroom is mentioned in few concepts but not in details,

while ‘how’ IK should be incorporated in the Science classroom is silent. This ‘how to’ could be an impeding issue for teachers to be able to implement this call for inclusion. This issue of ‘how to’ incorporate Indigenous Knowledge in the Science classroom is yet to be fully explored by Science educators, and that is the gap my study intends to fill. In the next section, I explore the two forms of knowledge (IKS and WS) for teaching in the Science curriculum.

Forms of Knowledge

Indigenous Knowledge (IK) and Western Science (WS)

Knowledge happens as a result of an experience gained by individuals directly or indirectly, and it varies from one individuals’ experience to another within their culture and context. According to Odora-Hoppers (2009) “Indigenous Knowledge Systems is referred to in different ways in different parts of the world, under different circumstances. South Africa recognises ‘Indigenous Knowledge Systems’ as systems of knowledge in philosophy, Science, technology, astronomy, education, mathematics, engineering, etc, that are grounded in the total ‘cultural’ heritage of a nation or society and maintained by communities over centuries” (p. 609). However, Cobern and Aikenhead (1997) posited that Science is a ‘subculture of western or Euro-American culture’, therefore, “western Science is can also be called subculture Science” (p. 3). Science has no single definition due to its complex nature, but Gilbert (1991) views western Science “as a process of constructing predictive conceptual models” (p. 73). People hold different worldviews regarding WS and IK. However, Hewson and Ogunniyi (2011) view IK as that which existed in the non-western world before the beginning of colonialism; it is the everyday knowledge of the common people about their everyday life experience.

According to Odora Hoppers (2009) in most part of the world where colonialism and European nationalism was deeply rooted, for example, in Africa, "all the knowledge systems that people had used for generations were unilaterally declared unfit, irrelevant, primitive, or even evil" (p. 609). Therefore, in South Africa today, the Science taught in schools is basically from the Western Science point of view (Botha, 2012), which focuses on developing learners' scientific literacy in schools. Odora Hoppers (2004) and Onwu and Mosimege (2004) posit that regardless of the strong motivation for IK to be incorporated in the intended policy document, as well as acknowledged worldwide as a system of knowledge, its validation and acceptance still causes issues among educators, scientists and learners. Because people share different worldviews, this could be an impediment to its inclusion into Science teaching. My study will therefore explore teachers' IK, and their views of the possibilities of incorporating IK into their Science teaching. This section would be discussed further in the next chapter.

Rationale of the Study

The purpose of my study is to explore teachers' IK, generate awareness of IK use, and elicit the possibility of using this knowledge in their teaching of Life Sciences in the classroom to improve Science teaching and learning for indigenous learners. Most research exploring the reasons behind indigenous learners' inability to perform well in assessment or in their Science classroom focuses on the "the epistemological basis of knowledge construction of Science and indigenous Science" (Abrams, et al, 2013, p. 2). In the learning outcome 3 (LO3), the curriculum mandated the teaching of Science in schools to be taught within the context of learners' cultural and societal knowledge (DoE, 2003). However, Ramorogo and Ogunniyi (2010) posited that Science teachers have faced issues of implementing LO3 on the inclusion of Indigenous Knowledge into Science in their classrooms since the inception of the new curriculum. From the

inception of C2005, the Department of Education (DoE, 2003) called for the inclusion of IK into Science classrooms because: first, the experiences, wisdom and the ways that the South African indigenous people used and implemented their knowledge in preserving and sustaining their environment over centuries are reflected in IK; second, due to colonization, most of the practical skills, wisdom and knowledge of the indigenous people since 300 years ago is believed to have gradually diminished and eventually lost due to marginalization. Therefore, there is need to rediscover as well as inspect the value and relevance of IK presently for South Africa and perhaps in Africa at large.

Odora Hoppers' (2009) conceptualization of IK as an inclusive knowledge in alignment with Onwu and Mosimege (2004), explains that "Indigenous Knowledge is an all-inclusive knowledge that covers technologies and practices that have been and are still used by indigenous and local people for existence, survival and adaptation in a variety of environments" (p. 2). IK as viewed by scholars such as Ogunniyi (2007a) and Odora Hoppers (2004) is a knowledge that is changing as it is evolving and developing (non-static), and is obviously influenced by its interaction with several other knowledge systems as well as circumstances both externally and internally. Due to its evolving and developing nature, Onwu and Mosimege (2004) posit that it deals with contexts and content in other fields such as engineering, agriculture, "medicinal and indigenous plant varieties" and other "social systems" (p. 2).

Ogunniyi (2011) is of the opinion that every individual has different experiences of their culture, environment, and belief, to mention a few, but most teachers are not aware of their IK. For example, as an African student, whenever we travelled to the village (rural region), I would encounter my grandmother and cousins processing palm oil, kernel oil and some village neighbours making black soap for bathing. But I never knew the scientific terms of this processes

and how important they were to the indigenous people in the village until I became an adult. I never knew that this knowledge was indigenous because I saw it as a usual village activity. But during my Science classes, the concepts of saponification, separating techniques were taught by my Science teachers; if only they knew that they could integrate such knowledge while teaching these concepts, it would have helped me and other learners in the classroom with similar experience, because then we would have been able to relate the concepts to our experience of such processes. This could be the same for most learners and teachers who grew up in the rural area and learnt Science in Eurocentric ways of knowing, since our Indigenous Knowledge was marginalized and we were made to believe that there was only one way to learning Science. This entirely means that every individual including the teachers already have Indigenous Knowledge and their knowledge might enable them to use it to teach Science meaningfully to learners who have the same experience as I did. This shows the level at which our African ways of knowing (IK), language and identity have been marginalized and deemed unfit to be used as a worldview. In South Africa, the studies on the implementation of teachers' IK (Ogunniyi, 2004; De Beer & Whitlock, 2009) have been very significant in that they focus on practicing teachers in their classrooms and provide insights into particularly those teachers that will influence the implementation of the integration of IK in the Science curriculum. Integration of IK and Westernized Science into Science teaching according to Hewson and Ogunniyi (2011) will provide learners with relevant foundation for effective Science learning as well as encourage diverse viewpoints of the people in a diverse society. In alignment with this, Lave and Wenger (1991) are of the opinion that effective learning is entrenched within learners' daily activities, their context, culture and geographical and social environment. Learners' construction of knowledge is socially-mediated due to their cultural experience (Stears et al., 2003).

Although, the NCS (2002) and CAPS (2011) policy documents encouraged teachers to incorporate IK into their Science teaching, it needs to be established as to how the NCS (2002) and CAPS (2011) provides guidelines on how teachers should go about this. Therefore, this study explores teachers' IK and their perception about what and how they integrate IK as part of their teaching practice in their diverse classroom. Furthermore, it is anticipated that this study will contribute to the knowledge and practices of integrating IK in the curriculum content (Life Sciences) by providing recommendations of how teachers could integrate IK in their classroom. It will also help in documenting some of the cultural knowledge obtained from the teachers to enable learners to have access to diverse cultural practice to enhance Science learning.

Significance of the Study

The implementation of integrating IK and Science by Science teachers is yet to be fully understood, and several researches are still being carried out regarding the use of this knowledge (Hewson, 2008; Ogunniyi, 2007a & b). Various studies on the implementation of integrating IK have been carried out recently; for example, Naidoo and Vithal (2014) looked at the approaches teachers adopted in integrating Indigenous Knowledge into their Science teaching. Furthermore, Ogunniyi and Hewson (2008) examined the methods teachers adopted in integrating IKS into their Science using argumentation-based courses; while Ogunniyi (2013) investigated the training of teachers on how to integrate Indigenous Knowledge in the Science classroom. In addition, Keane (2008) studied some community members and schools in Kwa Zulu-Natal. The purpose of her study was to understand what hope the indigenous community had for IK and what knowledge is appropriate for inclusion in the curriculum policy for integration. However, some studies, such as Aikenhead and Huntley (1999) and Dziva et al. (2011) investigated the views and conceptions of teachers regarding the integration of IK and its relevance in the

curriculum and classroom. However, what and how teachers should incorporate IK into their Science teaching is yet to be adequately explored. According to Naidoo (2007) inadequate resources are provided for teachers to support them, and this is because in South Africa, the textbooks provided for Science teachers have no cultural inclusivity for their classroom activities. For example, the Science textbooks have more of the Eurocentric examples and classroom activities, names of organisms, or scientific processes are mostly written in scientific terms, and so on. Although, the CAPS (2011) document indicated the inclusion of IK into the teaching and learning of Science, however, it does not state how the teachers should integrate IK with their Science teaching. Therefore, the significance of this study was to focus on the Life Sciences teachers' IK, and what and how they integrate Science and IK into their teaching practice in the Science classroom. Furthermore, by eliciting Science teachers' understanding of IK, this study also provides insights on the awareness the teachers have regarding IK, as well as to find out whether this knowledge was developed through their lived experiences. This study, which investigated the IK of teachers and how they intended to incorporate such knowledge into Life Sciences teaching and learning, might be relevant for Science teachers who find themselves teaching in multicultural classrooms. Since IK has not yet been well documented and made easily available to teachers in schools, even though it exists, this study documents the views of Science teachers on the possibilities of integrating IK in the classroom.

Problem Statement

Recognizing IK in education signifies the acknowledgement of diversity in agreement with the South African constitution. According to Horsthemke and Schafer (2007) issues regarding whether IK is required for inclusion in the curriculum in some communities have been raised. However, in the learning outcome three (LO3) of NCS policy document for Life

Sciences, integrating IK was encouraged in order to achieve a culturally relevant teaching and learning practice, by considering learners of different cultural backgrounds (DoE, 2003). According to the DoE policy (2003), the inclusion of IK in the Life Sciences for grades 10-12, was intended to reveal "the interrelationship of Science, technology, Indigenous Knowledge, the environment and society" (p. 16). The Curriculum and Assessment Policy (CAPS), as the most recent reformed document introduced in 2012 continuously make provision for IKS (Department of Basic Education, 2011). CAPS acknowledge teachers difficulty in implementation of IK in teaching, and thereby recommended that teachers give relevant examples that can be connected to each scientific concepts, and these concepts should be related to the cultural and societal context of learners to curb the conflicts that might emanate between the Science concepts views and the views of the learners. According to Naidoo and Vithal (2014) in South Africa, there is a shift in the debates regarding "why Indigenous Knowledge (IK) and IKS should be included in Science to considerations of 'how' they could be integrated, and about the pros and cons of managing different worldviews—IKS and Western modern Science—and their meanings and place in curricula" (p. 253).

However, Ogunniyi (2007a) in his study with teachers' integration of IK, found that, although teachers understood, knew the value and the need to integrate IK into their classroom teaching, most of them still struggle with the inclusion of IK into their Science classroom teaching and learning. One of the reasons identified by (Ogunniyi, 2007a) is that most teachers learned Science within the framework of Westernized knowledge, therefore; they may not have the knowledge of 'how' to use it in the classroom. Before IK could be integrated in the Science classroom, the teacher needs to have a level of IKS to help the learners to learn what they are doing. Teachers have IK, but do they know how to implement such knowledge is a question to

be asked? However, the policy documents did not stipulate how teachers should integrate IK with Science teaching and learning. Integration of IK into Westernized Science learning could be achieved if teachers understand what knowledge they have and how to integrate such knowledge into their classroom teaching. It is on this ground that my study intends to generate teachers' understanding of IK, the awareness they have of their knowledge and their perception on the possibilities of integrating such knowledge into Science teaching. What is to be integrated on one hand and how it should be integrated on the other hand could be investigated.

Aim of the Study and Research Questions

The purpose of this study was to explore, analyse and document the IK of Life Sciences teachers, what and how they intend to integrate such knowledge in their teaching and learning practice. In addition, the study intends to understand their views regarding the possibilities of incorporating IK with their Science teaching and learning in selected school settings in Gauteng Province of South Africa. My study also aims at generating awareness in teachers who are not conscious of their IK, and those who are aware but not able to incorporate it into their Science teaching. This creates a better understanding of how Westernized Science and IK can be incorporated in the multicultural Science classroom in the South African context.

My study investigated various aspects of: first, I explore what IK teachers possess in addition to the possibilities of incorporating it with Westernized Science teaching and learning. This sheds light on understanding and analysing their views of the knowledge, and equipping them further in IK, which is, making them become conscious of their knowledge. This study intends to generate awareness and encourage teachers who are willing to preserve the knowledge

of the people (IK), and also make Science accessible to learners in the classroom. This would contribute also to documenting the IK of the people (Mosimege, 2005).

Secondly, I explored the perceptions teachers have of integrating IK with their Westernized Science teaching. Analysing the policy documents (NCS 2003 and CAPS 2011) helped in revealing what the curriculum says about why, what and how teachers should teach IK in the Science classroom. Thirdly, I planned to work with teachers to adopt and adapt IK resources (cultural artefacts, indigenous tools, products, etc.) for teaching Westernized Science in the classroom; this could have enabled a successful incorporation of indigenous and scientific knowledge in the Science curriculum, thereby enhancing western Science learning among African learners. During data collection, due to limited time, I was only able to discuss some of these teaching methods with teachers, as to which cultural artefacts to use in incorporating IK. I explained to teachers, the simple methods of creating these artefacts and how they can use them to enhance their Science teaching and learning in the classroom. In alignment with this, Naidoo and Vithal (2014) posited that "IKS and WS should be incorporated for the enhancement and growth of scientific knowledge with the proviso of course that what is taught at school is sensitive to the current multicultural classroom" (p. 261).

Fourthly, I was to find out what and how the teachers intended to integrate their IK into their Science teaching and learning. I believe all of these put together will help teachers become more conscious of their IK. According to Brayboy and Castagno (2008) the effect of integrating IK with western Science will enable teachers to reflect on their IK as well as try to identify with and participate in the activities of the local community.

Summary of the Chapter

In this chapter, I have provided a synopsis of the South African history from the time of colonialism, apartheid and post-apartheid. For this study, I present a background on the developments in the South African curriculum, especially the events of the post-apartheid era. I also provided change in curriculum from the apartheid content-based curriculum, C2005 OBE curriculum to the present CAPS (2011) used in teaching Life Sciences and how the curriculum mandates teachers to incorporate IK into their Westernized Science teaching and learning. I present the importance of the inclusion of IKS into Westernized Science teaching and its influence on a culturally relevant teaching and learning practice. The rationale, purpose and problem of the study were outlined in this chapter. The issues of implementation of IKS identified by scholars were also presented; and this study still seeks to address part of this issues.

Chapter Two

Background to the Study and Literature Review

In South Africa, in 1994, the first democratically elected government began concerted efforts to reorganize the education system in order to open up opportunities for the developments of all cultural groups in the country following about fifty (50) years of apartheid system of government. For this recognition to take place, one of the ways adopted by the democratic government was to ensure the introduction of a curriculum that was culturally relevant, with the inclusion of Indigenous Knowledge System (IKS) in the school curriculum (a curriculum common to all). The change in the South African policy helped to redress the marginalization of the Africans' IK by apartheid. According to the Department of Science and Technology (DST, 2004) the reform process encouraged the IK of the indigenous communities of all domains such as the Sciences, tourism, agriculture, health and economics and politics.

In this chapter, I provide brief background of the study by referring to the introduction of the new South African curriculum reform and the challenges of implementation. The introduction of OBE in the curriculum was a way of ensuring learner-centred education in schools by making sure that all learners were involved during teaching and learning processes. I conducted literature review on the definition of knowledge and the funds of knowledge in connection with multiculturalism. After apartheid, the educational system was restructured and the integration of all schools (White (including British & Afrikaners), Indian, Coloured and Black) took place. This made the South African classroom multicultural in nature after the desegregation of schools from White, Indian, Coloured and Black to mixed race. The views of

scholars on multiculturalism was discussed and critiqued in detail in this chapter and how it affects the inclusion of IK in the classroom.

In this chapter, I discuss the background of the study and how funds of knowledge deals with various individuals' cultural backgrounds which leads to the multicultural nature of the classroom and its effect on teaching and learning. It is known that cultural backgrounds influence people's worldviews, and this is also discussed in this chapter. I discuss the different definitions of IK by different scholars, the Nature of Indigenous Knowledge (NOIK) in depth and its relationship to the Nature of Science (NOS) and pedagogy. Teachers' IK and the possibilities of incorporating it into their Science teaching is discussed as well. I discuss the issues emanating from the implementation of IK with Westernized Science and its relevance to Science education.

Background to the Study

Despite the advocacy for the integration of IK and Westernized Science in classrooms globally, there is still a drag in its efficacy in the curriculum reform in most parts of Africa today. However, most literature on the inclusion of these worldviews have expressed that most of the problem could be because of teachers' struggles and inability to integrate both worldviews in the Science classroom (Mpofu et al., 2014). Also, Ogunniyi (2011) posited that this challenge could be because teachers have been taught Science in Eurocentric ways during their teacher training education, and other reasons given by researchers. Additional reasons include, lack of curricular knowledge as most teachers are not aware of the mandate to integrate IK with their Science teaching. Curricular knowledge according to Shulman (1986) deals with understanding different strategies for teaching a specific topic and this includes knowing how to teach and what to teach (content) that has been clearly stated in the curriculum as an organized program. The subject

specific aims of the curriculum deal with understanding the content and making connections with the concepts. This could mean that teachers are expected to have knowledge of the curriculum by familiarizing themselves with the contents of the curriculum (curricular knowledge). Since the curricular reform in 1994, which helped to rid the curriculum of its apartheid content and introduced OBE to encourage social justice for all, teachers have encountered the problem of implementation (Dada et el., 2009; DoE, 2009). However, one of the principles of OBE recognize values of IKS, and part of the specific aim 3 of the curriculum is understanding "the relationship between indigenous knowledge and Science" (DBE, 2011, p. 13), therefore, it encouraged learner-centeredness in the classroom as part of its outcome. According to Vygotsky learner-centeredness deals with learner involvement, that is, the roles learners play in the classroom context in relation to their sociocultural context, to construct knowledge. At this point, learners are allowed the opportunity to know how their culture, experiences, social structures, and histories shape their thought processes (Malcolm & Keane, 2001). In this case, the teacher only helps facilitate the learning process as the more knowledgeable other. The question is, if teachers are not familiar with the content of the curriculum, how then can they understand totally how to integrate IK and Westernized Science worldviews in their Science classroom?

Part of the ideas of pedagogy is for teachers to know their learners, this includes considering their cultural backgrounds and helping learners to cross the borders of Science in the classroom (Aikenhead, 1996). Hence, it is imperative to interrogate how teachers integrate IK with Sciences, to help learners value their IK which they bring from home, so as not to allow conflicting ideas among learners. These vary from learners' diverse cultural backgrounds, lived-experiences, learners' characteristic, and learning styles. The diverse knowledge learners bring from home can be classified as "funds of knowledge" (Ali et al., 2015; Anderson et al., 2017).

Funds of knowledge

The term ‘funds of knowledge’ have been used constantly by many scholars to stress the point on the need to identify individuals according to their personal experience, culture, values, history and interests from their various homes and communities. For example, Ali et al. (2015) and Chesworth (2016) posited that funds of knowledge are that which deals with learners’ potentials and active social and cultural participation in ‘multi-generational activities in their various families, communities, and schools. Funds of knowledge is historically and culturally situated as it deals with learners’ diverse cultural experiences, backgrounds, and interests which they bring with them to the classroom (Chesworth, 2016; Anderson, et al., 2017). I consider these funds of knowledge as essential family and community knowledge that learners bring with them into the classroom which goes beyond learners’ prior knowledge, as it deals with the holistic system within which the individual exists (Chesworth, 2016). This calls to mind the relationship between IKS and funds of knowledge. To my knowledge, IKS cannot be compared with funds of knowledge as they both deal with experiences, cultural and traditional practices of individuals and communities. For example, Science educators like Odora Hoppers (2004), United Nations Educational, Scientific and Cultural Organization (UNESCO), Ogunniyi (2011) defined IKS as a local knowledge, traditional knowledge, context-specific and so on. However, Anderson et al. (2017) posited that “funds-of-knowledge approach to research, learning and teaching involves close consultation and personal experience with families, it offers a powerful way to showcase their existing resources, competence, and knowledge” (p. 2). Funds of knowledge are regarded as all kinds of knowledge an individual has including prior knowledge both at home and in school (Westernized Science). This is not to say that IK does not consider learners’ prior knowledge, but it does not include learner’s experience at school, that is,

their school knowledge. This is why teachers are encouraged to make connections with learners' cultural experience and knowledge while enacting the Science curriculum, to ensure equality and access to Science learning in the classroom and a deeper understanding of the scientific knowledge especially in schools within the rural areas (Zain et al., 2010; Ali et al., 2015; Chesworth, 2016). This indicates that integration of IK with Westernized Science in teaching and learning of Science may help to ensure equality in Science learning for all learners in the classroom.

Globally, there are so many on-going Science education researches on the inclusion of IK in the classroom, for example; the National Research Foundation (NRF) have set aside a project on IK to help Science educators to bridge the gap between Westernized Science and IK, by creating IK awareness among teachers and Science educators, thereby enabling them make Science accessible to all learners in the multicultural classroom. A multicultural classroom is the classroom context which is inclusive of learners from different racial background, culture, and experience (Bhouraskar, 2020) and the teacher also who is an embodiment of his/her culture. In addition, the curriculum encourages inclusive education in all South African schools for "social transformation" and "valuing Indigenous Knowledge Systems". It is on this premise of awareness and inclusion of IK in South African schools that my research is focused on.

The Multicultural Nature of the Classroom

The perception of culture deals with everything that distinguishes a community or a group from another (Perso, 2012), which influences their attitudes, values, language, religion, behaviours, and beliefs that are socially acceptable (Zhou & Brown, 2015). Culture is linked to education because, learners and teachers in a classroom are embodiments of their culture, and it

influences the teaching and learning process in the classroom (Alsubaie, 2015). However, one of the ways culture is constructed is through an institution, hence, for this study my focus is on the school context as a social institution where classrooms are situated. The classroom context is multicultural in nature due to the diverse culture, experience and worldviews of learners and their teachers. According to Jayanthi (2017) "the students in the classroom have been multi-cultural, multi-racial, multi-religious and multi-generational. So, the classroom is always a challenge for the teachers, due to the diversity of children and their approaches, new situations etc". I agree with this statement because teachers have their own culture already, and then they must understand the culture of all the learners in their classroom as well as their individual differences to make teaching and learning successful. According to Taliaferro and Scholar (2003) "Understanding pupil's learning difficulties is a fundamental element in any educational activity, particularly when teachers come from a different community than the students" (p. 240). This indeed is challenging in a multicultural classroom and should prompt the provision of teaching resources that are peculiar to multicultural classrooms. According to Jayanthi (2017) there is need to equip and prepare teachers for these challenges since they are the facilitator of the teaching and learning process in the Science classroom. In addition, Bhouraskar (2020) posited that "Some of the top places that teachers can turn to for support include: school counsellors, principal and national association for multicultural education". All learners must be carried along (learner involvement) irrespective of their culture; however, for inclusivity to take place like the curriculum suggested, there is need to provide equal opportunities in learning Science for all learners from different socio-cultural backgrounds. Due to lack of resources in some schools, especially the rural community schools, the teacher can then plan a lesson and design a program that can help meet the need of the learners in his/her classroom (Bhouraskar,

2020). Teachers can also engage learners in peer to peer discussion where they get to exchange ideas or a question and answer sessions where they get to share their experiences, values of their culture and how they think it relates with Science. This will enable teachers to assist learners in crossing the borders of Science in the classroom (Aikenhead, 1996) without conflicting their ideas of Westernized Science and IK. Incorporating IK with Westernized Science in the classroom is a way of identifying the relevance of IK and recognizing the diverse ways of knowing in the classroom.

Defining Indigenous Knowledge and Indigenous Knowledge Systems

Hewson and Ogunniyi (2011) defined IK as a long existing knowledge of the local people, which existed in the indigenous world before colonization. Abrams et al. (2013) posited that the term IK is interpreted and defined differently by various researchers and organisations. UNESCO defined IK as "culture- and context-specific; non-formal knowledge; orally transmitted, and generally not documented; dynamic and adaptive; holistic in nature; [and] closely related to survival and subsistence for many people worldwide" (Abrams et al., 2013, p. 7). IK has been described also as "the local knowledge that is unique to a given culture or society … the basis for agriculture, health care, food preparation, education, environmental conservation, and a host of other activities" (Abrams et al., 2013, p. 7). In addition, Odora Hoppers (2005) defined Indigenous Knowledge System (IKS) as a traditional knowledge which includes "agricultural, meteorological, ecological, governance, social welfare, peace building and conflict resolution, medicinal and pharmaceutical, legal and jurisprudential, music, architecture, sculpture, textile manufacture, metallurgy and food technology" (p. 3). According to Ogunniyi (2007a) IKS is "a conglomeration…a redemptive, holistic, and transcendental view of human experience with the cosmos…" (p. 965). Hence, IKS is a "combination of knowledge systems

encompassing technology, social, economic and philosophical learning, or educational, legal and governance systems" (Odora Hoppers, 2002, p. 9, 10). Similarly, Odora Hoppers (2005) posited that IK is practiced within a cultural context and this cultural practices she listed includes "songs, rituals, dances and fashion; it also includes technologies that range from garment weaving and design, medicinal knowledge …, food preservation and conservation, and agricultural practices … to fisheries, metallurgy and astronomy" (p. 3). From Dei's (1993) perspective, IK deals with the cultural traditions, worldviews, beliefs, and values of the local people, which distinguish (separate worldviews), it from Westernized Science, because of its philosophical nature. This then indicates that both IK and Westernized Science worldviews differ in their philosophical underpinnings, even though they both have Sciences embedded in them. A quick look at the definition of the term 'worldview' might help to clarify the reason IK and Westernized Science are termed similar or different by some scholars even though they are both worldviews.

Indigenous Worldviews

The term worldview (in its simple terms) is how an individual or a group of people make sense of their world. Worldview is influenced by cultural values, experiences, language and the assumptions people have of their entirety (funds of knowledge) (Nisbett, 2003). According to Hart (2010) worldviews affects how people relate with each other, belief systems, assumptions and how they deal with problem-solving in their everyday life. The assumptions they have and that which others have of them mould how they view themselves and the position they occupy in the world. According to Cobern (2000) just by interacting with people, we are able to understand how they view themselves and the world around them. In addition, he posited that worldview is "culturally dependent, generally subconscious, fundamental organisation of the mind, which manifests itself as a set of presuppositions and predisposes one to feel, think and act in

predictable patterns" (Cobern, 1998, p. 155). Worldview for every individual differs because of their personal experiences (prior knowledge), self-esteem, history and socio-cultural contexts which according to Vygotsky (1986) influence an individuals' cognitive development and processes and behaviours in their environment. This is no wonder people from diverse cultural groups react differently to different situations. The people from the western world have a different view of the universe as compared to the people from Africa; they view concepts from different perspectives and tend to apply solutions to such issues with different mind-set because of their cultural influence. For example, a student from a western world could understand the concept of lightning from the perspective of electrical charges because s/he has been taught in the western way on how these charges take effect. But a child from a particular part of Africa might view the concept of lightning as a force that has been sent by the ancestors to destroy an evil person at that time, this belief system is also influenced by the cultural belief system such child was raised with. However, this affects how an individual construct knowledge (Vygotsky, 1986; Aikenhead, 1996); and how diverse social organisations develop different worldviews due to different social backgrounds. This ideology is common with IK worldviews and Westernized Science worldviews due to their differing cultures, which to an extent have differing perspectives because of their historical and philosophical underpinnings (Barnhardt & Kawagley, 2005; Odora Hoppers, 2006; Ogunniyi, 2011). According to Le Grange (2007) and Ogunniyi (2011) most learners only encounter western worldviews in the school context. However, it is imperative for teachers to be aware and understand the complication that this interaction may cause and help bridge the gap created during this interaction between IK and western worldviews.

Nature of Indigenous Knowledge (NOIK)

Indigenous Knowledge has been in existence from time immemorial, it is known as traditional ecological knowledge (Snively and Corsiglia 2001) but it is tentative, inferential, it can be observed, and it involves social, historical, and cultural context (Le Grange, 2007; Vhurumuku & Mokeleche, 2009). It is suggested that a philosophical framework be developed for a successful integration of IK into Science teaching (Cronje et al., 2015). According to these authors, the nature of IK framework encompasses ontology, epistemology, axiology, volition, and methodological aspects which are interwoven and inseparable. The ontological aspect deals with what IK entails and its meaning; the epistemological aspect involves the ways of knowing of the indigenous people; the volition aspect deals with willingness, values, attitudes and beliefs of the indigenous people; while the methodological aspect deals with "methods of wisdom in action" (p. 322). According to Aikenhead and Ogawa (2007) the perspectives of the nature of IK is multifaceted and it has various characteristics. Just like the NOS, the nature of IK also has its tenets which are suggested in the NOIK framework by several scholars (Cronje et al., 2015; Le Grange, 2007). These authors published the following tenets of Indigenous knowledge.

The Tenets of the Nature of Indigenous Knowledge

According to Ogunniyi (2004) and Le Grange (2007), the first tenet is that NOIK is "Empirical and metaphysical in nature". They both stated that the natural world is real, metaphysical in nature and predictable. "Indigenous observations are monist, and hence, they relate to a metaphysical inner space in systematic ways known to certain Elders within each community" (Aikenhead & Ogawa, 2007, p. 562). By monist these authors mean that the indigenous people deal mostly with entities, metaphysical aspect of their tradition. For example, the traditional or spiritual healers (Sangomas in South Africa) use spiritual powers to concoct

medicine from natural herbs and administer them to the sick through 'trial and error' and when this works, then there is a continuous use of that medicine. This method of healing differs from the conventional Science where all medications are experimented in a confined laboratory and then administered to rats to confirm its efficacy.

Secondly is that it is "resilient yet tentative". IK has been in existence for a long time and has survived from one generation to another (Hewson & Ogunniyi, 2011). It changes as traditions change due to new discoveries in time and space and it is flexible and transformative (Cronje et al., 2015).

Thirdly, IK is "inferential and intuitive". IK also has facts which can be observed and tested. It involves experiments, for example, the process of saponification and brewing of local beer. The indigenous people also observe and test natural and unnatural phenomenon (metaphysical) that occurs within their environment through experiment, and make inferences from them (Le Grange, 2007; Dei, 1993).

Fourthly, IK is "mythical and creative". This can be observed from the creative nature of the indigenous people in crafts, imaginations, reasoning. The myths and metaphors found among the indigenous people also play a unique role in their way of life (De Beer & van Wyk, 2011; Aikenhead & Ogawa, 2007). This occurs as a direct experience with nature in relation to their social world (Dei, 1993). For example, in the community of Shangani in South Africa, a young girl must not have sex at her young age, because if she does have sex, part of her hair will not grow for the rest of her life (personal communication with a teacher during my data collection on the 23rd of April 2019). This myth (a widely held but false belief or idea according to Cambridge dictionary) is creatively used by the elders of the community in the Shangani community to

prevent girls from misbehaving and contracting Sexually Transmitted Diseases (STDs) and Human Immunodeficiency Virus (HIV).

Fifthly, IK is "subjective in nature' "Indigenous ways of knowing are based on cosmology and interwoven with culture and the spiritual. "The elders can be influenced by prior ways of knowing and beliefs" (Cronje et al., 2015, p. 323).

Sixthly, IK is "collaborative, social and cultural in nature". According to Aikenhead and Ogawa (2007) the indigenous people's ways of living involves learning and communicating "in the oral tradition" by participating in mystical rituals, wildfire activities such as singing songs and dancing, storytelling, ceremonial dancing, and "modelling the practices of others" (p. 554). These social and cultural activities are situated in a particular cultural context; can be shared among members of a community and other communities (Barnhardt, 2008) and it is passed onto several generations (Aikenhead & Ogawa, 2007).

Seventhly, the nature of IK displays "wisdom in action". IK deals with everyday life of the local people and the knowledge is accumulated through practical experience by trial and error. It also involves imitations, repetition and ceremonial activities which enables the people to retain and reinforce ideas (Aikenhead & Ogawa, 2007; Cronje et al., 2015, p. 323). Aikenhead and Ogawa (2007) posited that "Indigenous coming to know is a journey toward wisdom or a journey in wisdom-in-action, not a destination of discovering knowledge" (p. 553).

Eightly, the nature of IK deals with "functional application". It deals with the everyday life of the indigenous people, skills and what and why things occur in nature (Agrawal, 1995; Aikenhead & Ogawa, 2007).

Ninthly, it deals with the "holistic approach of Indigenous Knowledge". According to Dei (1993) "it is holistic and an inclusive form of knowledge (p. 105). Several knowledge systems

can be found in IK such as, psychology, Science, religion and so on, it is a "conglomeration of knowledge systems" (Ogunniyi, 2007a, p. 965). For IK, all issues are addressed and solved in holistic ways (Senanayake, 2006). The nature of IK proves that there is Science in IK, just like there is Science in the Westernized Science. The next paragraph on Nature of Science (NOS) and its tenets which is similar to that of the NOIK will help us understand better the relationship between NOIK and NOS

Nature of Science (NOS)

In relation to the arguments concerning IK and western/scientific knowledge, there is need to explore the Nature of Science (NOS) and its relationship with IK. Further explanation on NOS will help in answering the research questions for this study which explores teachers' IK and how teachers incorporate the knowledge in the Science classroom. The aim of Science education is scientific literacy, and it could eventually create impact on the worldview of individuals (Lederman et al., 2013). Lederman (2007) posit that NOS has long been promoted as an essential content in Science education and has been included in several standard documents all over the world. NOS refer to the epistemological and ontological underpinnings of the activities of Science (i.e. scientific theories, history of Science) and the characteristics of the resulting knowledge such as scientific skills and investigations (Lederman, 2007). NOS is referred to usually as the 'epistemology of Science', the beliefs and values that are essential to the progress of 'scientific knowledge' (Lederman et al., 2013) as well as 'Science as a way of knowing' (Lederman, 2007; Michel & Neumann, 2014). These authors posited that because of the complex and multifaceted NOS initiatives or ideas, there is no agreement among the custodians of Science as to how the NOS should be defined. This is because; the notions of NOS have evolved,

judging from the logical thinking about Science (Lederman et al., 2013; Michel & Neumann, 2014). This has reflected in the way scientists, historians of Science, philosophers of Science and Science educators have defined the NOS. Since it is known that NOS is the epistemological underpinnings of the activities of Science, it also involves the processes of Science such as, observation, inferring and scientific inquiry (Lederman et al., 2013). Scientists view NOS as a scientific knowledge that is durable, and its tentative nature depends greatly on experimental evidence which is affected by social and historical contexts. According to Lederman et al. (2013) and Sumranwanich and Yuenyong (2014) there are seven aspects (tenets) of NOS which has been accepted as the most suitable in developing literacy in Science.

The Nature of Science tenets

Firstly, NOS is to "understand the nature of observation and inference". This deals with a descriptive statement regarding natural occurrence that are directly accessible to the senses as well as several observers being able to come to an agreement with ease. For example, observing the growth of a green plant in Life Sciences. The aspect that is inferential deals with the mechanism that is responsible for the plant growth. Such activities could raise the curiosity of learners, thereby making them eager to learn more Science. Bell (2008) posited that Science is concerned with the manifestation of a combination of both the process of observation and inference. Just like I mentioned with the tenets of NOIK, the indigenous people also observe phenomenon and make inferences with that which has been observed in the natural world.

Secondly, NOS deals with the "validation of scientific knowledge", and the provision of empirical evidence to support findings from observational data, that is, scientific knowledge relies heavily on empirical evidence from observed phenomenon to support scientific claims (Bell, 2008; Lederman et al., 2013). An example is the story behind the evolution of humans,

which has been supported with various fossil remains found by scientist. The indigenous people also validate their knowledge by consistent application of new knowledge discovered through observation of their natural world.

Thirdly, NOS involves "scientific methods" which relates with the systematic ways of doing Science. It deals with different ways of doing Science due to the scientist's standard of using several approaches in generating scientific knowledge (Bell, 2008). It involves scientific processes or activities of gathering and analysing data, such as observation and inferring during biological practical (Lederman et al., 2013). Although, IK does not follow the systematic scientific methods outlined by western scientists accordingly, but these processes are followed when they find themselves in the natural world.

Fourthly, NOS involves the "tentativeness of scientific knowledge" which deals with the fact that there is nothing as the 'truth' in Science. This is an indication that laws, facts, and theories are tentative, that is, they are subject to change or can be refuted by providing alternative empirical evidence to the former (Lederman et al., 2013). An example can be drawn from Jean Lamarck's theory of acquired characteristics which at that time did not have any genetic basis. It was later refuted with evidence from Darwin's' theory of natural selection. The tentative nature of IK gives it the benefit of discovering new knowledge through 'trial and error'. The African spiritual healers also discontinue any African traditional medicine or traditional practices that pose threats to the health and wellbeing of the people as explained above in the tenets.

Fifthly, NOS involves "imagination and creativity", and it deals with scientific innovations and incentives in the Science discipline. Although scientific knowledge is based on observations of a natural phenomenon, it also accommodates the human imagination and

creativity. It considers scientists' explanatory skills of an observed phenomenon (Lederman et al., 2013).

Sixthly, NOS involves "objectivity and subjectivity in Science". It deals with scientists' interaction with the object to be observed and the milieu of the phenomenon. According to Bell (2008) there is a place for objectivity and subjectivity in Science, and it involves their experiences, beliefs, previous knowledge, and expectations which eventually impact the production of scientific knowledge (Lederman et al., 2013). This is peculiar with the indigenous people of a locality.

Seventhly, NOS deals with "Laws and theories". These two are separate entities, and several misconceptions have been discovered as to how people believe theories later become laws. Lederman et al. (2013) and Bell (2008) both stated that laws and theories are varied because, one knowledge (theories) is unable to transform to the other (laws). Laws describe the relationships among observable phenomena, while theories are inferred explanations of observable phenomena. Vhurumuku (2010) posited that the perspective of the NOS recognizes the fact that Science is comprised of theories, facts, laws as well as processes, beliefs, investigations, and attitudes as human activities.

Both NOIK and NOS tenets share similarities although they do not undergo same processes. Hence, Aikenhead (1996) and Battiste and Henderson (2000) posited that all culture has Science, that is, Science as a body of knowledge is a sub-culture of Westernized Science and IK. Therefore, in the western and indigenous communities, every individual at some point is a scientist either directly or indirectly through hunting, farming, or fishing. To elaborate more on this, De Beer and Whitlock (2008) and Bell (2008) both stated that Science is embedded in historical processes and cultural assumptions which regulate how knowledge is encouraged and

apprehended. This could mean that Science teachers and their learners also have IK since they have their origins from a particular culture. In addition, Cronje et al. (2015) suggested that there is need for Science teachers to acknowledge the NOIK as contextualized and holistic worldview just like they would with the NOS.

Integrating NOIK with NOS in the Science Classroom

There is need for teachers to have a better understanding of the nature of Science because it influences the way they teach Science. According to Vhurumuku (2010) the ideas, beliefs, and assumptions an individual has regarding scientific processes and knowledge, shows his/her understanding of the NOS. Just like the belief, culture and assumptions of scientists and teachers affect their understanding of NOS and how they teach it; similarly, the beliefs, culture and assumptions of learners affect how they learn NOS in the classroom. During teaching and learning in the classroom, learners' understanding of NOS can affect their attitude towards scientific evidence, whether it supports their belief systems or conflicts with it (De Beer & Whitlock, 2008; Bell, 2008). However, Vhurumuku (2010) posited that the way in which learning opportunities are made available to learners in schools needs a radical change to enable them to achieve a considerable level of understanding of the NOS. To achieve this, one of the suggested ideas by De Beer and Van Wyk (2011) and Coe et al. (2014) was that teachers should adopt the right teaching strategies that could help them impart Science knowledge. Therefore, it is ideal to adopt other knowledge domains such as IK because of its cultural and historical foundations in Science (Ogunniyi, 2011). The CAPS curriculum highlighted a few concepts with 'what' IK should be integrated with Westernized Science in the classroom, however, the 'how' it should be integrated was not stated. Some of the concepts provided in the CAPS document with links to IKS include biomes, fossil formation, biotechnology, and some parts in plant diversity

(medicinal plants) for Grade 10 (DBE, 2011). The integration of IK and Westernized Science enables teachers to link learners' local knowledge to Science, thereby allowing for an improved understanding of the NOS and NOIK in the classroom (De Beer & Whitlock, 2009; Ogunniyi, 2011). However, Le Grange (2007) posited that "For non-Western learners, interaction between two worldviews characterizes much of their school experience, complicating the learning process and potentially resulting in cognitive conflict or as the literature describes it, cognitive dissonance/perturbation" (p. 581). In Africa to be precise, most learners gain their first experience of the interaction between indigenous and scientific views in schools (Ogunniyi, 2011), therefore Science teachers should be aware of such interaction as well as understand the complication it could cause for learners during teaching and learning praxis (Le Grange, 2007). However, the strategies teachers adopt to implement the integration of both worldviews might help to determine the extent of meaning making in the Science classroom.

Teacher's Knowledge and its Effect on Teaching Practice

Nilson (2013) posited that it is becoming apparent that the complex nature of science (NOS) teaching necessitates for further research studies investigating teacher knowledge which influences classroom teaching and learning process. However, with regards to the idea of teacher knowledge Nilsson (2013) posited that "*the complexity of teaching brings into sharp focus the need for more extensive research into the relationship between the different elements that constitute teacher knowledge, and how these are developed and further assessed during pre-service teacher education*" (p. 188). Nilsson's research about teacher knowledge reveals the importance of examining pre-service teachers' development of knowledge for teaching. Teachers' knowledge of a subject influences the means in which they teach individual concept in their discipline, and this knowledge depends on several factors such as: the teachers' pedagogical

knowledge (PK); understanding the nature of science (NOS); subject matter knowledge (SMK); and teacher beliefs (Ekborg, 2005). Mthethwa-Kunene et al. (2015) added that "*through that combination of knowledge, teachers gain a perspective that enhances their abilities to present specific topics in a specific subject area*" (p. 1141). This calls for a proper training of teachers in their subject matter and disciplinary knowledge, at the teacher education level. Teacher education training is imperative because, teachers are facilitators of learning and they play an important role in decision making based on sound science (Ekborg, 2005). If high school science learners' poor conception of Life sciences concepts is as a result of teacher's lack of content knowledge or inefficient teaching strategy, it would not be of good impact if this is not addressed (Rollnick & Mavhunga, 2015). Therefore, there is need to enhance the method used in training teachers during their teacher education training. "Content knowledge generally refers to the facts, concepts, theories, and principles that are taught and learned in specific academic courses" (the glossary of education reform, 2016, p. 1) such as Life Science, and it is "the amount and organization of knowledge per se in the mind of the teacher" (Shulman, 1986, p. 9). In the 2019 diagnostic report on learner's performance in matric, it was revealed that learners are still not making progress in their science learning. Therefore, the minister of education in the 2019 diagnostic report encouraged that "A strengthening of content knowledge in topics such as Reproduction in Paper 1 and Genetics and Evolution in Paper 2, will greatly enhance performance in the subject" (DBE, 2019, p. 139). This is worrisome because, teachers are the main bearers of content knowledge in the science classroom, therefore, the manner at which they are trained is imperative to science teaching and learning. According to Jadama (2014), subject matter knowledge provides basis for the development of content knowledge and thereby shapes teachers' classroom practice. Darling-Hammond (2006) posited subject matter knowledge is one

of the leading factors in 'teacher effectiveness' because, from a philosophical perspective, it influences the effort of the teacher in helping the students to learn subject matter (Jadama, 2014). Teachers' lack of subject matter knowledge or content knowledge could do more harm than good to learners in the science classroom. Teachers are unable to correct learner's misconception in the classroom (Jadama, 2014) if they lack content knowledge. However, aside from learning and acquiring various forms of knowledge, a teacher should be able to make science learning accessible to learners during classroom practice. This can be informed by their knowledge of the curriculum. According to Shulman (1986) curricular knowledge is "represented by the full range of programs designed for the teaching of particular subjects and topics at a given level, the variety of instructional materials available in relation to those programs, and the set of characteristics that serve as both the indications and contraindications for the use of particular curriculum or program materials in particular circumstances" (p. 10). Teachers' content knowledge and their ability to teach certain concepts well, using the right teaching strategy and materials contributes to their curricular knowledge. In the case of Life Science, Curricular knowledge deals with the teachers' ability to sequence and contextualize various concepts and also the ability to link the subject to other subject areas. For instance, the use of botanical gardens to teach ecology or population (contextualization), using the right representations to teach topics such as genetics, reproduction and so on. The minister of education in 2019, encouraged schools to ensure that teachers are provided with more professional training to in these concepts to enhance their content knowledge and to improve learners' pass rate in schools.

Indigenous Knowledge System and the Science Curriculum

It was stated in the OBE policy document that the essence of a new curriculum was to purge the apartheid curriculum of its racist content and to focus more on adopting a learner-centred curriculum for social justice and transformation. The CAPS 2012 policy document is a formal curriculum which addresses the inequity of all South Africans. The formal curriculum according to UNESCO (2015) is "the planned programme of objectives, content, learning experiences, resources and assessment offered by a school." (p. 58). It is from this formal curriculum teachers are expected to draft their lesson plans which they enact in the classroom by considering the objectives and learning outcomes of the formal curriculum.

To achieve this, some learning outcomes (LO) were outlined in the NCS, which was later modified to specific aims in the CAPS document as the current curriculum in use since 2012. However, specific aim 3 for CAPS document and LO3 were both outlined to achieve a transformative society through the inclusion of IK. Learning Outcome 3 (LO3, Life Sciences, Technology, Environment and Society) for Life Sciences states that "The learner is able to demonstrate an understanding of the nature of Science, the influence of ethics and biases in the Life Sciences, and the interrelationship of Science, technology, indigenous knowledge, the environment and society" (DOE, 2003, p. 12). Specific aim 3 in the Life Sciences FET phase is clearly stated as "Appreciating and Understanding the History, Importance and Applications of Life" (DBE, 2011, pg 17). This aim was further made explicit by explaining that

> Learners must be exposed to the history of Science and indigenous knowledge systems from other times and other cultures…. Since the knowledge that will be acquired in respect of Specific Aim 3 always relates to specific subject content, the content provides the context for learning about various aspects of Science in society. Science should

> therefore be taught in an integrated way in order 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 (p. 17).

Subject here refers to the discipline of Science taught in the classroom. The inclusion of IK in Science education applies to all disciplines like Odora Hoppers (2002) indicated in her study, and in all phases (GET and FET) of education as encouraged by the DBE. From the statement above, it is viewed that the inclusion of IK should contribute to scientific innovations (technology), due to its value in education and creates awareness on sustainability and improve the wellbeing of society. In addition, the inclusion of IK in school Science should make learning Science more accessible to learners from different socio-cultural background, a situation whereby none will be left out in Science learning (inclusivity). It is evident that the formal curriculum (CAPS) intends for IK to be integrated with Science in the classroom. Figure 2.1 below depicts the interrelationship between the formal curriculum (CAPS) and IK.

Figure 1

The Interrelationship Between the Formal Curriculum (CAPS), Informal Curriculum, IKS & WS.

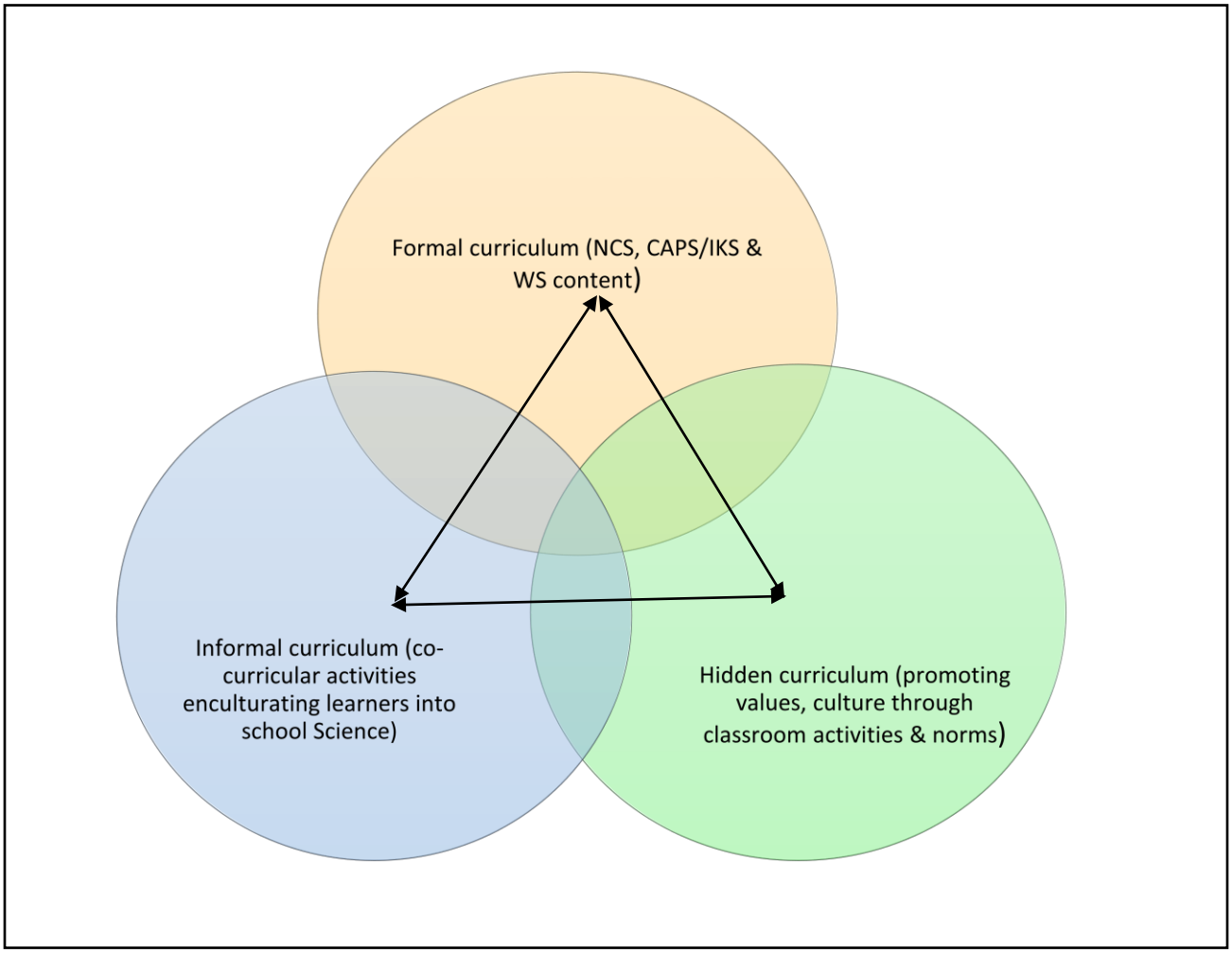


Figure 1 above is a description of the interrelationship between the formal, informal, and hidden curriculum and how they relate with Westernized Science and IK. The formal curriculum also known as the intended curriculum is a policy statement in the form of a document and it is what the Department of Education recommends to be taught in schools (Coleman et al., 2003). This is well reflected in the mandate stated in the formal curriculum (NCS 2003 & CAPS 2011) document for Life Sciences. However, the informal aspect of the curriculum is "the kinds of learning children derive from the very nature and organizational design of the public school, as

well as from the behaviours and attitudes of teachers and administrators" (Longstreet & Shane, 1993, p. 46). It involves the social co-curricular Science activities learners participate in to be enculturated into Science (Driver et al., 1994; Clark et al., 2008).

According to Cortes (1981) informal curriculum is the "massive, ongoing, informal curriculum of family, peer groups, neighbourhoods, churches, organizations, occupations, mass media, and other socializing forces that 'educate' all of us throughout our lives" (p. 24). This is imperative to learning Science, as this informal curriculum will help teachers to achieve the stated policy of helping learners to understand "the Relationship Between Indigenous knowledge and Life Sciences" (DBE, CAPS 2011, p. 17). For example, teachers may encourage learners to join the Science and art clubs in schools which might help learners to develop cognitive skills and strengthen the formal curriculum content taught (Driver et al., 1994). These co-curricular activities also help to promote the values and culture of Science through community of practice (Wenger, 2011). The hidden curriculum as indicated in the figure above deals with the norms maintained in the classroom context to encourage discipline, learning, culture and uphold scientific values in the classroom and respect for the teacher and peers. Longstreet and Shane (1993) stated that the term hidden curriculum "Refers to the kinds of learning children derive from the very nature and organizational design of the public school, as well as from the behaviours and attitudes of teachers and administrators.... "(p. 46). Hidden curriculum gives the teacher an opportunity to inculcate certain cultural values, beliefs, and norms in the classroom. It is a social skill that is not directly taught in schools or homes, but learners are aware of them due to the set norms both at home and schools. These three "curriculum elements" (Su, 2012, p. 155) are interwoven and cannot be separated from each other. The figure above displays the presence

and importance of IK and Westernized Science in the curriculum and the role they both play in curriculum implementation when integrated during Science teaching and learning process.

As the formal curriculum involves planned and organised activities to be enacted during the regular school period in the classroom, the informal deals with the learning experiences that take place outside the formal school setting among peers, teachers, media, community, parents, etc, like Cortes (1981) indicated in his study. From this viewpoint, learning involves active participation in the community of practice (Rogoff, 2008), and learners are enculturated into Science. Clark et al. (2008) posited that for meaning making to occur in the classroom, that is, to achieve the objectives of the formal curriculum, learners must also involve in a social interaction as they engage and share their knowledge and understanding among their peers. On the other hand, the hidden curriculum is also an informal curriculum, but it deals mostly with information, set values, norms, that are not explicitly taught or mentioned while enacting the formal curriculum and in the co-curricular activities outside the school setting (McCaslin & Good, 2019). Longstreet and Shane (1993) indicated that this could range from the time set for different subjects, sitting arrangement of learners in the classroom (the teacher standing in front of the classroom), the classroom set rules (learners raising their hands when they want to answer or ask questions), regulated behaviours such as eating only during break period, students walking into the classroom quietly, standing up when answering a question, competition for higher grades, etc. These social patterns of hidden curriculum are what prepares learners on how to exist and function in the social world (Giroux & Penna, 2012). The social patterns covertly imposed on learners can be identified as cultural capital (Bourdieu, 1986), and it "is especially transferred by family and education and may be institutionalized in the forms of educational qualifications" (Walther, 2014, p. 10). According to Dalmage and Isserles (2000) cultural capital is "a set of

tools and skills acquired through experience that includes knowledge about how to present oneself vis-à-vis relations of power" (p. 160). Therefore, the huge impact of the hidden curriculum on the formal curriculum should be highly emphasized as it transmits cultural capital. This is because the formal curriculum deals mainly with the organized school knowledge within a set time, while the hidden curriculum deals with the social construct of learners and their lived experiences (culture) within the society. The school has its own culture and the classroom is a sub-culture of the school, hence Aikenhead (2001) posited that most learners from different cultural background experience a change in culture as they move from their lived-world into the school world. This as he indicated makes Science learning a cross-cultural activity, therefore, there is need for the teacher (cultural broker) as a facilitator to help learners to cross these borders back and forth to avoid conflicting ideas in the Science classroom (Aikenhead, 2001).

My study explores teacher's IK and its integration with Westernized Science in the Science classroom. Teachers are expected to help learners have access to Science and this can be strategically done by integrating both worldviews in the Science classroom. As mentioned earlier, it is explicit that both worldviews (IKS and Westernized Science) share similarities in their tenets, which fits the description given to scientific knowledge by Aikenhead and Ogawa (2007) and the Department of Education as being tentative in nature, historical and socio-cultural in nature. The socio-cultural perspective of IK in the curriculum encouraged teachers to ensure that learners are "exposed to the history and nature of Science and indigenous knowledge from other times and culture…. Indigenous Knowledge Systems…., understand the different cultural contexts in which indigenous knowledge systems were developed….." (DBE, 2011, p. 17). Teachers are also encouraged to teach Science in a particular way, for example, it was stated in the CAPS document (DBE, 2011) that:

> Science should therefore be taught in an integrated way in order 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… Examples of indigenous knowledge that are selected for study should, as far as possible, reflect different South African cultural groupings (p. 17).

This task requires teachers to understand their own IK as well as that of the learners in their classroom by considering their individual differences and diverse socio-cultural background, but the question is, are teachers able to fulfil this mandate with the limited time table and teaching resources made available by the school?

Indigenous Knowledge and Westernized (modern) Science

The origin of modern Science was from Europe, which was formally known as natural philosophy in the 17th century (Aikenhead & Ogawa, 2007). In 1831, natural philosophy was renamed Science by the British Association for the Advancement of Science (BAAS) to set themselves apart from the natural philosophers. Science is referred to by some scholars as the Eurocentric knowledge system, Westernized Science or modern Science, which then spread across the rest of the continents, and is still used as a framework till now (Aikenhead & Ogawa, 2007). According to Jegede (1999a) modern Science is a European culture and it is known as Westernized Science or Eurocentric. According to this author, modern Science is considered by the western culture as 'the only path to acquire knowledge', and therefore it is distinguished from non-western (primitive) thought. IK on the other hand IK have been in existence for time immemorial, however, Le Grange (2007) stated that "Universalists on the other hand, argue that western Science is superior to indigenous perspectives on the natural world because of the

former's advanced predictive and explanatory powers" (p. 577), but initiatives are being set to review and integrate IK into the school Science.

In a study conducted by De Beer & van Wyk (2012) and Ogunniyi (2007a) it was revealed by Science teachers that Westernized (modern) Science and IK are two conflicting paradigms, but their paradigmatic levels are still very similar to each other than some fanatics of both knowledge would like to believe. Also, Westernized Science and IKS are seen by some researchers as being similar and can therefore complement each other during teaching and learning in the Science classroom, while some emphasize on the differences of both knowledge system, with the mind-set that they conflict each other (Vhurumuku & Mokeleche, 2009; Bohensky & Maru, 2011). A study conducted by De Beer and van Wyk (2012) in two different provinces in South Africa shows that some Science teachers believe that both knowledge systems are having conflicting ideas. Therefore, Odora Hoppers (2004) and Onwu and Mosimege (2004) posited that regardless of the strong motivation for IK to be incorporated in the intended policy document, as well as acknowledged worldwide as a system of knowledge, its validation and acceptance still causes issues among educators, scientists and learners. What differentiates IK from Westernized Science majorly is its local nature because, Westernized Science has its root in a community that is globally oriented, while IK has its origin in people's experience and their geographical location (Botha, 2010). "Creating a balance between two worldviews is the great challenge facing modern educators", who has the intention of incorporating IK and Westernized Science in their Science classroom (Battiste, 2002, p. 202). Comparing this two knowledge domains or paradigms could help in solving most of the issues emanating from its implementation and integration. Written literatures on these two paradigms

(IK and Westernized Science) can be categorized into two perspectives: scholars who share the view that the knowledge is complementary to each other and those who share the view of the two-knowledge body being dichotomous in nature. Scholars such as Battiste (2002) and Russell (2005) view the perspectives of these two knowledge domains as incommensurate and conflicting, with the reason that the underpinnings of these two knowledge domains are culturally different and their approach to reality emerge from opposite ends. Whereas, scholars such as, De Beer and van Wyk (2012) and Barnhardt and Kawagley (2005) and Shizha (2010), share the views that, both knowledge domains complement each other. They believe that IK and Westernized Science can be synthesized for a successful integration. Below is a figure illustrating the relationship between IK and Westernized Science.

Figure 2

The knowledge synthesis model adopted from Barnhardt & Kawagley (2005, p. 16).

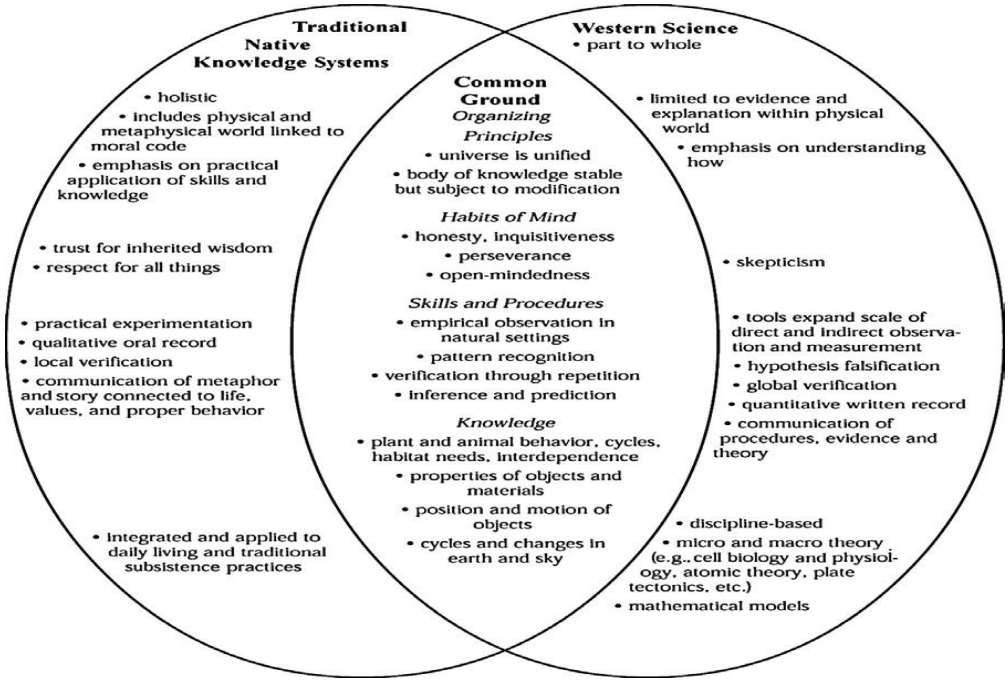


Figure 2 represents the worldviews distinctive to each of the knowledge domain and their shared characteristics in their separate spaces. Each of the knowledge domains from the right to the left are represented as traditional native knowledge systems (also known as IKS), common ground and Westernized Science, and the worldview perspectives peculiar to each of them are stated in their spaces. The common ground in the intersection of both knowledge domains shows the similarities they share. The common ground includes, organizing principles, habits of mind, skills and procedures, and knowledge. The organizing principles according to Barnhardt and Kawagley (2005) indicate that the IK is holistic and it is made up of metaphysical and physical world link, as it emphasizes on the "practical application of skills and knowledge" (p. 29). Barnhardt and Kawagley (2005) believe that habits of mind deals with the wisdom that have been passed from one generation to another, which guides everyday activities of the indigenous people, and also having respect for all things, especially nature and cultural practices of the people. For skills and procedures, they indicated that both traditional knowledge and western science it undertake empirical observation of the natural environment, as well as the application of scientific procedures. For knowledge, Barnhardt and Kawagley (2005) believe that both worldviews are known for their knowledge in plants and animals as well as their natural surroundings as a whole. This is to show that to an extent both IK and Westernized Science share similar characteristics, which could enable teachers to integrate both during the teaching and learning of Science. According to the study conducted by De Beer and van Wyk (2012) on the integration of IK and Westernized Science, most teachers in the study integrated IK into their Science classroom teaching by making one or two instances from the IK. Therefore, Science teachers should be provided with the skills necessary for integrating IK and Westernized Science effectively, to enhance easy border crossing between both knowledge domains (Botha, 2012).

Just as hypotheses are carried out in Westernized Science, indigenous traditional healers also carry out hypothesis on herbs or any other natural phenomenon they use in healing the common people (Ogunniyi, 2004; Le Grange, 2007). They also make observations of their environment such as the galaxies, weather, plants, earth, sea, and so on. Just like in Westernized Science; the indigenous people also make inquiry of their natural phenomenon. From a biodiversity point of view, the indigenous people were also able to identify and classify plants according to their physical and healing characteristics, way beyond the Linnaean classification system (Hens, 2006). De Beer and Whitlock (2009) in their study of integrating IK in the Life Sciences classroom explained how teachers can expose learners to the real world while teaching Life Sciences. They gave procedures on how learners were given the opportunity to participate on a hands-on activity by collecting plants that can be used for healing certain infections, and then teaching them how to extract the healing component of the plants through simple chromatography, applying scientific process. This helps learners to understand that the medications they take are not necessarily manufactured from chemical components through scientific methods, but they are manufactured using herbs and plants in their immediate environment. The holistic approach in IK is not contradictory to Westernized Science; rather it is complementary to it (Hens, 2006). Therefore, this study focused on teachers' IK and the possibilities of incorporating such knowledge with Science teaching and learning in the classroom.

The Importance of Indigenous Knowledge in the Science Classroom

The Department of Basic Education (DBE, 2019) recently gave a diagnostic report on Grade 12 matric learner's national performance in most popular subjects, inclusive of physical and Life sciences, from 2015 to 2019. For Life sciences; "The number of candidates who wrote

the Life Sciences examination in 2019 decreased by 9 004 in comparison to that of 2018. The performance of the candidates in 2019 reflects a drop at the 30% level from 76,3% in 2018 to 72,3% as well as at the 40% level from 51,7% in 2018 to 49,0%" (p. 139). However, the report on physical sciences revealed that from 2015 to 2019, there was an increase in performance from %58 to %75, and then it dropped to %65 in 2020. This is based on the fact that learners must score up to %30 as pass mark for their exam. The performance reported is not encouraging with the percentage achieved at %40 as shown in the diagnostic performance table. Below is table 1 depicting the diagnostic report on learners' performance in Life sciences from 2015 to 2019.

Table 1

Table depicting the diagnostic report of Life sciences learners' performance

Table 8.1 Overall Achievement Rates in Life Sciences

Year	No Wrote	No. achieved at 30% and above	% achieved at 30% and above	No. achieved at 40% and above	% achieved at 40% and above
2015	348 076	245 164	70,4	160 204	46,0
2016	347 813	245 157	70,5	157 224	45,2
2017	318 474	236 809	74,4	166 071	52,1
2018	310 041	236 584	76,3	160 208	51,7
2019	301 037	217 729	72,3	147 436	49,0

According to the report above, one of the aspects where learners have been underperforming is in "logical arrangement of ideas in essay writing" and some other concepts (DBE, 2019, p. 139). Underperformance can also be as a result of teaching learners in the language that is not their first language. According to Stroup et al. (2019) students who study science in a language different from their home language is likely to experience difficulty in interpreting and understanding questions. Therefore, it is recommended that the language of

instruction be considered and made explicit to all learners. According to De Beer and Whitlock (2009) "the scientific knowledge of indigenous culture, however, is less demanding cognitively than westernized science because it is based in experienced reality, and associated with a vocabulary more accessible to students" (p. 210). Since the aim of the South African curriculum is to make the classroom a more culturally relevant place, equal learning opportunities should be created for all learners in the classroom by considering the language of instruction (Msimanga et al., 2017). Learners' home language forms part of their culture and lived everyday experiences, and serves as "a raw material for knowledge construction" (Angaama et al., 2016, p. 1). Every indigenous learner bring their cultural knowledge or funds of knowledge to the classroom, therefore, such knowledge must not be neglected but used as a link to teach school science (Ramirez & Ross 2019). IK has been recognized as a knowledge system evolving from generation to generation, sustained and has been able to adapt to the changes in the natural world. There was a strong motivation to recognize and affirm the important role of IK in Science education in the development of the new curriculums, that is, National Curriculum Statements (NCS 2002) and the Curriculum and Assessment Policy Statements (CAPS 2011). It was suggested in the policy document that the Department of Education (DoE) should make the move of starting the phased integration of IK into the appropriate accreditation frameworks and curricula (DoE, 2003). This could be seen to reflect in the policy document. For example, the NCS from the perspective of the natural Sciences in the General Education and Training (GET) phase requires acknowledgement of indigenous practices, wisdom and technology of the common people. For Life Sciences in the Further Education Training (FET), the NCS recognises the interrelationships that exist between history, Science, technology, environment and society and IK. And for the physical Sciences, it emphasized on the IKS that is rooted in the social

practices and African philosophy that has evolved over the years. According to DoE (2004), these distinctions therefore do not undermine the fact that the IKS should be recognized and validated in the South African Science curriculum.

Kibirige and van Rooyen (2006) posit that though IK or traditional knowledge has been in existence for centuries, its negligence in the Science curricular has been evident for many years. This phenomenon of negligence is what Odora-Hoppers (2004) termed as 'knowledge apartheid'. Odora-Hopper (2004) and Senanayake (2006) then posited that the interest in reconsidering IK due to the failure of Westernized Science in curbing issues of poverty sustainability, hunger and certain illnesses has increased globally. Incorporating IK into Science is likely to increase the relevance of Science to learners in the multicultural classrooms (De Beer & Whitlock, 2009), thereby reflecting their diverse cultural background and enhancing knowledge construction (Botha, 2012) in the classroom. In addition, after various researches have been conducted in about 40 countries, the relevance of Science education project gave a recommendation that in order to reflect the culture and traditions of learners, the Science curriculum must be localized by incorporating IK in the Science classroom (Sjøberg & Schreiner, 2010).

The affordances held by IK for conceptual development among learners in the Science classroom are positive because, learners' cultural and traditional knowledge adequately aids the concepts in the formal curriculum. This, according to Kibirige and van Rooyen (2006), helps to curb the conflicting ideas learners have of western Science and their IK they bring from home. Therefore, the inclusion of IK in the Science classroom helps learners' social identities to be acknowledged, turning teaching and learning into a positive experience as well as enhancing change in learners' attitude towards Science (De Beer & Whitlock, 2009) and "enhance

knowledge construction" (Cronje, et al. 2015, p. 310). If the act of incorporating IK into Science teaching is adopted and encouraged by various institutions in South Africa, it will increase the esteem of the indigenous people and allow their IK that have been established over time to be respected. This study investigates teachers' IK and how it can be incorporated with Science in their classrooms. It also looks at what and how the new curriculum instructs teachers to integrate Science and IK.

Issues Associated with Integrating Indigenous Knowledge in the Science Classroom

According to Jansen and Christie (1999) the new Science curriculum implored all Science teachers to incorporate IK into Science teaching. Although the new curriculum statement had good intentions, there are still challenges faced by Science teachers in implementing the integration of IK and Westernized Science in the classroom because of some pedagogical lapses. These lapses are in the form of a model that is appropriate for enhancing the teaching and learning of Science in a socially constructive classroom (Ogunniyi, 2007a). This has raised issues among stakeholders (policy makers and teachers) because they are expected to implement a type of curriculum that has different instructional strategy compared to the 'fact orientated' curriculum they were used to. Teachers were not provided with the resources to teach the new curriculum; therefore, this poses a challenge to the Science teachers because the teaching and learning resources provided had few or no IK (Jansen & Christie, 1999). Some of the issues could also be that teachers have not consciously reflected on the IK they have, and how to teach Science using this knowledge (IK) as a tool. Therefore, learning the nature of IK in schools is an essential factor in learning Science, similar to learning the nature of Science. For Science teachers to teach the NOIK and NOS, they must be equipped with the necessary foundations and values of the two knowledge systems (Dekkers & Mnisi, 2003). However, Ogunniyi (2012)

emphasized on the philosophical controversies emanating from the integration of IK worldview with that of scientific worldview, which is seen as two different entities.

Rogan (2004) offered various reasons why teachers are unable to implement the new policy: (a) teachers' pedagogical knowledge is yet to change since the inauguration of the curriculum 2005 (C2005), even though the curriculum has been revised over again; (b) the idea of what learner-centeredness is, is wrongly conceived by teachers; (c) teachers are lacking in the aspect of innovation and initiative in Science classroom teaching and learning, which eventually leads to different views of seeing the curriculum as intention and as a practice. The misconception and misinterpretation teachers have about what IK consisted of could be the major impediments to the implementation of IK in the Science classroom (Rogan, 2004). This then brings me to ask the question whether this problem could be as a result of their total reliance on textbooks and other resources permitted by the DoE? This perhaps is a question to be asked to know what ways to mediate in this issue of non-implementation of IK. For example, in a recommended Grade 10 textbook for Life Sciences (everything Science, grade 10 Life Sciences version 1 CAPS), a concept under plant and animal tissues seems to have the intention of integrating IK and western Science (applications of IK and biotechnology), but on a closer look, it is observed that the content of the textbook emphasized on pure Science concepts with little mention of IK. An example of the mention of IK for this concept is on the subtopic, traditional medicine and the following was written on the textbook to explain it: "In the World Health Organisation definition of traditional medicine, they incorporate a list of plant and animal product-based therapies as well as spiritual practices as part of traditional medicine. Up to 80% of people in African and Asian countries rely on traditional medicines for their basic health care needs. In South Africa, broadly there are two types of practitioners herbalists and diviners.

Herbalists use plants to prescribe remedies to ailments. Diviners are said to communicate with ancestral spirits in order to diagnose problems and ailments. In Africa, traditional healers rely on up to 4000 plants for remedies. Pygneum, a traditional medicine has been used in Africa and elsewhere to treat early forms of cancer for example". The statement above was the only written evidence of IK under this concept. It seems that when a teacher has little or no understanding of IK, the prescribed Westernized text-book may become the foundation on which they base their teaching, which tend to challenge their ability to implement the Specific Aim 3 of the CAPS document. My study is guided by the following research questions:

(1) How is IK represented in the grade 10, 11 and 12 Life Sciences curriculum in South Africa?

(2) What perception do teachers have about Indigenous Knowledge?

(3) What are teachers' experience and the possibilities of integrating IK and Life Sciences concepts to promote Science in the classroom?

Summary of the Chapter

In this chapter, I shed more light on issues of colonialism and apartheid in relation to knowledge marginalization of the African people. I discussed a brief background of the study in relation to the funds of knowledge as a unique individual cultural background and experience. This unique cultural background of various stakeholders (policy makers, teachers and learners) is what makes the classroom a multicultural context. A multicultural classroom involves learners from different cultural backgrounds, experience and race. Therefore, there are different IK which are brought into the classroom. IK as discussed in this chapter is defined as context-specific and the knowledge of people from a particular community. I interrogated the nature of indigenous knowledge and its relationship to nature of Science. In addition, I discussed the relationship

between IK and Westernized Science worldviews. Because of the ongoing debate on IK implementation with Science, I discussed the issues that could emanate from the incorporation of both worldviews. The importance of IK in promoting Science learning was also discussed in this chapter and the research questions guiding this study were posited in the paragraphs above.

Chapter Three

Theoretical Framework

In the previous chapter, I reviewed some selected works authored by other science educators that are relevant to my study. I reviewed some culturally related literatures that are relevant to classroom science teaching and learning since my study investigated teachers' IK and possibilities of integrating it in the Science classroom. This study adopted the constructivism theory as the theoretical framework. The theoretical frameworks chosen for this study will help in unpacking research questions, objectives, and data analysis. In the previous chapter (chapter one), I explained how the curriculum was reformed from the apartheid content to an outcome-based curriculum and CAPS, which encouraged a learner-centred approach to learning (DoE, 2003; 2007). A learner-centred approach to learning is a constructivist's paradigm which encourages that learners construct their own knowledge through experience for cognitive development to take place (Zhou & Brown, 2015). This constructivism theory examines a person's ability to interpret and make sense of the reality that exists around them (Lee, 2011). However, the teacher as the 'More Knowledgeable Other' (MKO) in this context, plays the role of a facilitator by organizing activities and providing information for learners during classroom teaching and learning to enable them to construct their own learning effectively (Liu & Chen, 2010). This is considered relevant to this study because students bring into the classroom their everyday knowledge and experiences that could be an alternative conception to scientific knowledge. Efforts made on including the students' everyday knowledge (IK) could make the concepts they are being taught easier to relate with and that could eventually improve their understanding of the concepts.

Constructivism Theory

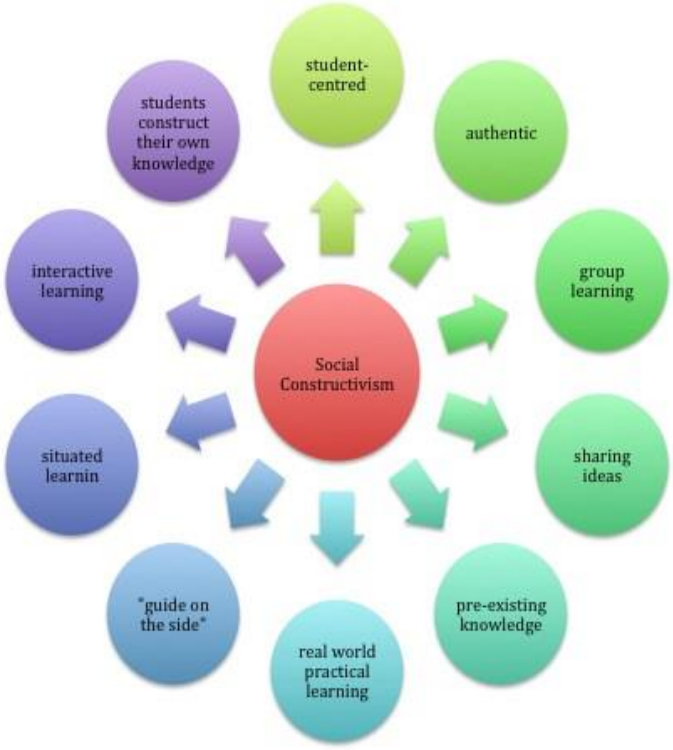
Constructivism is a theory in education which considers learners ability to construct new knowledge as "active agents" and not as passive learners (Nola & Irzik, 2006; Bada & Olusegun, 2015, p. 66). Constructivism has its root in philosophy, epistemology and psychology, which is linked to Piaget's theory of cognitive development. "Despite the existence of various forms of constructivism, such as cognitive constructivism and social constructivism, advocates agree that it is the individual's processing of stimuli from the environment and the resulting cognitive structures that produces adaptive behaviour" (Brandon & All, 2010, p. 90). Constructivism is a paradigm that has been adopted by many Science educators because of its progressive and diverse nature, because it encourages good teaching practices in schools. It is a paradigm that has been widely accepted in Science education for considering teaching and learning and as a learner-centred approach (Taber, 2011). It deals mostly with how individuals make sense of their experience in the natural world. The theory of constructivism recognizes the role teachers play as a facilitator and not as a knowledge transmitter (Taber, 2011; Zhou & Brown, 2015). "The constructive theory encourages learners to be active creators of their own knowledge. The role of the learner is to select and transform information, construct ideas, and make decisions, while relying on a cognitive structure" (Brandon & All, 2010, p. 90). Constructivism also recognizes that learners in a constructivist classroom must be actively involved in the teaching and learning process by participating fully in the activities of the classroom and constructing their own knowledge. Haneda (2006) posited that "Individuals do not simply receive, internalize, and construct knowledge in their minds but enact it as persons-in-the world participating in the practices of a sociocultural community" (p. 808). This happens as a result of the cognitive apprenticeship (knowledge construction and enactment) they experience to become members of

a community (classroom Science) with the help of their teacher as a facilitator in the classroom context. However, various theories have emerged from this theory of constructivism (Taber, 2011), and can be interpreted in different perspective such as the social cognitive theory (Piaget, Bandura), experiential learning theory (Kolb), multiple intelligence (Gardner), sociocultural theory (Vygotsky), and many more. All these theories are interconnected as they describe and influence different teaching and learning process for cognitive development.

Vygotsky developed his social learning theories by putting into consideration the individuals' social context during the learning process (Taber, 2011; Zhou & Brown, 2015). These theories emphasize on the social interaction that takes place during teaching and learning, considering the cultural-historical and inter-personal influence on cognitive development. The socio-cultural aspect of constructivism talks much about an individual development in their socio-cultural environment, although, social constructivists such as Vygotsky (1978) believe that social learning takes place before development, that is, an individual learn from his/her social environment (social learning) which further influences development. Development is a socially mediated process which depends more on the external environment since the interactions with the environment would be internalised and therefore influence development. Below is figure 3 depicting the activities which take place in the development of a learner in social constructivism.

Figure 3

Diagram depicting the social activities involved in social learning



Vygotsky (1978) posited that learning is a social activity and all the functions that take place in the cultural development of a child happen in two levels: first, at the social level and second, the individual level. Vygotsky emphasized on the connection that exists between the social world and an individuals' cognitive development, especially the role culture and language plays in the learners' development in the social world (Zhou & Brown, 2015). In Vygotsky's views, cognitive development encourages a student-centred and constructivist approach to learning, whereby the potentials of learners are accommodated in the social context. The social world Vygotsky meant was the interaction between the learners and the teacher, learner and peers, as well as the historical and sociocultural impacts on learning and its context (Zhou & Brown, 2015). Vygotsky asserted that social interaction (collaboration among peers) plays an active role in promoting learners' cognitive development.

Culture and Language

Vygotsky (1978) emphasized on the fact that learners at a young age tend to be very curious and want to be actively involved in the activities of the classroom, thereby constructing their own meaning through discovery, and developing new schemas (mental representation of a concept). From his theory of cognitive development, we can observe the emphasis on: "the significance of culture; the role of a principal proponent of culture: language and; the student's relationship with and development within this sociocultural world" (Zhou & Brown, 2015, p. 33). Vygotsky (1968) viewed culture as comprised of socially acceptable behaviour, beliefs and attitudes that is created through institutions, systems, symbols and tools (language) as a product of the society. Culture deals with an active outcome of both historical developments and events, it influences human behaviour and mental functioning, and hence it is a product of 'human development' (Zhou & Brown, 2015). The relationship between personal development and cultural context is complex in nature; therefore, humans produce culture and at the same time are products of it (Zhou & Brown, 2015). According to Vygotsky (1968) culture is what influences this transformation because it produces language formation, symbolism that describes non-primitive consciousness as well as forming the social processes responsible for adopting patterns of behaviour, known as the features of that culture.

However, Zhou and Brown (2015) posited that language is a cultural tool which aids social interaction and influences attitudes and behaviour as well as development of the said culture. Language is "an ordered system of meaning and symbols, in terms of which social interaction takes place" (Cobern, 1991, p. 31). How learners understand the natural world is said to be a cultural phenomenon, while the act of learning at school is viewed as culture acquisition (Aikenhead, 1996). This means that learning is naturally influenced by individual's culture and

experience as they develop within their community, but they get acculturated into the school culture through certain learning process. Aikenhead (1996) reported that if generally the subculture of Science agrees with learners' cultural views, Science learning will have the tendency of supporting learners' view of the natural world. But if at odds with learners' view, it has the possibility of disrupting learners' view of the world by marginalizing it. Therefore, to sustain learners' view of the natural world, teachers need to help learners to cross the borders of the Science classroom during teaching and learning in the classroom. Teachers are social actors in the classroom social context; therefore, language as a social tool is used to communicate Science during teaching, to construct meaning in Science concepts. Lee (2001) posited that "to achieve equitable outcomes with diverse students, teachers need to have both knowledge of Science and understanding of the students' languages and cultures. It is a challenge for teachers to integrate Science and students' languages and cultures in ways that are meaningful and relevant for their students" (p. 500). This means that when teachers understand and consider learner's diverse culture and language in the classroom, they are likely to help learners to understand Science better and improve their cognitive skills. The knowledge learners bring to the classroom is very important because it enables them to construct meaning as they participate in the classroom environment (Driver & Oldham, 1986). This is because learners are said to be responsible for their own learning by constructing meaning in the Science concepts in the classroom and making sense of the innovative ideas through reconstruction or a discussion with a more knowledgeable peer or the teacher. Hence, the learners gradually internalize the phenomenon that was once external (Scholtz, Watson & Amosun, 2004). Internalization deals with an individuals' internal acceptance of social beliefs, values and attitudes of a particular

context as his/her own, thereby altering the individuals' psychological nature through internalization (Zhou & Brown, 2015).

This can be related to learners' IK being marginalized through the assimilation (acceptance) of the subculture of Science. For this reason, a teacher needs to reflect on his/her IK to help learners preserve their culture, and allow the process of accommodation to take place in the Science classroom. "Learning Science in the classroom involves children entering a new community of discourse, a new culture" (Driver, Asoko, Leach, Mortimer and Scott, 1994; p. 11). Therefore, the social interaction that takes place in the classroom is the main bases of classroom activities. Hence, formal learning of Science is an activity that is situated in the Science classroom and the teachers and learners (social actors) in the classroom are the members of this community (social context).

Community of practice

Lave and Wenger (1991) stipulated that learning is situated within a community of practice (CoP) which is the classroom itself. As teaching and learning of Science takes place in the classroom, learners are said to be a part of a 'community of practice' whereby embodiment of a belief system takes place and then certain change in behaviour is provoked. As earlier discussed, IK is a social knowledge or experiential knowledge learners bring to the classroom context. The theories which laid emphasis on social context and learning as an individual, promotes the appreciation of culture, history and language of every community (IK) (Aikenhead, 1996). This is an indication that, for every indigenous learner in the classroom, Science learning can be made meaningful, by referring to learners' prior knowledge and relating them to the subculture of Science (Aikenhead, 1996). The interaction that takes place among learners and their teachers, the artefacts and the language used in the classroom contexts are known to be

historically, culturally, and socially determined (Clark et al., 2008). This type of learning is focused on the "sociocultural views of learning and an understanding of the learning process acquired through both teaching and research" (Clarke et al., 2008, p. 323). Lave and Wenger (1991) posited that in this socio-cultural perspective, learning is viewed as an activity that is situated in a 'community of practice', which is the classroom context. Vygotsky (1968) explained how learning is mediated or affected by signs and tools (computers and language) which are situated within the cultural and social context where they exist. In this case, the school context where this study was conducted is a social and cultural context where learning is situated. The teachers who participated in this study and their learners belong to a community of practice (Lave & Wenger, 1991) where knowledge is constructed by learners and the teachers facilitates the learning process using mediation tools.

Teachers as Mediator in the Classroom Context

Since constructivism is about knowledge construction, teaching and learning process can be seen as a social practice. The focus of this study is on teachers' IK which is known as a social knowledge (Rata, 2011) due to the cultural practices and experience of the individuals involved. My research is located within the discipline of Science education where scientific knowledge can be communicated and constructed through the language of Science as a cultural tool, in the social community of Science (Driver, Asoko, Leach, Mortimer & Scott, 1994). This kind of scientific knowledge cannot be merely discovered by individual learners on their own, by undertaking an empirical enquiry, it is the duty of the Science teacher as a facilitator to enable learners discover how knowledge claims are validated and generated. This makes sense because of the multicultural nature of the South African classroom context, which needs to be considered (Driver et al., 1994). The teacher in this context is seen as the more knowledgeable other (MKO)

because according to Vygotsky (1978), it refers to a person who has a higher ability and understanding of a task compared to the learner. Within the classroom context, the teacher, an adult, computer enabled gadgets and a peer could represent a more knowledgeable other (Moll, 2001). Vygotsky's emphasis on this MKO shows that a learners' understanding of a concept in the Science classroom is as a result of the teacher's, intervention and mediation in the classroom. In relation to MKO, Vygotsky mentions the notion of the zone of proximal development (ZPD) whereby the child receives encouragement and guidance from the teacher or a more skilled peer. He refers to it as a point between the knowledge a learner has about a phenomenon and what the learner does not know about the phenomenon. The knowledge a teacher has regarding IK could be used to enhance ZPD by integrating Westernized Science and IK in the classroom context.

Since my study is focused on teachers' IK and how it is incorporated in the Science classroom, it is related with the interaction between the teachers and their learners in the classroom as a learner-centred approach. Also, the outcome-based, NCS and CAPS curriculum suggested a constructivist learner-centred approach in the Science classroom during the curriculum reform. McCown, Driscol and Roop (1996) posited that learner-centred approach is a philosophy guiding teachers' practice, that is, how they teach in general (teaching and learning strategies and course design) and the kind of interaction that takes place in the classroom. From this perspective, power dynamics is said to have taken place. Power dynamics in the classroom deals with the kind of teacher-student interaction that is promoted by the teacher through questioning and feedback given to the students' responses to shape classroom discourses (Nystrand, Wu, Gamoran, Zeiser & Long, 2003).

Also, Bourdieu (1994) is of the opinion that power dynamics takes place between the classroom, which is the main field of activity, and the connection of structures (mental

representations) and agency (the will to act). Bringing in Bourdieus' theory of habitus which deals with physical embodiment of cultural capital, dispositions, skills and habits that are deeply rooted because of everyday life experiences of humans; teachers are viewed as the key actor in the classroom dynamics that takes place during teaching and learning. Social world in which the humans occupy as social beings is divided into various fields of practice, where they compete for different kinds of capital known as; social, cultural and symbolic capitals (Bourdieu, 1967). The social capital deals with the relationship an individual has within their environment. This kind of relationship can occur among peers at school, students and teachers, work place, schools, and so on. Cultural capital deals with the knowledge and experience an individual has of his/her environment such as their academic background, culture and work life (funds of knowledge). The symbolic capital deals with recognition, status, honour and respect accorded to an individual due to distinct behaviour or achievement (Bourdieu, 1994). Therefore Cannon (1990) posit that teachers can help develop critical thinking skills among learners by helping them appreciate their different views and varied realities. And this could be achieved through interaction and building understanding and multicultural contact among them. The author emphasized on the fact that a positive contact can happen if learners of different statuses work together to achieve a shared goal for a collective achievement through the support of the institution (Cannon, 1990). By so doing, learners are able to appreciate and embrace each other's' culture and language, appreciate the differences that occurs among them and appreciate history and IK of the group of learners from the rural area. This kind of approach enables learners to understand the situation of ethnic groups, social classes, and group situations in a historical content (Cannon, 1990). This is related to the idea of critical pedagogy (CP) where Freire (1972) termed it as a method of teaching that is actively against stigmatization, cultural, social, and cognitive oppression of any

form in the society. The theory is established on the principle that for learning to take place, there is a need for a social interaction and collaboration among peers and teachers; knowledge should be situated, that is, it should involve an authentic context relating to the knowledge field. All these takes place in a social context which Bourdieu termed as a 'field of activity'. Vygotsky's principle of teaching and learning emphasize the student-centred approach to teaching and learning where social interaction is believed to influence learning. In this study, the importance of student-centeredness was reiterated because; the specific aim of the curriculum was to encourage a learner-centred teaching approach. This study investigated teachers' views of the possibilities of achieving these aims in the classroom, using IK. The teachers who participated in this study are the facilitators of their science classroom (social context). His ideas regarding social influence on cognitive development is known to reflect the role a teacher plays as a MKO in their teacher-student interaction in the classroom and the importance of culture and language as a tool to convey socio-cultural impacts on learners (Zhou & Brown, 2015). They mentioned that learners' ability to construct their own knowledge through social interaction with their peers and teacher is a benefit from the application of a learner-centred approach adopted by teachers in their Science classroom. This study focused on teachers' IK and the possibility of incorporating such knowledge with Life Sciences teaching in the classroom context. However, as teachers are embodiment of their culture, they bring their cultural knowledge with them to the classroom and this could influence their teaching practice. This constructivism theory deals with the teaching and learning practice that takes place in the classroom context and how the teacher being the more knowledgeable other will help learners to construct meaning in the classroom. As mentioned above, the constructivism theory gave rise to several other social theories, including the socio-cultural theory by Vygotsky. All these theories (MKO, CoP, CP and situated learning)

were bricolaged to make meaning and interpret teachers' IK and their views of the possibilities of integration in the classroom.

The Art of Bricolage in Science Education

Lévi-Strauss (1966) introduced the art of bricolage with the aim of conceptualizing the indigenous peoples' mode of thought. According to Kincheloe (2001) it deals with diverse 'method of inquiry' in relation to different philosophical and theoretical indulgence of several components that is faced in the research process. Bricolage is an art of creatively or strategically re-combining and 'making do' of existing resources (tapestry) (Baker et al., 2003; Baker & Nelson, 2005). According to Duymedjian and Rüling (2010), bricolage can be compared with activities that involve the search for new resources in addressing new opportunities. Some researchers used bricolage as a methodological approach (Denzin & Lincoln, 2000), in innovations (Halme et al., 2012) and from a structuralist's perspective it is used as a meaning making tool (Lévi-Strauss, 1966). In this study, various theories with different perspectives were used to describe and make meaning of what and why of the phenomenon under study. The amalgamation of all the theories explained in this chapter is a mirror to see the interrelationship between these theories and how they influence teaching and learning by considering the teacher's and learners' experience in their socio-cultural background (IK) as a factor for knowledge construction. The theory will help to unpack and answer the research questions that have been posed for this study. The concepts that emanates from this theory will be used as subheadings in analysing the results that emerges from the data collected for the study. Therefore, teachers' IK and how they integrate such knowledge with teaching Life Sciences by considering learners' socio-cultural background alongside theirs, will serve as a unit of analysis for this study.

Summary of the Chapter

In this chapter, I discuss the theoretical frameworks guiding this study. The socio-cultural theory by Vygotsky and some other theorists such as Piaget, Bourdieu and Freire was discussed and interwoven. The reason these theories of constructivism are combined and used is because they help to promote and encourage a culturally relevant teaching and learning process in the Life Sciences classroom. Life Sciences classroom mostly involves hands on activities both within and outside the classroom context as a learner is enculturated into Science through cognitive apprenticeship. These practical activities promote learning through experience, and it involves the act of 'learning to do by doing' as constructivists encouraged, and reflection abetted by dialogue of the teachers' IK. The teacher as the more knowledgeable other was discussed in line with the social activities happening in the classroom, which leads to how they help learners cross the borders of Science in a multicultural classroom. This emphasizes on the idea of applying a student-centred approach as encouraged by CAPS, and to promote the incorporation of IK in the Science classroom.

Chapter Four

Research Methodology

Research involves a logical and systematic investigation which enables researchers to understand a phenomenon more than they did previously. When conducting a research, several motivations emerge, such as one's curiosity, field of practice, as well as what, why and how to improve this practice. All of these inform what a researcher wants to investigate as well as the research design they choose to carry out their investigation. According to Merriam and Tisdell (2015) the design a researcher chooses must correspond with the question they intend to ask and whether the design matches the researchers' skills, personality and worldview must be considered. The aim of this research is to understand teachers' IK and the possibilities of integrating such knowledge with Life Sciences in different school settings in Gauteng province of the republic of South Africa, as mandated by the Department of Education. The study also aims to explore how the policy documents (NCS 2002 and CAPS 2012) represent IK for integration during teaching and learning practice in the Life Sciences classroom.

In this chapter, I interrogated the various research methods, explained them, and I provide detailed explanation of the research method I used for this study, the rationale for using such research method and the instruments adapted to answer the research questions posed for the research in Chapter 2. I provided in detail the various research instruments used to collect data for this study and also described each instrument. How data was collected and analyzed for all the instruments used was explained in this chapter and all ethical procedures are provided.

Research Design

Research is an investigation that involves the engagement and contribution of new knowledge, improving a practice and addressing issues in a field. As an investigation, research deals with proffering solution to social and scientific issues through a systematic analysis and objective (Merriam & Tisdell, 2015). There are three main types of research methodoloies which includes qualitative, quantitative, and mixed-method research (Creswell, 2014; Merriam & Tisdell, 2015). The qualitative methodology has its basis on interpretivism (Kuzel and Like, 1991; Altheide and Johnson, 1994) and constructivism (Vygotsky, 1968) which relates with the notion that individuals seek to understand the world in which they live and work (Guba and Lincoln, 1994; Denzin & Lincoln, 2011; Creswell, 2014; Mertens, 2018). A qualitative research methodology deals with understanding peoples' views and experiences (subjective) (Denzin & Lincoln, 2005), it makes use of words to get data then analyze them in various ways (Braun & Clarke, 2013), and it is naturalistic and holistic in nature (Bodgan & Biklen, 2011). Quantitative research on the other hand is objective and uses numbers to get data, thereby analyzing them with the use of statistical techniques (Braun & Clarke, 2013; Merriam & Tisdell, 2015). For quantitative research approach, the researcher and the participants are both independent entities, and therefore the researcher is incapable of influencing the phenomenon under study and vice versa (Guba and Lincoln, 1994, p. 110). However, mixed-method research approach deals with the use of both qualitative and quantitative methodologies. According to Creswell (2014) mixed-method is a research approach used in different disciplines to investigate and gather data both qualitatively and quantitatively, integrate them and then use the interpretations drawn from both data to solve educational issues (Merriam & Tisdell, 2015). Below is a table depicting the differences between the three research methodologies.

Table 2

Depicting the Summary of Quantitative, Qualitative, and Mixed Method Research Approaches (Adopted from Creswell, 2003, p. 3-26).

	Quantitative	Qualitative	Mixed Methods
Philosophical Assumptions	• Postpositive knowledge claims	• Constructivist, advocacy or participatory knowledge claims	• Pragmatic knowledge claims
Strategies of Enquiry	• Experimental designs • Non-experimental designs e.g. surveys	• Narratives • Phenomenology • Ethnographies • Grounded Theory • Case Studies	• Sequential • Concurrent • Transformative
Specific Research Methods	• Predetermined • Closed, instrument based questions • Performance, attitude, observational and census data • Statistical analysis	• Emerging methods • Open questions • Interview, observation, document, audiovisual data • Text and image analysis	• Both predetermined and emerging methods • Both open and closed questions • Multiple forms of data drawing on all possibilities • Statistical and text analysis
Motivations for selection	• Test a theory or explanation • Identify factors that influence an outcome • Understand the best predictors of an outcome	• Understand a concept or phenomenon due to insufficient or new research • Identify unknown variables	• Generalise findings to a population whilst developing a detailed explanation of the concept or phenomenon

My study engaged with a qualitative, interpretive and case study research method. It is qualitative because qualitative researchers conduct their research in real-world settings (McMillan & Schumacher, 2010), and they are interested in knowing how people construct their world and interpret their experiences (Denzin & Lincoln, 2005). My study was conducted in a school setting in South Africa and the participants included teachers of Grade 10, 11 and 12 Life Sciences classes. The nature of a qualitative research is that it contains various set of interpretive

and material practices, making the world more visible (Denzin, 2008; Creswell, 2014). My study is interpretive because of the natural context and settings (Creswell & Creswell, 2017) where the research is situated. According to Denzin (2008) the characteristics of qualitative research is that; first, it focuses on meaning and understanding, that is, effort is made to understand situations in their natural context, as well as the interaction there in. Secondly, another characteristic of qualitative research is that researchers are viewed as a "primary instrument for data collection". Third, qualitative research is inductive, that is, researchers build concepts and theories by gathering data in the field. This data gathering includes interviews, documents, observations that are combined to form a larger theme or theory. Fourth, qualitative research is "richly descriptive", that is, what a researcher has learnt about a phenomenon is conveyed using words and pictures collected while conducting the research. It could be description of the participants, context, and activities of interest, collected through interviews, field notes and excerpts from recordings during observation. Because my study is qualitative and interpretive, it featured most of the characteristics mentioned above. My study is focused on understanding the in-service teachers' IK and the possibilities of integrating their IK with Westernized Science in the Life Sciences classroom. What knowledge teachers have and how they use the knowledge to promote learning in the classroom setting is of utmost importance to this study. Also, the researcher is a participant in this study because; she was fully involved in the data collection process. Data collected for this study was descriptively analyzed due to the researchers' ability to gather data through questionnaires, interviews, and document analysis.

My study engaged with a qualitative case study approach as a research strategy. The reason for this was that my study is situated within a school context which required an astute and deep description of participants' lived experiences. However, it is focused on understanding the

IK of Life Sciences in-service teachers and the possibilities of integrating IK with teaching Life Sciences in the classroom as a case study. Yin (2015) posited that in a research study, when the in-depth description of a social interaction is emphasized by the 'method modeled' for the study, the case study is the most appropriate methodology for it. In this case my study presents an in-depth description of the social context (school) and the participants, as they are the social actors within this social setting. According to McMillan and Schumacher (2010) and Merriam and Tisdell (2015) a case study is viewed as one of the several approaches used to investigate thoroughly the interactions which takes place between a small group of people.

In alignment with this, Yin (2009, 2015) posited that a case study investigation is carried out in real-life context; as the researcher is mostly interested in knowing how the study impacts the phenomenon and how it is influenced by its context. However, Merriam and Tisdell (2015) posited that "It is an in-depth description and analysis of a bounded system" (p. 37). Lewis (2015) and Yin (2009, 2015) surmised that a case study is a qualitative approach whereby researchers investigates a 'bounded system' (single case) or 'multiple bounded systems (multiple cases) over an in-depth, detailed data collection over time. These multiple sources of data could be through interviews, questionnaires, documents and reports, audio-visual materials. My study involved a multiple case study because data was collected from four different bounded systems, that is, four different peri-urban township school contexts in Johannesburg, Gauteng province.

A qualitative interpretive research paradigm was hence used to collect data from teachers who have their own perceptions about Life Sciences and IK and how they integrate both knowledge views with Sciences teaching and learning. This research was undertaken to understand teachers' IK, their awareness of the knowledge and how they teach Life Sciences concepts by incorporating IK. Interpretive qualitative research for this study involved inviting

teachers to participate in a questionnaire and follow-up interview that enquired about how they incorporate their IK into Life Sciences teaching. The interview questions were determined by the questionnaire administered to Life Sciences teachers to understand their views of IK, their awareness of IK and the values they hold about the knowledge. The CAPS 2012 and NCS 2002 documents were analysed as part of this study, so as to understand what the curriculum says about what and how teachers should integrate IK into their teaching in the Science classroom.

Sampling and Data gathering Techniques/Methods

In a qualitative case study research, it is imperative to choose a sample or participants to be investigated to answer your research question (Taherdoost, 2016). A sample involves a small group of people nominated from a larger population for an investigation, while, sampling is the process involved in selecting this group of people for investigation purpose (Alvi, 2016). In qualitative research, there are mainly two categories of sampling, which are usually necessary. First, there is need to select the case to be investigated, and then select sampling within the case to be studied (Merriam & Tisdell, 2015). For a successful research to be carried out, a researcher needs to select what to research, where to carry out the research, when to conduct the research as well as whom to investigate. For a successful research into the understanding and possibilities of integrating IK and westernized science, I selected schools from the peri-urban region because of the population of learners who are from a partly poor and rich background, and also to understand teachers' views of the possibilities of integrating IK in their science classroom. According to Merriam and Tisdell (2015) sampling is of two basic types, and they are probability and non-probability sampling. Probability sampling is not necessary for qualitative research because it involves generalizations. It is mostly used for statistical research because it enables researchers to generalize the findings of the study from the selected sample to the population

where it was drawn (Merriam & Tisdell, 2015; Alvi, 2016). The most common type of probability sampling is the simple random sampling. Non-probability sampling is the most used by qualitative researchers. According to Merriam and Tisdell (2015) anthropologists view non-probability sampling as being logical in the sense that, a researcher must use data to solve qualitative problems by discovering occurrences, implications of the occurrence and what relationship links them, and not using data to answer 'how often' and 'how much'. For a qualitative research, a non-probability sampling approach is most appropriate, and its usual form is known as a purposeful sampling (Patton, 2015). Purposeful sampling with its connection to qualitative research is grounded on the assumption that a researcher intends to learn about and understand a phenomenon in-depth, and hence must choose a sample where the phenomenon can best be understood (Patton, 2015). It emphasizes the in-depth understanding of a particular information rich case. An information rich case deals with cases that could help a researcher to learn much about issues that are vital to the purpose of the investigation, hence the term purposeful sampling (Merriam & Tisdell, 2015, p. 96). A purposive sampling strategy was used to select the teachers who participated in this study. This type of sampling will be consistent with the employed qualitative research methodology in this study.

Purposeful sampling varies as debated by different researchers such as Patton (2015), Lewis (2015) and Miles et al. (2014). According to Merriam and Tisdell (2015) the most common types of purposeful sampling are: the snowball or chain sampling which deal with locating few participants who are important for your research and meets the criteria established for participation in your study. It works in such a way that after sampling, the researcher asks for referrals from the key participants of his/her study who in turn refers them to other key participants. The more referrals you get, the bigger the snowball becomes, allowing the

researcher to accumulate more new information-rich cases (Patton, 2015). Maximum variation sampling involves searching for negative occurrences of the phenomenon being investigated. It deals with identifying the phenomenon that represents extensive range of features that are of interest for the study (Miles et al., 2014). Convenience sampling deals with selecting a sample based on money, time and availability of participants, context and so on. For example, a researcher could decide to choose a sample of relatives and friends or colleagues at work. The credibility of this can be questioned and it could create bias and produce an "information-poor" cases rather than "information-rich" case (Merriam & Tisdell, 2015). Unique sampling involves atypical, unique occurrences of the phenomenon under study. In this type of sampling, a researcher might decide to investigate a phenomenon based on its special or unique attribute. For example, a researcher might decide to investigate a teacher who is not only teaching but has a post graduate qualification. In a typical sampling, a researcher might choose to select a sample based on normal features and situation of the phenomenon under study. According to Patton (2015) typical purposeful sampling deals with what is normal, typical, and average. My study adopted a typical purposeful sampling because it focused on normal Life Sciences teachers in normal classroom settings in peri-urban schools. No special attribute is expected of the phenomenon of interest.

Data Sample: Participants of the Study

Teachers teaching Grades 10, 11 and 12 Life Sciences in four peri-urban high schools (13 teachers) in South Africa were involved in this study. The teachers were African male and female Science teachers who are experienced in teaching Life Sciences education for about three years duration. Table 3 below shows the sample of the study and their information.

Table 3

Depicting the demographic information of the participants for this study

Participants	**Gender**	**Subject**	**Grades**	**Years of experience**
T1	Male	NS/PS	9, 10, 11, 12	11
T2	Male	NS/PS	9, 11, 12	12
T3	Female	LS	10, 11, 12	15
T4	Male	LS	11, 12	4
T5	Female	LS	10, 11, 12	20
T6	Male	LS	10, 11, 12	8
T7	Male	NS/PS	9, 10, 11, 12	14
T8	Female	LS	10, 12	4
T9	Female	LS	11, 12	4
T10	Male	NS/PS	9, 10, 11, 12	17
T11	Female	LS	10, 11, 12	5
T12	Female	LS	10	2
T13	Male	NS/PS	8, 9, 10	15

LS= Life Sciences; NS= Natural Science; PS= Physical Sciences

The reason for this is that purposeful sampling in a qualitative research requires one to understand what to investigate and then choosing the appropriate people or context. According to LeCompte and Schensul (2010) this method is known as a criterion-based selection, and it deals with deciding what attribute to look out for in a sample that is important to your study of interest, and then go ahead and choose the right context or people who match those chosen criteria.

Research Context

Qualitative research is usually carried out in real world context (McMillan & Schumacher, 2010), and it involves the description of the participants, context, and activities of interest (Denzin, 2008). This study was conducted in four peri-urban schools in the township of the city of Johannesburg metropolitan municipality school district in Gauteng. The township is ranked among the poorest location in Johannesburg, although, individual townships consist of a mix of wealthier and poorer residents. Most of the schools in this area are categorized as no fee paying public schools and they are categorised into five quintiles. The schools where this study was conducted are both quintile three and four schools. Quintile three schools are 'no fee-paying schools', while quintile four schools are fee-paying schools. The quintile school systems are classified according to their location in poverty or slightly wealthy areas. The community where these schools are located inhabits 98% blacks, %0.11 whites, %1.03 coloured, %0.11 Asian and %0.21 consists of other races population. The languages spoken in this geographical area where these schools are located are: %37 of the population speaks IsiZulu, %8.68 speaks IsiXhosa, %1.31 speaks Afrikaans, %5.14 speaks Sepedi, %15.53 speaks Sesotho, %12.34 speaks Setswana, %2.34 speaks English, %4.48 speaks IsiNdebele, %0.73 speaks SiSwati, %3.44 speaks Tshivenda, %8.86 speaks Xitsonga, and other languages are %1.13. All four schools had black learners. The learning resources in these schools are not up to standards, hence, the need for funding from government to support the no fee paying schools. The languages that are dominant in these schools are IsiZulu, IsiXhosa, Sepedi and Sesotho, hence, the classroom is multicultural in nature. The teachers and learners in these schools speak more than one language, that is, they are bilingual and multilingual. This was confirmed by the teachers during their interviews. These schools were chosen for the research because they were culturally, socially,

and academically diverse in nature. Out of the four schools, one was an only girl's school, while the rest were mixed schools. The teachers in these schools comprised of both male and female who are mostly South Africans and a few of them are from other neighbouring countries like Swaziland and Zimbabwe, and other countries like Nigeria, Congo. Out of the 13 Life sciences teachers who participated in this study, 11 were South Africans, one was from Zimbabwe and one from Swaziland.

Data Collection Stages

The data collection process requires three stages; the entry stage (having access to the field or site of research, data collection stage (collecting the required information for the study) and exit stage (leaving the site after there is no more information to be collected (Merriam & Tisdell, 2015). I participated in the activities of the research as well as recording the ongoing activities of the data collection process during the interviews. The three stages of data collection were engaged with for both questionnaire and interview data collection processes.

The first stage was the 'entry stage'. At this stage, permission was taken from Gauteng Department of Education (GDE) to approve entrance into the school and for the activity to take place. Permission was taken from the ethics committee in the university where the researcher is studying for a degree, to evaluate whether all ethics protocols were followed. The provincial department of Education also gave their permission to go into the schools in a particular district, the principal and the participating teachers further gave their consent to participate in this research.

The second stage was the 'Data collection stage'. At this stage, after the researcher gained access into the study site, then they must start getting familiar with the environment. At

this point, a researcher should start building rapport with the participants by trying to fit into the daily routines of the participants. The moments the researcher becomes familiar with the context and have already started observing what need to be studied in the setting, then data collection may commence (Bodgan & Biklen, 2011). This process was engaged with during data collection for my study. I familiarized myself with the participants by visiting the school and having a rapport with them. I introduced the participants to the study and explained the procedures of the research before engaging them with data collection. This stage involved two phases:

First data collection phase

Data was collected in the school's first teaching term. This was achieved by administering questionnaires to participating teachers to understand their IK and to ascertain whether the teachers are aware of their IK and how they intend to or incorporate it with their Life Sciences teaching.

Second data collection phase

This took place during the second term of the year. Data was collected by means of follow up interview that was face-to-face and one-on-one. This was to further probe responses on the questionnaire, and to elicit from teachers how they currently incorporate IK with Life Sciences teaching in the classroom. The interviews lasted for the duration of about 40 minutes to 1 hour each. The interviews were audio recorded and then transcribed verbatim and analysed. The teachers were interviewed using a semi-structured interview questions developed for the study from their responses from the questionnaire (see appendix 3). This helped in eliciting 'participating teachers' understanding and awareness of their IK. All interviews were audio recorded to enable the researcher to have substantive evidence. According to Merriam and

Tisdell (2015) and Adams and Cox (2008) all information written down as well as recorded mechanically during the period of data collection, eventually becomes the raw data where the findings of a study emerges.

There were a total of thirteen Life Sciences teachers who participated in this study, from Grades 10, 11 and 12 classes in four peri-urban high schools in the Gauteng province, South Africa. These schools comprised of majorly black African learners, therefore teachers were purposefully selected on the basis of their background and knowledge on African Indigenous knowledge to gauge their knowledge of IK and whether this influenced their teaching of Life Sciences. Also, the teachers were selected based on the fact that they teach Life Sciences at the FET level. The teachers' interview responses were transcribed verbatim and sent to teachers to member-check to ensure validity of the research. The transcribed data were coded and analysed as they were received. For this study, all aspects of methodology and data collection follow from the research questions (McMillan & Schumacher, 2010).

Third stage was the 'Exit stage'. At this point in time a researcher is expected to consider leaving the setting where data is being gathered. This happens when enough data have been retrieved and there is saturation of information. Patton (2015) suggests that a researcher should start thinking about an exit strategy at this point. Bodgan and Biklen (2011) also suggests that a researcher could leave the setting of the research by reducing the number of times they visit the research setting gradually, instead of just leaving and ending abruptly this phase of the study. This is due to the relationship that has been established with the participants of the research. Although, most times researchers feel that they have not captured enough of the information they need that is relevant for the study, this could therefore make them stay longer than they have envisaged. But Preissle and Grant (2004) believe that no researcher can get it all or all right as

they ask themselves whether they have covered all "variation of pattern" that is important to their study (p. 180). I ensured that the setting of my study was adequate for me to capture all data necessary for my study. This I ensured by reflecting on the captured and analyzed data, and then a follow-up interview was conducted based on my reflections on previous data. This I did to ensure that I gathered enough data as well as staying with the plan of how many samples that is perceived to be appropriate for my study. However, I exited the context of study the moment data seemed saturated and occurred repeatedly. In this case, there were repetitions of responses regarding the phenomenon under study.

It was the researchers' intention to collect rich data by using questionnaires and interviews to probe the participants of the phenomenon as well as document analysis. In alignment with this, McMillan and Schumacher (2010) posited that in a case study, collecting multiple data helps in having adequate information on the phenomenon that is being studied. This study was framed theoretically from a constructivism lens. In this regard, Niewenhuis (2007) explained that qualitative research entails an understanding of the processes and social and cultural contexts underlying different behaviours while mostly answering the "why" questions.

Instruments for Data Collection

In conducting a qualitative research, the design of the study, sample selection, method of data collection and trustworthiness must be ensured. To elicit detailed information regarding teachers' IK and the possibilities of integrating IK with Westernized Science; interviews, questionnaire as well as content analysis of the NCS 2002 and CAPS 2012 document were the methods used to collect rich qualitative data in this study.

Document Analysis

Printed and non-printed documents (electronic materials such as computer and internet-based documents) are systematically reviewed and evaluated through a process known as document analysis (Bowen, 2009). Document analysis involves the process whereby textual data are reported in a summarized form, and it is done by examining how frequent certain words (data) occur and in what fraction they occur in the content analysed (Basit, 2010).

Another method of data collection for this study was through document analysis of the policy documents. Just like interviews and questionnaires, document analysis is also a research tool, and it is used for data triangulation, which is a combination of different methodologies to study same phenomenon (Bowen, 2009). For this study, analysis of the policy documents was done to understand what the document requires the teachers to teach and how they should incorporate IK into their Life Sciences teaching. According to Bowen (2009) and Merriam and Tisdell (2015) in qualitative research, document analysis is a process whereby a researcher interprets documents to give meaning to the topic of assessment. However, Bowen (2009) posited that this process of analysis includes coding the content of the document to form themes, which is similar to how interview transcripts are analyzed. The three main types of document analysis by O'Leary (2014) include: public records, which deals with official documents of an organization such as transcripts, annual reports, syllabus, and policy manuals, and so on; physical evidence (artefacts) such as objects that can be found where the study is being carried out. Such artefacts could be handbooks, agendas, flyers, posters and training materials; lastly, 'personal documents' deal with first-person interpretation of peoples' experiences, actions and beliefs (reflection journals, e-mails, incident reports, newspaper, calendars, and so on (O'Leary, 2014). Corbin and Strauss (2008) also posited that during document analysis, it is required that

the data obtained for research should be well examined and interpreted to gain understanding, develop empirical knowledge and elicit meaning. Various forms of documents can be analysed, ranging from books and brochures, journals, newspapers, advertisements, diaries, charts, policy document, etc. For this study, the document analysis was carried out on two policy documents (NCS 2002 & CAPS 2012 curriculum) to investigate how the curriculum policy mandated teachers to integrate IK with Life Sciences concepts in their Science classroom. These two documents were analysed from the introduction to the assessment of the Life sciences subject. Thus, this study fills the knowledge gap on how teachers integrate IK with Life Sciences as part of their pedagogic classroom practice. Responses from items 9-11 in the questionnaire were used to support the results from the policy document analysis (NCS 2002 & CAPS 2012).

Before engaging with the analysis of the policy documents, I read through the documents to have a better understanding of the content of the documents as suggested by scholars (Basit, 2010; McMillan & Schumacher, 2010). For me to be able to understand and respond to research questions, the following approaches as suggested by McMillan and Schumacher (2010) were adopted. The authors recommended the following steps to be followed during document analysis; the first step is to ‘locate the artefacts’, that is the documents to be analysed; second is to ‘identify the artefacts’, this can be done by collecting copies of the documents; third is ‘analysing the artefacts’, which requires in-depth description of the origin of the documents, the purpose of the documents, the audience of the documents, that is who should use the documents, where and how it should be used; the fourth is to ‘criticize the artefacts’, that is, to determine how authentic and accurate the document is and the meaning it poses in the social setting (in this case, the social setting is the school context); the fifth is to ‘interpret the meaning of the artefacts’ in justification with the questionnaires and interview for the study. These

recommendations were strictly adhered to while analysing the documents. A detailed description of these documents can be found in the next chapter of this research. The purpose of this document analysis was to understand whether the South African curriculum outlined how teachers are supposed to integrate IK, since it is anticipated that the documents should detail what IK the teachers are meant to bring into their classroom teaching approach and practice and the reason it should be integrated in the Life Sciences classrooms. To ensure authentication and accuracy, the documents were taken from the original website of the DBE as McMillan and Schumacher (2010) suggested in step four above. The documents were developed to help teachers with pedagogic guidelines for teaching certain concepts progressively in the classroom. After reading through the documents, the contents of the documents were analysed according to the codes and themes generated. A thematic analysis was done on these documents: "Thematic analysis is a method for identifying, analysing, and reporting patterns (themes) within data. It minimally organises and describes your data set in (rich) detail" (Braun & Clarke, 2006, p. 6). These authors suggested that when engaging in thematic analysis, a researcher must: familiarize themselves with the collected data; generate initial codes; search for themes; review the themes generated; define and name the themes and produce reports on the themes generated. These processes were adopted in generating themes for the document analysis. After reading through the documents, from the first page of the documents, all the concepts and terminologies in the policy documents were broken down into codes, then, another set of codes were generated to ensure that all related IK concepts were captured. These codes were then separated into implicit and explicit IK. I looked out for trends on the information explaining why IK should be integrated, what IK is recommended and how IK should be integrated with westernized science. An example of the codes and themes generated can be found in the analysis chapter. The implicit

IK codes are the codes that do not directly state or explain IK, while the explicit IK codes directly depict the IK in the documents. Sub-themes emerged after reading relevant literatures which are related to the research questions, and the themes were expanded on through the responses from questionnaires and interviews. The themes were generated using relevant questions, for example, why IK should be integrated with Life Sciences in the classroom; what Indigenous Knowledge should be integrated in the Life Sciences content and how Indigenous Knowledge should be integrated in with Life Sciences. The two documents were analysed separately to understand the trend from the former curriculum (NCS 2002) to the latest curriculum (CAPS 2012) as explained in the first chapter. The policy documents were finally interpreted, and the interpretations justified the data collected from both the questionnaire and interviews (this can be found in the analysis chapter). The document analysis was used to answer research question one, while the questionnaire and interviews were used to answer research questions two and three respectively.

Questionnaire

In a qualitative study, different forms of data collection can be adapted to understand the phenomenon being studied. One of the instruments used to collect data for this study was a questionnaire. In research, the questionnaire is the most common data collection tool and it is also a primary source of data collection (Adams & Cox, 2008; Okeke & Van Wyk, 2016). Okeke and Van Wyk (2016) further explained that a questionnaire is a form of enquiry with series of systematically arranged questions given to participants to acquire data for research.

According to Siniscalco and Auriat (2005) and Adams and Cox (2008) questionnaires as research instruments are used by researchers to collect data from participants about their personal experiences, views, context, and social related issues. Babbie (2010) refer to a questionnaire as a

document which contains questions that are designed to prompt information that is suitable for analysis; they are designed to encourage participants of a study to respond towards the completion of an investigation (Okeke & Van Wyk, 2016). Questionnaires are used by researchers to enable participants to be involved in a research, however, Cohen et al. (2005) posited that participants are not observed as an object of the research process, but rather observed as subjects. According to Okeke and Van Wyk (2016) the questions contained in a questionnaire must be free from unnecessary jargons, bias, double-barrelled questions, ambiguity and emotionally charged terms, for the participants to understand them correctly.

Okeke and Van Wyk (2016) are of the opinion that the type of questionnaire considered appropriate for a particular study can be determined by the problem to be investigated and the objectives of the study. It must consider the 'who', 'when', 'where', 'what' and 'how' of the situation of the research. According to Cohen et al. (2011) the size of the sample determines the structure of the questionnaire, that is, usually if the sample is large, the questionnaire will be more structured, numerical and closed; and if the sample size is small, the questionnaire may be more open and wordy. Therefore, in most cases, questionnaires that are designed for larger samples are mostly quantitative and the smaller samples are usually qualitative in nature (Cohen et al., 2011). For this study, a small sample (13 Grades 10, 11, 12 teachers in four peri-urban township schools) of participants was used to investigate, give a detailed and descriptive analysis of the phenomenon under study. Okeke and Van Wyk (2016) posit that in a questionnaire, the questions are in two categories, and they are: closed-ended and open-ended questions. According to the author, closed-ended questions are structured kind of questions, they usually require a yes or no, true, or false answers and rating scales. They are time-consuming while constructing them

but can be completed in a short time. In closed-ended questions, participants are not free to present their views as in open-ended, and the responses expected of them are usually rigid. It is mostly used in quantitative or evaluative research where respondents are expected to choose appropriate answers as they deem fit. The advantage of a closed-ended question is that the responses are easy to code, analyse and compare and it can be answered by anyone, whether literate or not, as long as the wording is straight-forward and simple. It is restricted in such a way that participants can only respond to alternative responses given by the researcher, which can lead to mixed feelings for the participants (Okeke & Van Wyk, 2016). On the other hand, open-ended questions are less structured and pre-fixed alternatives are not given to participants as in closed-ended. For this study, participants were given the opportunity to express themselves and the expected responses were not limited. For example the following questions are samples of the nature of the questions administered, Q1: "What do you understand by the word, indigenous knowledge"? Q2: "What does indigenous knowledge system mean to you"?

The above questions were examples of the types of questions teachers were asked to elicit their IK. From the participant's responses, a researcher could develop a question for an interview, and more ideas from the participants could be revealed to the researcher to deepen the research. Most times, participants might give unnecessary or irrelevant and long responses to questions, and sometimes no answer is given. Also, sometimes open-ended questions might be intimidating, thereby getting the participants confused and lost. However, to circumvent this issue, the questionnaire was piloted before it was formally administered for the main study. This study adopted the open-ended type of question, as it allowed for participants to express their views freely about IK and how they incorporate IK with their Science teaching. Participants also had the opportunity to express their views on the importance of IK to Science teaching.

According to Okeke and Van Wyk (2016) there are basically two modes in which questionnaires can be distributed to participants, that is, online questionnaires and paper-based questionnaires. A researcher may decide to choose a particular type based on the type of study being carried out and based on convenience (i.e. time and distance). For this study, a paper-based questionnaire was administered to participants since participants might not have access to the internet to be able to respond. The questionnaire allowed participants to be actively involved by asking those questions that were related to their IK and subject of specialization. While administering a questionnaire for a study, Cohen et al. (2005) advised that research participants must not be forced to complete a questionnaire for a study by a researcher; instead the participants should be invited to complete the questionnaire, it should be their personal decision to participate voluntarily. Participants' voluntary participation in completing the administered questionnaires was ensured in this study.

McMillan and Schumacher (2006) and Okeke and Van Wyk (2016) posited that data collection tools are known generally to have both strengths and weaknesses, the weaknesses of a questionnaire is such that: first, it is not as flexible as an interview question, therefore, it is advisable to administer it along-side an interview; second, the rate of responses from mailed questions may be low due to lack of interest and time, and might be accepted as final data since, the participants might not be reachable; third, questions that are biased may alter the findings of the study; fourth, scoring of open-ended section of the questionnaire is most times difficult; fifth, the questions are only restricted to the participants that can read and write. The strengths are: first, they are easy to code, score and analyse; second, participants are given enough time to give their responses; third, it encourages anonymity of the respondents in the sense that participants do not write their names on the questionnaire; fourth, it can be answered at the participants' time

and pace; fifth, training is not required for coding, analysing and interpreting data. Although, I disagree with this fifth reason because, researchers need to learn how to use various analytical tools for coding and data analysis through webinars organized by the organization where the research is taking place. This study considered the strengths and weaknesses mentioned above, to enable the participants enough time to complete and return the questionnaires. It was the responsibility of the researcher to administer the questionnaires to the participants of the research and later on collect the filled questionnaires in order to avoid delayed emails.

Description of data collection tool (questionnaire)

This section describes the structure of the questionnaire and the items. The open-ended items were tabulated, and the possible meanings briefly explained in the table. Follow-up questions for the interviews were also established in this phase.

Structure of the questionnaire: Teachers' Indigenous Knowledge System Questionnaire (TIKSQ)

The questionnaire for this study (TIKSQ) was adapted from an existing instrument by Cronje et al. (2015) which were used to investigate teachers' views on the Nature of Indigenous Knowledge and NOS (VNOIK). The questionnaire was developed based on the Views of Nature of Science (VNOS) and the Nature of Indigenous Knowledge (NOIK) framework (Cronje et al., 2015). The questionnaire items were suitable for my study because of its ability to elicit teachers' views of IK and the perception they hold regarding its integration. Most of the questions were modified by the researcher and supervisors who are knowledgeable and familiar with the phenomenon to suit the study. The rationale behind the questionnaire was to elicit

teachers' IK, after which the teachers' responses were used to develop questions that were used to interview them and further elicit their views of IK.

The questionnaire (check appendix 3) for this study had three sections, the first section comprised of the participants information (gender, specialization, experience, etc.) the second section comprised of open-ended questions and it targeted to answer research question two and three, and more information was acquired during the interview. Section three comprised of an open space for more information from participants.

The Open-Ended Questions. The open-ended questions had 11 items and were analysed deductively. Table 4 below shows the items (questions) of the questionnaire that was adapted for this study and the possible connotations of the items.

Table 4

Depicting the items of TIKSQ adapted for this study

Teachers' Indigenous Knowledge System Questionnaire (TIKSQ)	
Questionnaire Items	**Possible meanings**
Q1: What do you understand by the term, indigenous knowledge? Please explain	Participants' view of Indigenous Knowledge
Q2: What does indigenous knowledge system mean to you? **A)** As a person **B)** as a Science teacher	Participants' personal and professional view of Indigenous Knowledge
Q3a: Is indigenous knowledge important? Yes/No	Participant's' views of the importance of Indigenous Knowledge.

3b: Is indigenous knowledge Science? Yes/No	Participants' understanding of IK as Science
Q4: What makes indigenous knowledge different from other knowledge system (for example, Westernized Science)?	The differences between IK and other knowledge systems (ways of knowing)
Q5: Practitioners of indigenous Science (e.g. elders, herbalists, traditional healers) observe nature to generate knowledge. Do they do experiments? Yes/No How do they validate this knowledge?	Understanding the Science in IK and its relationship with WS
Q6: How is Indigenous knowledge carried on from one generation to another? **6b:** Does this knowledge stay same? Yes/No	The means in which IK is preserved and its existence
Q7: Myths are stories that are told in different cultures by elders from one generation to the next. What roles do you think myths and rituals play in indigenous knowledge systems?	The roles myths and story-telling plays in preserving IKS
Q8: How does indigenous knowledge reflect the social and cultural values of a people?	Participants' views of the social and cultural values of IK among the people
Q9: Can indigenous knowledge be used to explain Life Sciences concepts in the school context?	Participants' views of the possibilities of integrating IK and WS in Life Sciences
Q10: How can Life Sciences be taught in the classroom using indigenous knowledge? Please explain and provide examples	Participants' views of the possibilities of integrating IK and WS in Life Sciences classrooms
Q11: Does the curriculum explain what and how you should implement indigenous knowledge in the classroom? Please provide	Participants' knowledge and view of the mandate of the curriculum to integrate IK

an example from the CAPS document.	and WS in the Science classroom and how this can be done.
More information regarding indigenous knowledge	Participants' additional views of IK

Table 4 above represents the 11 items posed to elicit teachers' IK and the possibilities of integrating such knowledge with Westernized Science in their Science classroom. The first eight items on the questionnaire were posed to ascertain teachers' views of IK, while the last three questions were posed to elicit teachers' knowledge of integration and how this can be done in the Life Sciences classroom.

Interviews

Interview in qualitative research is a technique in data collection, it is viewed as a systematic activity a researcher could learn to do well (Merriam & Tisdell, 2015). According to DeMarrais (2004) it is a process whereby researchers engage participants in a conversation based on questions that are related to the study of interest. It is done to elicit information from the participants based on their shared experience on the phenomenon under study. Merriam and Tisdell (2015) explains three main types of interview when conducting a research, this includes, structured or standardized, semi-structured and unstructured interview. The structured or standardized interview is usually an oral method of a written survey (Merriam & Tisdell, 2015), it is used mostly when a large sample is involved in a research, to generalize the obtained findings (Opie, 2004; Merriam & Tisdell, 2015). The limitations of structured interview are in its inability to allow participants to divulge other necessary information or their perspectives of the world that could enrich the data, thereby restricting them within expected responses suggested by the investigator (Breakwell & Rose, 1995; Merriam & Tisdell, 2015). Semi-structured interview always provides adequate data because of its flexibility in allowing participants to give several

responses without restriction (Descombe, 2008), and also gives the researcher the chance to probe any particular aspects that come up as well. The questions in semi-structured interview are worded flexibly and less structured; therefore, participants have the freedom to give more information as they could while the researcher has little control over their responses (Merriam & Tisdell, 2015; Opie, 2004; Descombe, 2008). The interview is also guided by questions that have been listed by the researcher, to be explored during the interview. This helps the researcher to respond and understand the situation on ground, the respondents emerging worldview, as well as innovative ideas emerging from the topic (Merriam & Tisdell, 2015). The unstructured interview is informal, and it provides huge amount of data which requires more expertise and a lot of time to analyze (Opie, 2004). There are no pre-determined questions, and it is basically exploratory. According to Merriam and Tisdell (2015) it is more useful for a researcher who does not know or have enough information about a phenomenon to ask appropriate questions. Both the structured and unstructured interviews are inappropriate for my study because specific and depth of information is needed for my study, which cannot be achieved from the structured interview, the time constraint from huge data and sourcing for expert researchers might not be achievable. The suitable interview used for my study was the semi-structured interview because, it enabled me to probe the ideas of the participants further and understand their views regarding the teaching of IK and how they intend to incorporate it with their teaching. The semi-structured interview questions were inspired by the responses from the questionnaire administered to participants to further elicit their understanding of IK. The following are examples of the interview questions that were asked during the one on one conversation with participants. The focus of the interview was to find out the teachers' understanding of IK; explore how they use IK in the classroom, and how they thought they could integrate IK better in the Science classroom teaching practice and;

to examine their understanding of what the CAPS document says about integration and how they implement it within the classroom practice. The complete questions can be found in appendix 4

In this study, I used the research questions to organise the data into episodes. To achieve this, data was transcribed and then analysed just like Boyce and Neale (2006) suggested. As Merriam and Tisdell (2015) explained that data analysis is a process used in answering research questions posed in a study. For data transcription, the audio recordings from interviews were transcribed verbatim and they served as raw data for this study. After the transcription process, the data was member-checked (respondent validation) by soliciting feedback from the interviewed participants on the transcribed responses and emerging findings. This helped in ensuring accuracy of the data as well as reducing the errors that might emanate from the transcription process.

The transcribed data was coded by assigning emerging themes to the data as I analysed the transcripts, this was a way of transforming data as I analyse. Merriam and Tisdell (2015) suggest that the transcribed data should be read over and over again to make sense of the data until themes begin to emerge and patterns formed. The emerging themes can be subsumed into each other or expanded. The segments in a data set found to be responsive to the research questions of the study is known as a "unit of data", and it is a possible answer to the questions posed (Merriam & Tisdell, 2015). The authors further explain that any meaningful segment in a data is a unit of data. In my study, teachers' indigenous knowledge and the possibilities of integrating it with their teaching was my supposed unit of data.

Trustworthiness of the Study

In qualitative research studies, data quality is immensely important, and it is determined in most cases by the quality of each strand that is involved. Trustworthiness is regarded as an amalgamation of both validity and reliability (Letts et al., 2007). Furthermore, the quality of findings and data is classified by the authors to consist of dependability, conformability, credibility, and transferability. Hence, Cohen, et al. (2005) posited that validity is an important key for effective research. Validity in a qualitative research could be achieved through the number of participants approached, richness, depth, and scope of data collection, as well as researcher objectivity. There is a possibility that the combination of different methods of data collection and how it is analyzed and interpreted could strengthen the validity of a research. Merriam and Tisdell (2015) viewed validity and reliability as concerns which can be adopted by paying attention to the conceptualization of a study and the manner at which the collection, analysis and interpretation of data and the presentation of findings are done. According to Creswell (2014) qualitative and quantitative criteria in a mixed methods design are applied to give assess to the trustworthiness of a study. Trustworthiness in a qualitative research has approaches based on questions and worldviews that can be used to establish the trustworthiness and authenticity of a study (Merriam & Tisdell, 2015). Lichtman (2013) posited that the criteria for a good qualitative research is when the researchers' role and their relationship to the phenomenon under study is explicit, emphasize the importance of the topic under study, making explicit on how the study was carried out, and presenting convincingly the findings of the research. In all research, internal validity focuses on the meaning of reality, it interrogates how research findings correlate with reality, how consistent are the findings with reality, are researchers measuring what they intend to measure? (Merriam & Tisdell, 2015). However,

Maxwell (2013) agreed that reality can never be captured, this is because "validity is never something that can be proved or taken for granted: it has to be assessed in relationship to the purposes and circumstances of the research, rather than being a context-independent property of methods or conclusions" (P. 12). Reality is interpreted by directly accessing the participant's interviews and observations because the participants are the primary instrument of data collection. According to Merriam and Tisdell (2015) there are various strategies to ensure the internal validity of a qualitative research. The first and the best strategy to ensure internal validity of a research is through 'triangulation', and it is of four types: use of multiple theories, multiple sources of data, multiple methods, and multiple investigators. Triangulation is viewed as the main strategy for ensuring validity and reliability in a study. Multiple sources of data were used in this study to triangulate data collected. Triangulation will be explained in detail in the next section. The second strategy to ensure internal validity of a research is known as the 'member check or respondent validation'. Maxwell (2013) posited that in this method, a researcher solicits feedback on findings emerging from a set of people interviewed. This helps the researcher to avoid misinterpretation of participants' views and their perspectives of what is happening or what they do, as well as identifying biases that might arise from what they observed. The data collected for this study were transcribed verbatim, and the emerging transcripts were sent to each of the participants of the study for member-checking. This was done to ensure trustworthiness of the research findings. The third strategy to ensure internal validity by Merriam and Tisdell (2015) is 'adequate engagement in data collection'. This involves making sure that the emerging findings and data collected for the study is saturated. The moment the researcher realizes that there is no new information emerging from the data, and begins to hear or see similar results repeatedly, and this could imply that the data or findings are saturated.

This strategy according to Merriam and Tisdell (2015) is more meaningful when a researcher is trying to get close to how participants view and understand a phenomenon. For this study, data collected were adequately engaged with to ensure that all information was saturated, and no information was left out. The fourth strategy to ensure internal validity is 'researchers' position'. It deals with the effect a researcher has over his/her research and vice versa (Probst & Berenson, 2014; Merriam & Tisdell, 2015). Researchers are expected to explain their dispositions, assumptions, views and biases regarding the research they are about to conduct, this is because it enables the readers to understand a researchers' value and expectations, how they interpreted data and how they arrived at a particular conclusion (Maxwell, 2013; Merriam & Tisdell, 2015). The fifth strategy for ensuring internal validity is 'peer examination/review'. This strategy takes place when peers or a committee is set up to critique a research that has been conducted by a researcher. The critique is done to give a feedback to the researcher as to where and what can be strengthened in the research. The article is often sent to peers who are familiar with the study. The article can also be sent to colleagues to review thoroughly by looking through the data and assessing the plausibility of the findings based on the data provided (Merriam & Tisdell, 2015). The data collected for this study was peer reviewed by members of the research group and supervisors who understands the phenomenon under study.

The internal validity strategies mentioned above was taken into consideration in this study. In my study, the content of the interview schedules was extracted from direct response from teachers' views of IK. The validity of my study was enhanced through triangulation of the data collected from different sources such as questionnaire, interviews, and document analysis. I looked out for consistency when comparing the findings from the data sources to enhance the result obtained from the study. While designing a study, qualitative researchers should be concerned about validity

and reliability as factors to be considered as well as analyzing results and judging the quality of the study (Patton, 2015).

The internal validity was enabled by having the interview items scrutinized by senior academics in the relevant fields (Maree & Van der Westhuizen, 2014). Validity establishes whether or not the study actually measures what it is supposed to measure (Phillips, 2008). To reduce the chance of researcher bias and provide triangulation, data collected was analysed from multiple sources, including questionnaires, transcriptions of participant interviews and analysis of the curriculum documents. Qualitative researchers are mostly interested in the consistency of research findings with the data collected. Therefore, the consistency and dependability of the findings of this research was ensured by triangulating data collected for the study and peer review.

Triangulation of Data

Triangulation in qualitative research is one of the most common methods of making sure that there is credibility of findings in a study. Triangulation deals with the use of various data sources in a way that the coherent justification for the themes is built with the evidence gathered (Jonsen & Jehn, 2009). Patton (2015) surmised that triangulation is of different forms and they are: 'investigator triangulation' which involves the process of collecting and analyzing data by multiple investigators; 'theory triangulation' deals with having various hypotheses in mind to approach data. It helps researchers to understand how each of the hypotheses relates to the data collected for the study (Seale, 1999, p. 54); 'methodological triangulation' involves the use of different research methodology such as qualitative and quantitative methodologies to collect and analyze data in a study; and 'data triangulation' deals with the use of different data sources in a study. It involves comparing data collected from interviews, questionnaire and document

analysis at various places, time, and people. The author posits that "triangulation, in whatever form, increases credibility and quality by countering the concern (or accusation) that a study's findings are simply an artifact of a single method, a single source, or a single investigator's blinders" (p. 674). Hence, my study adopted the data triangulation method. Due to the nature of this study, data was triangulated using questionnaires, interviews, and document analysis. Document analysis was carried out to understand why, what and how the curriculum expects teachers to integrate IK and westernized science before administering the questionnaires. The questionnaires were then designed adapted and refined to elicit teacher's views of IK and the possibilities of integrating such knowledge with their Life sciences concepts in their science classroom. To elicit more information from teachers and to ensure credibility of the data source, one-on-one interviews were conducted with the participating teachers. The responses from the questionnaires administered to teachers were analyzed and some common trends were formed. These trends were used to develop questions for the interviews and each of the teachers was asked to provide more information regarding their responses on the questionnaires. Triangulation of the data that emerged from these instruments helped to validate the findings of this study (Merriam & Tisdell, 2015). Triangulation of data was used in this study to build coherent evidence by cross-checking and comparing data collected through questionnaire, interviews and document analysis, as the three-main source of data collection to understand teachers' IK and the possibilities of integrating such knowledge with Life Sciences in their classrooms.

Piloting the Study

This study adopted a qualitative case study research as a methodology as explained earlier. The focus of the study is to understand teacher's IK and the possibilities of integrating such knowledge with their Life Sciences teaching in the classroom. A typical purposeful

sampling was adopted for this investigation just like the main study. To ensure feasibility and validity for the main study, a pilot study was designed and carried out with Life Sciences teachers before the main study was carried out. Thirty-eight questionnaires were given out to teachers and only 8 of the questionnaires were returned by teachers. The sample size includes eight male and female teachers from three peri-urban high schools in the township of Ekhuruleni metropolitan municipality school district in Gauteng, South Africa. The instrument for data collection for this pilot study was an eleven-item open-ended questionnaire.

Okeke and Van Wyk (2016) is of the opinion that a pilot study most times deals with a small investigation, having the aim of gathering information before the main study is conducted, and testing the validity and feasibility of the research procedures. A pilot study involves the use of instruments to run a trial for the main study; it is used to enhance feasibility in a study (Teijlingen & Hundley, 2002). Since it is a pilot study and not the main study, the researcher decided to make use of the small sample available for the pilot. However, it is said that, a researcher must take into consideration some factors while piloting their research, and such factors includes, "participants' understanding of the questionnaire, resources needed, time it will take to complete the questionnaire and how that may influence the attitude of the participants" (Okeke & Van Wyk, 2016, p. 372). The factors mentioned above were used to analyse the responses obtained from the participants and to ensure feasibility of the study.

Participants' Understanding of the Questionnaire

The data collected from the pilot study was analysed and it revealed that the teachers who participated in the pilot research understood the questions portrayed in the questionnaire. Almost all the teachers who participated answered all the questions except a few who skipped one or two questions. The percentage return of responses to the questions was 90%. As part of the roles of a

pilot study, this was done to ascertain whether the participants of the research responded to all the questions asked (Okeke &Van Wyk, 2016).

Each of the items and responses on the questionnaire were inter-rated by the researcher and other team members and the questions were rated 100% for understanding. It was agreed that the teachers showed understanding of the questions asked, by checking whether their answers were justified. This corresponds with Okeke and Van Wyks' (2016) opinion on checking whether the questions asked during a pilot study yielded "sufficient range of response" from the participants (pg. 378). In this case, the opinions of the participants on the soundness, readability and flow of the questionnaire (Okeke & Van Wyk, 2016; Shenton, 2004) was sought by the researcher, as encouraged by the authors. For example: one of the teachers who participated in the pilot study was asked about the simplicity of the questionnaire, and he said, and I quote "It was not difficult, it was open-ended". According to Guba and Lincoln (2001) one of the ways of ensuring the authenticity of the research is by ensuring fairness in the research as suggested.

In the end, it was agreed that most questions should be left the way they are, while some were adjusted for a better understanding. To make the questions easier, there were minor adjustments made on question 3, 4, 5, 7 and 8, due to some nuances as suggested by Okeke and Van Wyks' (2016) and Shenton (2004). However, one of the roles of a pilot study according to Okeke and Van Wyk (2016) is to rephrase questions that were not well answered by the participants of the pilot study as expected by the researcher. At the end of the inter-rating process, it was agreed that since only minor questions were adjusted, there will be no need to re-pilot the study.

Resources Needed for the Research

To pilot a study, resources for a successful pilot is also required. For example, money used while designing the questionnaire and going to the contexts where the pilot study is to be conducted must be considered (reaching teachers); modifying the questionnaire, reproducing the questionnaire and getting ready to give it out. This will help the researcher to have insight of what to do and how to go about them during the main study. A researcher may also need funding to be able to ensure a successful pilot study.

Time Taken and Attitude of the Participants

One of the resources that must be considered while piloting a study according to Okeke and Van Wyk (2016) is the time it will take participants to complete the questionnaire and how that may influence their attitude towards the phenomenon being researched about. This influence is known by researchers such as Guba and Lincoln (1985; 2001) and Mertens (2018) as a process whereby the participant's interest and awareness of IK were catalysed by the inquiry process. The time it took for participants to complete each questionnaire must be monitored, to help the researcher determine whether the time spent was reasonable enough (Okeke & Van Wyk, 2016) and if there is need to reduce and adjust the questions for a shorter time frame to ensure fairness (Shenton, 2004). For example, when a participant was asked about how much time it took to complete the questionnaire, he responded by saying that it took him 45minutes to complete the questionnaire. One of the participants indicated that he did not take note of the time because; it was completed at different intervals when they had the time to fill it. At the time of the pilot study, it was also found that most teachers were not interested in completing questionnaire, with the excuse of not having a free time to complete it. This can be a factor to be considered while

conducting a research, as teachers show lack of interest in participating in any research study, except when persuaded and motivated.

According to Okeke & Van Wyk (2016) a pilot study is not the main study; however, it is designed to ascertain the accessibility and feasibility of the research instrument before commencing data collection for the main study, that is, using the pilot study to test the worth of the study and whether the questionnaires needs to be adjusted or changed (Shenton, 2004). For this study, the worth of the research was tested, and the researcher saw the need to carry on with the main research while few adjustments were made to the questions. The adjustment was to make it a bit clearer than it was before, to ascertain a better response from teachers during data collection for the main study. Also, the relevance of the research was identified and related with from the responses given by the participants.

The responses from the questionnaires were inter-rated by the researcher and members of the research group to ascertain the credibility of the research (Guba and Lincoln, 2001). This also, helped in ensuring accuracy of the data as well as reducing the errors that might emanate from the questions. A thematic analysis was adopted to analyse the responses from the questionnaire. This help to understand teachers' IK, awareness and the possibilities of integrating their knowledge with Westernized Science in the classroom. The participants were given pseudonyms such as T1, T2, T3, T4…. for anonymity. Participation was voluntary, and participants were made to understand that they are free to withdraw from the research anytime they wished.

Ethical Considerations

All data collection processes emphasized in this study began and ended with ethical considerations. Ethical issues are inevitable in qualitative and quantitative educational researches Just like Creswell (2012) pointed out that quantitative and qualitative research in education inevitably carries ethical issues, because it involves data collection from peoples' experience and about them (Creswell, 2012). I ensured that I developed a good work relationship with the community where the research took place. This was done by observing all protocols and laid down rules by the community. Also, Merriam and Tisdell (2015) in their study explain that validity and reliability of a study is influenced by ethics of the researcher. Also, Patton (2015) recognizes the fact that the credibility of the investigator along-side the rigorous methods of research are crucial factors for ensuring the credibility of a qualitative research. Hence, the trustworthiness of the data collected is directly coupled to the trustworthiness of investigators who collect data and analyse them, and how they demonstrate their competence. Qualities such as: the research design, methods, analytical techniques are important in all research because there is need to trust that the research was conducted with integrity as well as the ethical viewpoint of the researcher (Merriam & Tisdell, 2015). It depends and involves rigorous thinking about everything including the data analysis. There are laid down rules, guidelines and policies by Government officials, professional bodies, and institutions, but the researchers' ethical practice depends on his/her own ethics and values (Merriam & Tisdell, 2015; Tracey, 2013). According to Tracy (2013) ethical issues can be situational (ethical issues in the research context) and relational (investigators' awareness of personal role and impact they have on relationships with participants). It goes beyond just collection of data but seeing the participants as humans/people and not just mere subjects for research story. Investigators must consider protection of the

participants from harm, allowing them right to their privacy, the idea of informed consent and issues regarding deception before embarking on the research journey (Merriam & Tisdell, 2015).

In qualitative research, data collection techniques through interviews have their own ethical issues. Therefore, Stake (2005) suggested that because "qualitative researchers are guests in the private spaces of the world. Their manners should be good and their code of ethics strict" (p. 459). Merriam and Tisdell (2015) explain that during interviews, participants are bound to either benefit from the research or run a risk of their privacy being invaded. They are likely to be embarrassed by the questions asked by the researcher or might regain self-value from the topic of discussion. Also, during observation if the researcher should observe a group of participants without their consent or awareness of the participants, ethical issues such as invasion of privacy and informed consent may arise (Merriam & Tisdell, 2015). Regarding ethical issues of psychology that might emanate during data collection, Patton (2015) suggests that a researcher might have to refer such a participant to resources to help in dealing with such problem. This is because the researcher is no therapist, judge, nor unresponsive to the suffering of participants or resurrection of their past experience, rather the main task is to gather data for the study.

Hence, for this study, I started by obtaining ethics approval from the University of the Witwatersrand non-medical human research Committee and Gauteng Department of Education (GDE). Teachers were provided with detailed information sheets regarding the research. Also, consent forms were given to the teachers of the classes selected for the research, the principal of the participating schools concerned to indicate their willingness to voluntarily participate in this study. Teachers were asked to sign the consent forms given to them before the commencement of the research. Permission for voice recordings was also obtained from the participants of the

study. The consent forms explained the purpose of the study, its benefits, the confidentiality, and anonymity of the data to be collected.

It was indicated in the consent forms that the participants' freedom to withdraw at any stage without any negative effect on them will be allowed and this was strictly adhered to during the process of carrying out this research. In summary, in the process of reporting this study, pseudonyms (T1, T2, T3……) were assigned to the participants of the research and no personal information was revealed during the course of this research. As a researcher, all ethical issues that could emanate from the study were avoided as much as possible.

Data analysis

To answer the research questions, data collected for this study were analysed so as to develop a holistic understanding of the teachers' IK and the possibilities of integrating such knowledge with their Life Sciences teaching and learning. As explained before, data for this study was collected through questionnaire, interviews, and document analysis and the interviews were audio recorded and analysed verbatim. Merriam and Tisdell (2015) posited that "qualitative data analysis is primarily inductive and comparative" (p. 201)

Boyce and Neale (2006) in their study revealed that qualitative studies typically display a great volume of data to be analysed, summarised, and interpreted. Data analysis is a process that involves the organization and interpretation of visual materials (linguistic) to produce statements regarding dimensions and structures that are implicit and explicit. This structures and dimension create meaning-making and what is represented in the material to be analysed (Flick, 2014). The moment data collection is done, there is need to organize and manage it, after which categories must be formed.

In relation to the step by step of data analysis, the explanation given by Boyce and Neale (2006) is that in the process of analysing data, the researcher must first transcribe the data collected and secondly, analyse all interview data by reading carefully through the interview responses and looking for patterns or themes among the participants, then making groups of themes in a meaningful way. According to Merriam and Tisdell (2015) data collected for a study and its analysis can be done in and out of the setting. There is a possibility that an investigator can simultaneously be doing some simple analysis while in the process of data collection and between the activities of data collection.

Organizing and managing data involves devising some systems early in the study. This process involves coding. Coding according to Maxwell (2012) is the main categorizing strategy in a qualitative research which deals with fracturing and rearranging the data by placing it into categories that can help in its comparison. Coding is a process of assigning words to various parts of data to give easy access in retrieving some specific fragments of the data (Merriam & Tisdell, 2015). For this study, coding was done manually to ascertain a better organizing and understanding of the data. Since the process of data analysis involves making sense out of the data, it also involves reducing, consolidating and interpreting what the investigator has seen and read as well as what the participants have said (Merriam & Tisdell, 2015).

Data was triangulated by cross-checking the data that was collected both from interviews, questionnaires, and document analysis. This enabled me to identify the consistency of the emerging findings, ensuring the authenticity of the data and internal validity of the research. Researcher bias was avoided by understanding the views of the participants as well as taking note of the exact views of the participants.

Summary

In this chapter, the use of a qualitative case study was discussed in-depth. Qualitative research involves real life experience in the context of the participants. Case study methodology in relation to a qualitative research was discussed and how it fits the research. A purposeful sampling chosen for this study was discussed and how data was collected from different participants of the research was stated as well. The use of instruments such as questionnaires, interviews and document analysis to collect data for this study were explained in detail. The method of data analysis and Ethical considerations for the study was discussed in-depth.

Chapter Five

Results and Discussion

This research examined teachers' IK, how they integrate such knowledge in their multicultural Science classroom (see chapter two) and also probed their ideas on how IK could be further integrated into classroom teaching practices with the aim of making Science more accessible to learners. This study engages a qualitative case study design and data were collected from four peri-urban schools in the Gauteng province as presented in the methods section. The responses gathered via participants' response to questionnaires and interviews were coded and then themes were formed and were categorized using the Barnhardt and Kawagley (2005) Venn diagram of the relationship or link between indigenous and westernized worldviews of Science. Also, the South African NCS (2002) and CAPS (2012) policy documents were analysed to understand the curricular focus and expectations of IK for teaching and learning of Science in the multicultural classroom, as well as instructions on how it should be integrated. More details of the research design have been provided in the methodology section, including the methods of data collection. In this Chapter, the results and discussion from the data collected for this research study are presented in three parts. Part one represents the document analysis of the NCS

(2002) and CAPS (2011) policy documents (this will answer research question one), part two represents the results and findings from the qualitative data collected via questionnaires and interviews (this will answer research question one two and three) while part three represents an integrated discussion on the research questions that have been addressed.

PART 1: Document Analysis

Words that reflect IK in the curriculum were searched for and analysed on how they were used, why they were used and what they were used for. In this study, I analysed the content of the South African policy documents (NCS 2002 and CAPS 2011), by generating codes and themes through the application of thorough and practical knowledge of the phenomenon (IK) under study. The policy documents were analysed in connection with the phenomenon under study and based on literature described in the methods section, this analysis helps to provide insight on the significance of IK in the curriculum documents and its integration in the Science classroom.

Analysis and Interpretation of NCS 2002 and CAPS 2012 Policy Documents

The data presentation of the policy document analysis is made up of codes and themes that were generated during the content analysis. The codes and themes were provided (tables 4, 5, 6, 7, 8, 9) in the next section as an example of what it represents. The NCS and CAPS policy documents analyzed were for Grades 10, 11 and 12, Life Sciences subjects. Below is a description of the features of the policy documents, while a detailed description on the history of both documents NCS 2002 and CAPS 2012 can be found in the first chapter of this research study.

Description of the NCS 2002 Policy Document. The NCS for Life Sciences for Grades 10, 11 and 12 is a formal curriculum which is divided into four chapters. Each chapter is aligned to the curriculum as follows. Chapter one deals with the general description of the design and principles of the NCS from Grades 10 to 12, introducing the reader to the curriculum. Chapter two gives a thorough description of the definition, scope, purpose (why), career links and the

subject learning outcomes. This chapter also gives orientation to the subject statement. Chapter three, deals with prescribed content (what to teach .i.e. the intended curriculum), and contexts for subjects and assessment standards for each of the learning outcomes. The proposed context and content to attain assessment, teach and learn are provided at the end of this chapter. Chapter four of the NCS covers the 'generic approach to assessment' recommended by the NCS. A table describing the subject specific competence is constructed at the end of the chapter. The NCS provides the scales, codes, and competence descriptions for each grade. The codes generated for the NCS 2002 policy document can be found in appendix 7.

Description of CAPS 2012 Policy Document. The CAPS 2012 is a South African policy document that is divided into four sections, and each section describes the content of the document as outlined next. Section one introduces the audience to the curriculum background and overviews, aims, and time allocation for various learning phases (foundation, intermediate and senior). Section two describes the Life Sciences content and its organization in the curriculum, the purpose and the three specific aims of learning Life Sciences, time and resources needed to teach Life Sciences. This section describes 'why' Life Sciences and IK need to be integrated in the classroom. For example, "Appreciating and understanding the history, importance and applications of Life Sciences in the society" (DBE, 2011). Section three describes Life Sciences content in different Grades 10, 11 and 12; this includes what to teach in the Life Sciences classroom. Section four contains general assessment of Life Sciences, formal and informal for Grades 10, 11 and 12, assessment requirement for Life Sciences from Grades 10-12, and end of year examinations procedures.

The contents of both documents NCS 2002 and CAPS 2012 were analyzed and the identification of IK in the curriculum revealed three main themes, i.e., why there should be a

focus on IK while teaching Life Sciences, what to teach (what IK should be integrated with Life Sciences) and how to teach (examples can be found in the next sections of analysis). The reason for this document analysis is to identify how IK is represented in the policy documents and how this relates to the teacher's expression of the possibilities for integration of IK in classroom teaching of Life Sciences. The themes and codes referred to below follow the method outlined by Braun and Clarke (2006) as explained in the methods section. Tables (5, 6, 7, 8, 9, 10) depicting the codes generated, and the themes that emerged from the NCS and CAPS documents analysis are presented in the next section. Themes 'why IKS, what IKS and how IKS can be integrated' emerged from the data for this study.

Research Question 1: How is Indigenous Knowledge represented in the Grades 10, 11 and 12 Life Sciences curriculums (NCS & CAPS) in South Africa?

The codes generated were further broken down into sub-codes and themes were formed. The implicit IKS are the codes which are more aligned with Westernized Science, but could still relate with IK. For example; on the implicit column, social transformation, human impact on the environment, new knowledge discovery, carrying out investigation and experiments, to mention a few, are all everyday concepts related with Westernized nature of Science. They are not indigenous to the South African context alone. However, the implicit IKS are referred or implied in the document with the IK not necessarily showing clearly. The concepts mentioned above can also be found in IK, but in this case, the curriculum did not clearly state its relationship with IK. The explicit IKS are concepts that connotes and are closely related to IK or are directly IK concepts. They are concepts that come across quite evidently in the policy documents focusing on IKS. As shown in tables 5 and 6; 7 and 8; and 9 and 10 below, three themes emerged as to how IK is represented in the curriculum, namely; why IK should be integrated with Life

Sciences; What IK should be integrated with Life Sciences and; how IK should be integrated with Life Sciences in the classroom. The policy documents (NCS and CAPS) were both analyzed to answer the above research question using the mentioned themes (see table 5 and 6; 7 and 8; 9 and 10 below). Arguments presented below reveals that the key information acquired from the examination of policy documents, indicates the need to integrate IK with Westernized Science in the Science classroom. The data from the document is presented below.

Theme 1: Why IK should be integrated with Life Sciences in the classroom

Considering the description of both policy documents, it was stated that the general aim of implementing IK in the curriculum was for the purpose of "equipping learners, irrespective of their socio-economic background, race, gender, physical ability or intellectual ability, with the knowledge, skills, and values necessary for self-fulfillment, and meaningful participation in a society as citizens of a free country" (DBE, 2011, p. 4, NCS). Also, it is based on the principles of attaining social transformation (DBE, 2011 & DoB, 2003). It is focused on enabling teachers and learners to have the sense of "valuing Indigenous Knowledge systems (DoE, 2003, p. 1. NCS); acknowledging the rich history and heritage of this country as important contributors to nurturing the values contained in the constitution" (DBE, 2011, p. 5. CAPS). Also, one of the specific aims of Life Sciences that promotes the inclusion of IK in the classroom is specific aim 3, "which relates to understanding the applications of Life Sciences in everyday life, as well as understanding the history of scientific discoveries and the relationship between Indigenous Knowledge and Science" (DBE, 2011).

For the learning outcome in NCS, the IK was not explicitly outlined. However, the purpose of the learning outcome came out explicitly where it was stated in the document that:

> This Learning Outcome raises learners' awareness of the existence of different viewpoints in a multicultural society and encourages open-mindedness towards all viewpoints. These viewpoints are based on scientific knowledge, beliefs, ethics, attitudes, values and biases, and may change over time due to new information (DoB, 2003, p. 12).

Apparently, the purpose of the inclusion of IK in the curriculum is clearly stated as teachers are mandated to integrate this worldview (IK) with their Life Sciences teaching to create "greater awareness of the ways in which biotechnology and knowledge of Life Sciences have benefited humankind; a deep appreciation of the unique diversity of past and present biomes in Southern Africa and the importance of conservation" (DBE, 2011). Below are tables (5 and 6) depicting the codes that were generated from the document analysis of NCS and CAPS and the emerged theme 'why IKS'.

Table 5

Depicting Generated Codes and the Emerged Theme from the CAPS Policy Document

CODES		THEME 1
EXPLICIT IKS	**PAGES**	
To promote knowledge in local context	5, 6	
To Equip learners of diverse culture		
To acknowledge the rich history of South Africa		
To appreciate diversity of organisms in South Africa		
Understanding the history of Science and IKS		
Teaching IKS relating to specific topic		
Exposing learners to indigenous knowledge of diverse cultures		
Indigenous knowledge rooted in a different worldview		
Linking IKS to specific areas of Life Sciences subject content		

Understanding the Relationship between IKS and Science		
IMPLICIT IKS		**WHY IKS**
Social transformation		
Human impact on the environment		
New knowledge discovery		
Carrying out investigation and experiments		
Systematic approach to Science enquiry		
Appreciating the unique diversity of the biomes		
Development of scientific knowledge		
Understanding of Science roles in the society		
Understanding the importance of conservation		
Development of scientific skills		

Table 6

Depicting Generated Codes and the Emerged Theme from the NCS Policy Documents.

CODES		**THEME 1**
EXPLICIT IKS	**PAGES**	
Accessing relevant information from different contexts	1, 2, 4, 10	
Valuing indigenous knowledge systems		
The need to address the legacy of apartheid in all areas of human activity and in education		
Ensuring that the educational imbalances of the past are redressed		
Participate as responsible citizens in the life of local, national and global communities		**WHY IKS**
Be culturally and aesthetically sensitive across a range of social contexts		
Compare scientific ideas and indigenous knowledge of the past and present culture		
Recognize the wide diversity of knowledge systems through which people make sense		
Knowledge embedded in African philosophical thinking and social practices		
Acknowledge the rich history and heritage of South Africa		
An important contributor to nurturing the values contained in the Constitution		
IMPLICIT IKS		
Social transformation		
Human rights, inclusivity, environmental and social justice		
Understanding the interrelationship of Scienc33e		
Understanding the influence of ethics and biases in Life Sciences		
Accessing knowledge		
Using Life Sciences concepts to explain phenomena		
Develop a high level of knowledge and skills in learners		
To assist problem solving in all fields		

I have looked at the 'why IKS' theme because it represents the purpose of integrating IK in the curriculum. It depicts the reasons teachers should integrated IKS with Westernized Science in the classroom, and this resonates with the three broad specific aims and objectives of the curriculum. Table 4 and 6 above depicts the codes that were generated from data and the emerged theme 'why IKS'. The codes represented in the explicit IKS section are codes that directly connote IKS in Southern Africa. The codes represented in the implicit IKS section do not directly connote IKS, although they can be found in the IKS context. They are more directly linked to Westernized Science. The reasons for integration are explicitly stated, and all of these aim at a particular purpose of building an egalitarian society, where every culture (indigenous and western) is considered in upholding the history of the nation. The "why Indigenous Knowledge should be implemented in the curriculum" is clearly stated from the examples given above, and it is obvious in the concepts to be taught in both policy documents.

Theme 2: What Indigenous Knowledge Should be Integrated in the Life Sciences Content (NCS & CAPS)?

The content and concepts in the Life Sciences curriculum was analyzed to identify the IK content in the document. In this document (NCS & CAPS), what IK teachers should integrate with their Life Sciences teaching was both implicit and explicit depending on the concept to be taught, hence the need to code them accordingly. In the CAPS policy documents for Grade 10 under term 2 in strand 1, a major concept **Applications of Indigenous Knowledge Systems and Biotechnology** was outlined, and the following concepts such as: traditional technology, e.g., traditional medicines and healers; medical biotechnology, e.g., immunity, vaccines, antibiotics and blood transfusions were mentioned. These outlined concepts were to be taught using the application of Indigenous Knowledge systems and biotechnology. These concepts were found

under the concept of plant and animal tissues for Grade 10 (DBE, 2011, p. 28). Another example is in the Grade 10 concept: **Biosphere to ecosystems**, under which you find **Biomes**; Terrestrial and aquatic biomes of Southern Africa and how climate, soils and vegetation influence the organisms found in each; the location of the different biomes in South Africa. For strand 3 **Environmental studies**, for Grades 10, term 3, it was stated that:

> This section is structured to expose learners to some of the interactions that occur in nature and to the terminology and concepts that describe them…… This will enable learners to contextualize the meaning of these terms and concepts within the familiar contexts of their local area as well as Southern Africa as a whole. The local area context is also used to introduce how humans influence the environments in which they and other organisms live. (DBE, 2011, p. 33).

This statement above is an indication that the policy document requires teachers to integrate IK and Westernized Science during their classroom practice, therefore, what IK to be integrated was provided in the concepts above. However, the concept of environment in terms of human activities and interactions with the natural environment; abiotic and biotic factors- effects on the community (DBE, 2011, p. 33), to mention a few were all outlined for integration. All these concepts indicate the content that is required of teachers to teach in their Science classroom and the need to integrate IKS with Life Sciences. The theme ‘what IKS’, represents the IK content and concepts of the curriculum that teachers are expected to integrate with Westernized Science in their classrooms. The codes were generated from different concepts of the curriculum and were broken down into explicit and implicit IKS and then the theme ‘what IKS’ emerged. Table 7 and 8 represents the emerged theme ‘what IKS’ and codes generated from the document analysis of NCS and CAPS.

Table 7

Depicting Generated Codes and the Emerged Theme from the CAPS Policy Document.

CODES		THEME 2
EXPLICIT IKS	**PAGES**	
The location of various biomes in Southern Africa	Page 33, 36, 37	**WHAT IKS**
Biodiversity and endemism in Southern Africa		
Indigenous and endemic species		
Bivalves and ammonites found on Makhatini flats in northern KZN		
Trilobites in the Karoo		
Evidence of key events in South Africa of life history		
Soft-bodied animals in Namibia, Northern Cape		
Evidence of single-celled fossilized bacteria (stromatolites) in South Africa		
Forests of primitive plants such as *Glossopteris* near Mooi River and Estcourt		
Terrestrial and aquatic biomes of Southern Africa		
IMPLICIT IKS		
Learners should recognize patterns and trends		
Application of knowledge in new contexts		
Teaching resources within the school context		
Collecting and presenting data in the forms of drawings and descriptions		
Making measurements		
Using celery and pumpkin stalks to observe thickening		
Fossil formation and methods of dating them		
Identifying patterns and relationships in data		
Support and transport systems in plants		
Biodiversity within the ecosystem		
The concept, structure and function of ecosystem		

Table 8

Depicting Generated Codes and the Emerged Theme From the NCS Policy Document.

CODES		THEME 2
EXPLICIT IKS	**PAGES**	
Searching for information about South Africa as the cradle of mankind	Page 37, 38, 40	
technology, indigenous knowledge, the environment and the society		
Identify and investigate scientific ideas and indigenous knowledge of past and present cultures		
Investigating home remedies for nutritional disorders		
Describing diverse ways of using resources in developing products		
Describing the use and abuse of fossil fuels		
Identifying concepts, principles, laws, theories and models of Life Sciences in the context of everyday life		

Exploring scientific ideas of past and present cultures		**WHAT IKS**
Comparing industrial production of fermented beer		
Reporting on the impact of resources		
Comparing food preservation in South Africa to the traditional method		
Making use of the local people as sources of information		
Differentiate and analysing the impact of non-indigenous plants on the environment		
Collection and analysis of data on community diseases		
IMPLICIT IKS		
Scientific inquiry and problem solving	Page 39	
Investigate phenomena relevant to Life Sciences		
Critical thinking and other skills		
Analyse, synthesize and evaluate data		
Compare data and construct meaning to explain findings		
Explain patterns in the data in terms of knowledge		
Describing research findings on diarrhoea in the community		
Looking for evidence for the causes of respiratory problems		
Evaluate experimental findings		
Construction and application of Life Sciences knowledge		
Using books and magazine to collect information on nutrition		
Describing the causes of various digestive problems		
Explaining causes of nutrition problems		
Researching causes and effects of HIV/AIDS		
Interpreting and making meaning of knowledge in Life Sciences		
Debates about the origin of life		

The concepts in tables 7 and 8 respectively are examples of the content teachers are required to teach, and it depicts explicit IKS and implicit IKS content to be taught in the Science classroom for Grade 10, term 1. Although, there were more implicit IK words found in the content of both policy documents compared to the explicit IK. The analysis done on these two documents, revealed the content on IK that is meant to be taught within the classroom context by Life Sciences teachers. As shown in the example above, it is evident that IK, as mandated by the policy statement, is imperative to teaching Sciences in the classroom. However, for a nation calling for the inclusion of IK, there is need to encourage and empower teachers on the inclusion of IK to promote the history and heritage of South Africa. In most cases, a very limited number of examples were given for only few concepts in both policy documents. For example, for the

concept of evolution in CAPS, for Grade 12, teachers were encouraged to teach human evolution by making reference to cultural evidence and main fossil sites in South Africa (DBE, 2011, p. 63). These examples were found only in few explicit cases in the content of the curriculum and it does not portray the supposed importance placed on IK in the mandate. If a mandate is given and reasons for the mandate were also clearly stated for IKS inclusion, it is anticipated that there would be more information regarding IKS in the document. However, when analyzing the NCS and CAPS documents there seems to be a gap on how information on IKS can be used by teachers to demonstrate its importance to Science teaching and learning However, for this study, the content of the policy documents do not have sufficient information on what IK teachers need to do and how to use IK as part of their Science classroom teaching practice. This is evident in table 6 and 7 presented above.

Theme 3: How IK Can Be Integrated In the Life Sciences Classroom According To NCS and CAPS

After analyzing the CAPS (2012) and NCS (2002) policy documents for Grades 10, 11 and 12 Life Sciences, it was observed that there was IK embedded in these documents on 'how' it should be integrated in the classroom, although not explicitly, considering the mandate and the purpose of the mandate (please refer to table 9 and 10 below). But surprisingly, even though the curriculum mandated the teachers to integrate IK with their Science teaching, it seemed that teachers were not provided with any explicit guidance on how to teach the content in the curriculum except in one concept in the CAPS curriculum, for Grade 12. In this instance, in the concept of human evolution as conveyed in the previous section, the curriculum encouraged teachers to help learners to research and discuss and share different information about cultural and religious explanations (DBE, 2011, p. 65). For NCS, there was no evident indication on the

teaching practice that teachers could use to teach or integrate IK in the Science classroom. Second example can be found in the CAPS (2012) document for Grade 11, term 4: for the concept "Human Impact on the Environment: Current Crises for Human Survival: Problems to be solved within the next generation". Teachers were encouraged to make reference to "Rhino poaching in South Africa: read articles and make suggestions on how it can be prevented" (DBE, 2011, p. 52). The theme 'how to teach' represents the procedures on how teachers are expected to integrate IK with Westernized Science in the classroom. Table 9 below represent the emerged theme 'how IKS' and the codes generated from the document analysis of CAPS while table 10 below shows that no codes were generated on the 'how IKS' should be integrated with Westernized Science in the NCS document analysis.

Table 9

Depicting Generated Codes and the Emerged Theme from the Caps Policy Document.

CODES		**THEME 3**
EXPLICIT IKS	**PAGES**	
***		**HOW TO INTEGRATE IKS**
IMPLICIT IKS		
Observe biodiversity within the ecosystem used	Page 52	
Location of coal deposits in South Africa (map only)		
Construct models using beads		
Examine fossils at a museum or photographs of fossils Humans and pre-humans (Gauteng, (Cradle of Humankind)		
Food test on a pineapple juice and solid egg white in a plastic straw		
Choose and investigate an ecosystem within the school context		
Build on prior knowledge		
Rhino poaching in South Africa		

Table 10

Depicting no Information on the 'How IKS' can be Integrated in the Policy Document.

CODES		THEME
EXPLICIT IKS	**PAGES**	
*No codes were generated for this section	***	
IMPLICIT IKS		
*No codes were generated for this section	***	

For the CAPS document, the explicit IKS section had no generated codes for IKS in the theme on how IKS should be integrated. However, the codes in the implicit section do not directly connote IKS, although they can be found in the IKS context. They are more directly linked to Westernized Science as seen in table 9 above. For example: 'observe diversity within the ecosystem used' is a statement encouraging teachers to help learners to observe their environment and understand biodiversity. This concept could be taught based on the westernized theory provided in a textbook; it does not state explicitly how teachers should go about it and what IK should be considered. However, a direct and explicit IK could indicate that, teachers should talk about, for example, species of organisms that are indigenous to South Africa and how they influence the environment. In the case where such can be directly interacted with, teachers should know how to interact with such. Another example is with the statement 'construct models using beads'. This statement informs teachers on what to do to teach the concept, but how they should construct this model using beads is not explicitly stated in the policy document. Most teachers and learners could be familiar with the use of beads for beautification or traditional purpose, but they might not be familiar with its use in the classroom. For the NCS document, there was no information on how IKS can be integrated with Life Sciences in the classroom.

from this analysis, it is evident in this study that the curriculum did not indicate or provide teachers with ‘how’ to integrate IK with Life Sciences in their teaching practice.

My argument here is that, teachers are left with the responsibility of how to incorporate this instruction with their Science teaching. The ‘how’ they should integrate IK with Life Sciences was not explicitly stated in the policy document. A suitable teaching strategy and an example of IK idea could have helped teachers to teach this concept better, considering the multicultural nature of the classroom. A third example where the integration of IK is more easily seen is in the CAPS document for Grade 10, for the concept, the chemistry of life, where it clearly stated that teachers should “construct models of simple and more complex molecules using beads or plasticine” (DBE, 2011, p. 28). The use of beads by individuals, especially in Africa has been in existence since time immemorial. Beads are cultural artifacts used by Africans for art work and beautification, decoration, marriage, spiritual purposes, (Fakoyede & Otulaja, 2019) to mention a few. However, teachers could know what beads are because they are likely to interact with it in their everyday lives and it is indigenous to Africa as their everyday knowledge (Hewson & Ogunniyi, 2011) but, knowing how to utilize the beads to construct molecules could be a challenging task for them (Fakoyede & Otulaja, 2019). I have decided to talk about these concepts because of their link to IK even though the ‘how’ was not explicitly stated in the document. This study was done in the Southern African context, it is important to situate the concepts being taught to learners within their familiar context using IK. Guidance on how to integrate IK and Westernized Science should be provided for teachers in the curriculum, since they are expected to use the curriculum as a teaching guide. This is important because, it will enable teachers to make learning Science more accessible to learners of diverse culture in the Science classroom, thereby, enabling them to appreciate Science better.

As it was revealed in the policy document analysis in this study, the "Why IK should be integrated with Life Sciences in the classroom" was stated clearly in the policy documents (NCS 2002 and CAPS 2012), "What indigenous knowledge to be integrated with Life Sciences content" was also found in the curriculum but not very explicitly, especially in most topics to be taught. The "How to integrate Indigenous Knowledge" was a problem found with the policy documents. According to Ramorogo and Ogunniyi (2010), teachers have encountered issues on the implementation of IK since the new curriculum was launched. This could be a contributing factor as to why teachers do not integrate IK with Westernized Science in the curriculum. The know 'how' to teach or integrate IK is considered a procedural knowledge, which according to de Jong and Ferguson-Hessler (1996) and Shulman (1986) is regarded as the possible ways or strategies teachers use to make concepts understandable to learners. With this knowledge of IK and procedural knowledge, teachers are able to enhance scientific literacy in their science classroom. According to Osborne et al. (2003) issues of Science literacy have been discovered in the history of Science education, and it is been deliberated upon in such a way that it reviews the rationale behind the teaching of Science; what Science education should be taught in schools and how Science should be taught and organized; and at whose interest should Science education be taught. How to teach involves the use of appropriate instructional materials and strategies to teach Science in the classroom, for example, the curriculum could aid the teachers by providing them with explicit examples of materials, context and strategies of how they could integrate IK and Westernized Science to teach specific concepts. Policy makers could adapt studies that have been conducted by researchers such as Aikenhead (2001), Barnes (2006), Bartlett (2007), Ogunniyi (2011), and Fakoyede and Otulaja (2019) to encourage a more culturally responsive teaching. Culturally responsive teaching enhances student's achievement and it requires a teacher

to create a welcoming and supportive environment for all learners by giving them the opportunity to learn irrespective of their diverse culture and linguistic background (Barnes, 2006). This can be done by introducing cultural artifacts to learners during teaching and learning of Science in the classroom. According to Bartlett (2007) the use of cultural artifacts in teaching plays an important role in enhancing literacy in the classroom, especially for learners whose literacy performances are questionable. Similarly, teachers who have a good idea of the composition of the class cohorts and cultural backgrounds of their students are better off creating examples that are specific to that cohort.

Based on the findings from my study, rather than focusing on Eurocentric curriculum (Shizha, 2005), more examples of IK should be made available to teachers in the curriculum and how they should be used to teach different concepts. Therefore, my study shows that both knowledge views should be incorporated in the Science teaching and learning to relate with learner's everyday experiences and their socio-cultural views. If teachers do not have the strategy on how to integrate IK with Life Sciences, the call for inclusion of IK and the purpose of acknowledging and enriching the rich history and cultural heritage of South Africa (DBE, 2011) will probably not be achieved in the Science classroom. Therefore, in response to research question 1, it is evident that the curriculum does not indicate how teachers should integrate IK with Westernized Science in their Science classroom. Therefore, there is need to adjust the way in which IKS is represented in the Science curriculum to achieve the set goals.

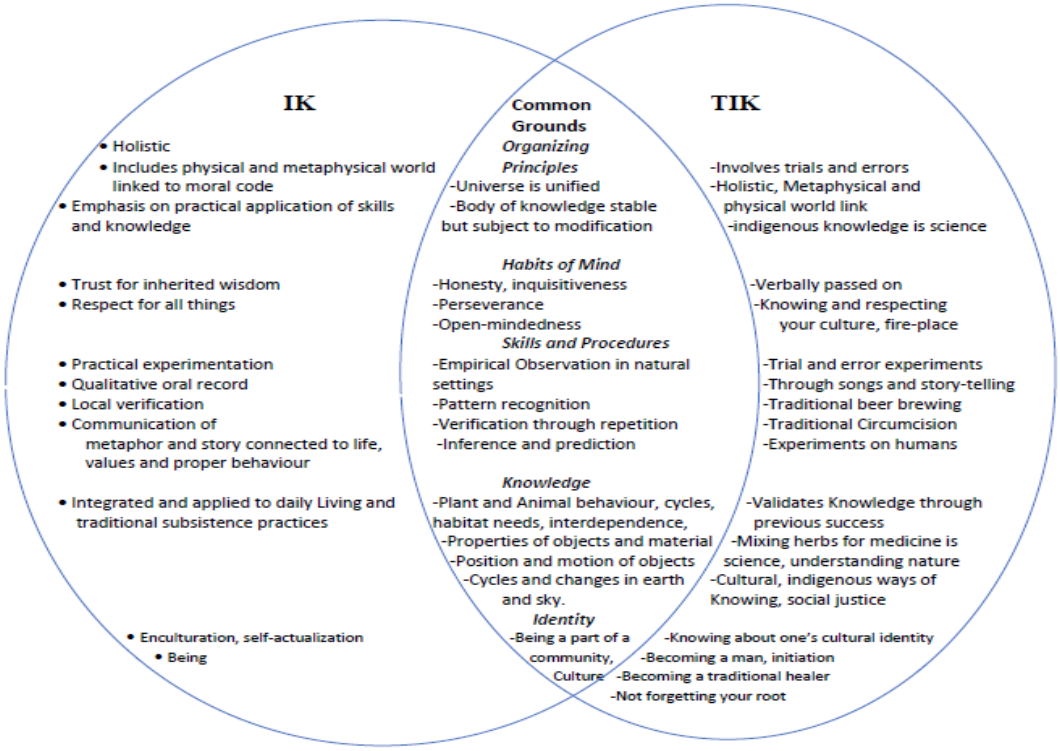
PART 2: Teachers' Perception

Research Question 2: What Perception Do Teachers Have About Indigenous Knowledge?

This research question was posed to understand teachers' awareness of IK and their perception regarding this knowledge. The first five items on the questionnaire were posed to ascertain teachers' perception of IK; details of the questions can be found in the methodology chapter (table 4 and appendix 3). The questionnaire responses from teachers were broken down into codes in tables, and then themes were formed based on the analysis of my data (figure 4). Reoccurrence of certain responses was further broken down into themes using the Barnhardt and Kawagley's (2005) various common grounds between IK and Westernized Science (please see figure 2 in chapter 2). These themes were used to analyse teacher's responses from questionnaires and interviews, as it reflected on the responses given by the participants. On the knowledge synthesis diagram (figure 4), the responses from teachers' interviews were tagged Teacher's Indigenous Knowledge (TIK). TIK represents teachers' views about IK, and this was compared to the IK views as defined by Barnhardt and Kawagley (2005) and the common ground as seen in the figure below. The figure below is an example of the themes and categories generated from teachers' responses on IK during the interview.

Figure 4

Teachers' views of Indigenous Knowledge. Adapted from Barnhardt and Kawagley (2005)



Theme 1: Organizing Principles

Responses from teachers reveal that IK is holistic in its approach to dealing with traditions and culture, as seen in figure 4 above. When teachers were asked about their views of what IK means to them as a science teacher, from their responses they explained that IK is knowledge that has developed from the philosophies of various societies. They further explained the non-static nature of IK and how it has been passed on from one generation to another as shown in figure 4. For example: T1 opined that "It means I have to understand the skills and philosophies developed by societies with long history of interaction with my natural surroundings." According to T12, "It is knowledge deeply rooted in Science that has been passed down from generation to generations, and it is deeply rooted in history." The third teacher opined that IK to him as a

science teacher means to "Be able to perform rituals (metaphysical world) for any event that needs it, the future is imperative to elders, that is why knowledge was passed through stories."

From the responses above, findings from this study shows that the teachers understand the principles and underpinnings of IK in relation with Science. These teachers who gave the responses above teach Life Sciences and Natural Sciences subjects, and they are from South Africa. They are multi-lingua, that is, they speak English, Shona and IsiZulu. Findings show that teachers who participated in this study view IK as a body of knowledge embedded in Science and passed down from one generation to the next. From the excerpts above, T13 opined that IK is metaphysical in nature and helps the indigenous people to interact with nature. Teachers are of the opinion that the indigenous people developed skills that helped them to survive and interact with their natural surroundings and these skills had philosophical underpinnings that have been passed from one generation to another. T12 opined that these skills have Science embedded in them and have been in existence for generations. According to T13, the metaphysical aspect of IK is mostly practiced by the spiritual leaders or elders of the community as they perform rituals to heal and to sustain their knowledge. This means that, IK is a sub-culture of Science and the knowledge teachers have can be used to teach Westernized Science. From their views I would say that the teachers who participated in this study are aware of their IK and its philosophical underpinnings.

The organizing principles according to Barnhardt and Kawagley (2005) indicate that the IK is holistic and it is made up of metaphysical and physical world link, as it emphasizes on the "practical application of skills and knowledge" (p. 29). Also, western Science involves perspectives from part to whole, with physical evidence and explanation of the world, and means that both worldviews are unified and can be modified. Just like the teachers stated, Dei (1993)

also opined that the nature of IK is holistic and inclusive in its approach, and Ogunniyi (2007a) described it as a "conglomeration of knowledge system." IK is rich with different cultural practices such as farming, traditional healing, hunting, fishing, sustainability, dancing, singing, folklores, and so on (Odora hoppers, 2004), which makes it a knowledge system filled with scientific attributes. For this study, it shows that teachers are embodiment of IK and they understand its principles as a body of knowledge.

Teacher's views of socio-cultural perspective and importance of Indigenous Knowledge as Science

When the teachers were asked of the importance of IK, the following response ensued. For example, T8 believes that IK is important because "A person is born with a sense of belonging (culture) of which has an impact on human development, cognitive capacity and reasoning". However, T2 also opined that "They are important in such a way that they define one's identity which could be used in learning during formal education". These two teachers are from a clan in South Africa, they both teach in the same school in a peri-urban region of South Africa. T2 is Tsonga speaking and is a male with 12 years teaching experience in Sciences. A one on one interview was held with T2 regarding his opinion of the importance of IK, to further elicit his ideas, he stated that:

> It is very important. You know the cultural values; they go a long way. For example, in the upbringing of a person, giving them cultural set of cultural values, which are going to impact a lot on what that particular person is going to mix with other cultures. Tsonga people are very respectful people, part of it being the fact that they go through the initiation that taught rules, how to conduct yourself when you are in the midst of other people (T2).

On the other hand, T8 is isiZulu speaking, a female with 7 years teaching experience in Life Sciences. During the interview with her, she mentioned that IK is a culture that "formed the basics of the education that we have now".

Looking at the responses from both teachers, it can be deduced that they recognise that every individual is an embodiment of their culture, which forms their identity and gives them a sense of belonging just like Vygotsky stipulated. IK is underpinned with cultural practices and principles of the indigenous people, which thereby influence their identity as a person. How a person is raised by their families and community, and the value they hold plays an important role in their lives. She emphasize on the impact of indigenous values on the people of a community, and She further stated that within her community, great priority is placed on respect and it influences the way people present themselves in the public and obey the rules of the community. These cultural practices reveal that individuals share a relationship among their community and this relationship is held together by their cultural values. As Zhou and Brown (2015) opined, "humans are not only producing culture, but are also products of culture themselves" (Zhou & Brown, 2015, p. 33). Culture as defined by Zhou and Brown (2015) deals with behaviours, beliefs and attitudes that are socially acceptable, and it is formed through institutions, tools (language) and symbol systems which are societal products of human. However, Vygotsky in his quest to understand the interaction between humans and their environment stipulated that every human transformation and practices are influenced by culture; hence, culture influences human behaviour and personal development (cognitive development). Culture influences the functionality of the mind (mental functioning) at a particular time (Bennett & Savage, 2004; Zhou and Brown, 2015).

Both teachers were embodiment of their own cultural practices and they speak different languages, which makes them unique to their own culture. What I meant is that, they have their lived experiences in their socio-cultural community and this has shaped who they have become and their belief system (Bennett & Savage, 2004). In this case, there is a link between cognition and culture. From their response above, they revealed that language and culture plays a role in the being of an individual, that is, it defines the disposition of an individual as well as people of a community. As socio-constructivist would say, language is a cultural tool; it is used as means of communication among members of a community. Language enables individuals to communicate their thoughts and it aids social interaction among the teachers and learners in the classroom (Zhou & Brown, 2015). The significance of IK in this study is to promote the culture of Science using Science language as a tool in crossing the cultural borders in the classroom like the teachers stated. Science as a sub-culture is embedded in the cultural practices of the indigenous people, and it is what gives them a sense of belonging and aids in the continuation of life. The theme, organizing principles, reveals teacher's perception of IK as a holistic body of knowledge and its relationship with Westernized Science.

Theme 2: Habits of Mind

Indigenous Knowledge System as a Community of Practice (CoP)

Some of the codes in this category reflect participants' views of what IK entails, regarding the aspect of trust, rules and inherited wisdom that guides the indigenous people. The participants of this study were asked about how IK is preserved and carried from one generation to another and how its social and cultural values are reflected among the indigenous people of a community, some teachers stated that;

> They are communicated or taught within certain community and other communities still practice that knowledge. Again, they have been written down for the next generation to access…… The one important role it plays is to build morals and character in the generations. And gives people a common vision as a common vision which is to look after one another and the environment we live in. (T8)

> Through traditional education, where adults tell stories, teach young ones the practical knowledge of culture. By performing ceremonies through, singing songs, storytelling, myths, village meetings. Indigenous Knowledge practices are mostly unique to particular groups. How are these practiced and valued says a lot about the community, such as performing rituals, respecting adults, dressing a particular way, etc. (T12)

T8 opined that IK helps to build morals and places a responsibility on the people of a community on the concept of 'unity' and care for one another. The fire place activities, myths, songs and story-telling are the activities identified by these teachers as ways of transferring IK from one generation to another. The narratives given by these two teachers reveal their understanding and awareness of IK. They are of the opinion that every community has its own uniqueness as regards their IK. This idea could help teachers to adopt a better teaching strategy while teaching learners in a diverse classroom. The two teachers who gave their responses above identify with the Zulu community and they both teach Life Sciences however, the teachers who participated in this study came from different cultural communities and backgrounds. Therefore, both the teacher and learners bring with them to the classroom several funds of knowledge that can influence teaching and learning, as there is Science embedded in IK. For example, during an

interview session with a teacher, he mentioned that Science is embedded in IK, and then further said;

> Plants, the environment, animals, oxygen that we breathe in, carbon dioxide, we breathe out, all the natural resources, they are able to use to create this sense of life that we are in today. So all the environments are indigenous and it can be used to create Science, which is the study of life. (T6)

The teacher (T6) is a male and he speaks five indigenous languages (isiXosa, isiZulu, Sesotho, Sipede, Setswana), he grew up in rural area of South Africa. The teacher has been teaching Life Sciences for 8 years, and he teaches Grades 10, 11 and 12. The teacher has experience with teaching this subject. T6 opined that since IK is holistic and involves everything within our environment; therefore it is scientific in nature. In this case, the teacher understands the Science in IK, and can use it to make Science accessible in the classroom context. The teacher is the facilitator (social actor) who negotiates what happens in the classroom as cognitive development takes place among learners (Vygotsky, 1968; Moll, 2001). As this social activity takes place (teaching and learning), there is an exchange of ideas between the teachers and learners, which encourages the integration of Westernized Science and indigenous Science during classroom teaching practice, as Westernized Science and IK are both ways of interpreting the world (Hewson, 2012). Findings from this study show that teachers perceive IK system as a body of knowledge that is practiced among different indigenous communities, which forms their unique way of life. From the responses given by teachers, IK is passed down from one generation to another through spoken words and cultural practices by the elders of the community.

Indigenous Knowledge and Science

The teachers who participated in this study have a strong perception that there is Science in IK. For example:

> It can be used to explain how the world works…...There is a relationship between Science and Indigenous Knowledge, I think the relationship for me would be, I think modern Science actually exists from Indigenous Knowledge because yeah, everything that is explained in modern Science, it's actually something that has existed and that is been practiced by people, indigenous people for many years. Hence, when I teach, I am able to explain concepts in Science using Indigenous Knowledge, because I think there is definitely link there. So I think modern Science exists from Indigenous Knowledge. (T9)

This was the opinion of one of the teachers who participated during the interview. This teacher is a female and has been teaching Life Sciences for 3 years, she is multilingual, that is, she speaks isiXhosa, Tsonga, Sesotho, Venda and English fluently. From her statement above, she is able to identify the link between the underpinnings of Science and Indigenous Knowledge. For this study, some of the participating teachers displayed quite a lot of enthusiasm in their ideas of IK and its connection to Science. For T11, "Indigenous knowledge is unique because it involves local knowledge, wisdom and traditional Science".

In their views of IK and Westernized Science, they believe both worldviews share similarities, even though one is given more credit than the other due to documentation. T9 and T11 are both of the opinion that IK itself is Science because Westernized Science has its root in IK. Therefore, there is a strong link between both worldviews. They hold a strong conviction that

IK have been in existence among the indigenous people for centuries before it was modernized and tagged a western knowledge. The teachers could have a point in their belief, however, based on the evidence gathered for this study, in my view, I would say that teachers are not aware that all cultural scientific knowledge including the western scientific knowledge is a sub-culture of Science, and there is Science in both worldviews. Every cultural practice and scientific knowledge is indigenous to a particular community where it is practiced. Teachers who believe that there is Science in IK could have the tendency to incorporate IK with Westernized Science using learner's everyday knowledge or cultural knowledge.

Teachers' Understanding of the Science in IK

From the findings above, teacher's understanding of what IK is could be a factor to enhancing scientific knowledge in the classroom, making Science accessible to all learners in the classroom. Barnhardt and Kawagley (2005) believe that habits of mind deals with the wisdom that have been passed from one generation to another, which guides everyday activities of the indigenous people, and also having respect for all things, especially nature and cultural practices of the people. This is evident in one of the tenets of the nature of Indigenous Knowledge by Aikenhead and Ogawa (2007) which stipulates that the nature of IK deals with 'wisdom in action' by the elders of the community. Some of the traditions and cultural practices are passed down through imitations, repetitions and rituals that the people of the community are able to retain, and passed down to other generation (Cronje et al., 2015). Based on the deep experience of the indigenous people located within a certain geographical area, IK is socially constructed (Moulaison et al., 2017). According to the authors, the United Nations designated indigenous status to members of a community who identify themselves as a part of the community. However, these communities must be deeply rooted in the "pre-colonial settlement, maintain a

strong link to the land, and hold distinct social, economic or political systems and language, culture, and beliefs" that is totally different from that of the dominant society. Such communities have a common practice they are known for and can be identified with.

Therefore, teachers and learners who identify with different cultural group have different experiences which they bring into the classroom as practitioners of a community of practice (Lave and Wenger, 1991), as culture influences learning (Vygotsky, 1986; Zhou & Brown, 2015). "Culture influences the knowledge and experiences people bring to the classroom, the ways in which they communicate, the expectations they have for how learning will occur, and the ideas they have about what is worth learning" (Austin et al., 2001, p. 11). Community of practice can arise from any domain comprised of human activities such as the classroom where teaching and learning takes place (Farnsworth et al., 2016). The Westernized Science is a sub-culture of western culture while Indigenous Science is a sub-culture of IKS and both can be integrated in the classroom context. However, the classroom is multicultural in nature, and it is a social context as argued by Vygotsky, however all the teacher-student activities, communication (language), teaching methods (collaboration), taking place in the classroom influence the way learners construct knowledge (Austin et al., 2001). Farnsworth et al. (2016) stated in their interview with E. Wenger that learning is not an individual activity but a social process that takes place (situated) in a historical and cultural context (classroom). The idea for inclusion of IK and Westernized Science in the curriculum gives credit to the fact that IK is collaborative, social and cultural in nature as indicated by Aikenhead and Ogawa (2007), as it involves learning and communication, making integration affordable for teachers. Therefore it is revealed in this study that some teachers believe that there is Science in IK and it can be integrated with Westernized Science, while some teachers have a different perspective that there is no science in IK. The

different perspectives held by teachers in this study could influence how they teach Science to different learners in different communities and this could cause conflicts of interest in Science teaching and learning.

Theme 3: Skills and Procedures

Teachers' Views about the experimental processes and Tentative Nature of Indigenous Knowledge

For this study, participants were asked to share their view on whether IK uses experiment to discover new knowledge and the tentativeness of IK, the following view was expressed by them. T3 agreed by saying "Yes, the African potato has been used by the traditional healers as laxative for a long time. More recently, scientists have discovered that the African potato is one of the richest natural sources of sterols for immune system." T6 also agreed to the idea that experiments are conducted in IK by saying, "Yes, combination of plants and other natural resources is a form of chemical reaction." T10 opined that "Herbalist for instance, almost always administered traditional medicine in small concentrations; they only increase the concentration only if they would have observed the effect of the former." (T10). To elicit more information from the teachers regarding the tentativeness of IK, more interviews were conducted and the teachers surmised that:

> Yes, every herb that an herbalist will cure with, will first be tested, but not in a formal lab where concentrations and so forth is measured. It could be tested on a sick person and observations are made on the progress before it is accepted…..Um, I still believe that, discovery is not something that you discover, something that is going to be of use in the long run…. It goes through generations

> and then it gets to another. One will do it, somebody will remember that one tried to do something like this, let's see if I can maybe take it a step further. If I mix this one up, what is it going to be? So that tend to be some similarities in how they get to end product for both because, it is not something that you're saying, is the herbs now that is working, it's something that is tested from generations. Somebody will remember my uncle used to do things like this, but now I can maybe better it this way and so forth and so forth until it becomes perfect... (T2)

> Indigenous people were learning through mistakes and accidents, trials and errors, dance, and then they learn something new. I don't think they would quite take time, sit down, and find out what is happening. They bump into something, then they start going into some bit of exploration of that thing, sometimes they may not go far. (T10)

Although some of the teachers do not believe that it involves experiments, 7 out of 13 teachers who responded to the questionnaire are of the opinion that there is experimental process in establishing IK, four teachers do not believe that there is scientific procedures in IK, as illustrated below. T4 is a male and has three years of experience in teaching Life Sciences to Grades 11 and 12 students. The teacher is a South African and speaks isiXhosa fluently. The school where this teacher teaches is in the semi-rural area where people from different culture reside. When he was asked whether IK involved experiments, he said "No, they do not do experiment, instead they only deal with herbs they know that will produce good results. For example, the Khoisan people used to use aloe for thirst and other medical use, before it was westernized." This view may be as a result of the cultural practices this teacher has been exposed to in his community. However, two teachers were unsure of this idea, hence, they made the

following statement. T5 stated that “For that I cannot say yes or no. but for the fact that it has been going on for generations, some forms of credit needs to be given to this practice.” And T7 also said "Not sure, never heard of an experimental aspect of Indigenous Knowledge”.

Following an interview that was conducted to further elicit more ideas from T5 reveals that he agreed that there is experiment in IK. He stated that:

> Yeah, they do experiment because; I think they experiment with people, hence, their Sangomas [inaudible], people will say don’t go to this guy, don’t go to this guy, his medication is not working. This means they are experimenting on people, do you understand. Yeah, but western education, they experiment on animals, then they know that if this medication can treat a monkey, the chances are, it can work on a person because, we are closely related. But on the side, they do medication for people, if you have flu, the Sangoma will mix either one two three, they will give you combine loads of medications to take, then say if it works, you come back to me, if doesn’t work, it doesn’t work. So, they experiment. (T5)

T2 is a male South African, and he has been teaching Science for 12 years. The teacher is Tsonga speaking and according to him, he believes in the tradition of his people which reflects in most of his responses. It can be said that the profile and experience of this teacher makes him suitable to teach Science using IK because of his exposure to IK. He believes that every herb or medicines used by traditional healers in an indigenous community are first tested even though they do not undergo the rigorous scientific processes in the laboratory. The medicines are first administered and tested on a sick person to test its efficacy before further use on humans. This is known as trial and error as observations are made on the progress of the medicine or herb that

was administered before it can be accepted by the members of the community as a means to cure illness. T3 gave examples of the plant based medicines such as the African potato which is used as a laxative on persons as well as to boost their immune systems. This medicine can also be said to undergo the process mentioned by T2 above before it can be accepted to boost the immune system. The disadvantage of this trial and error for the indigenous people is the fact that an individual can die during this process, while for Westernized Science; it is mostly performed on animals in laboratories. Therefore, these teachers believe that some practices in IK also undergo testing, experiments and observations are been carried out on discoveries and herbs for healing the members of that community. Westernized Science also undergoes trial and error as indicated by Aikenhead and Ogawa (2007) as a means of testing and observing phenomenon that have been discovered or produced. The teachers who believe that experiments are performed in IKS, also believes that there is Science in it. Therefore, this idea could mean that these teachers are likely to use their cultural knowledge to enhance Science literacy in the classroom.

These teachers (T5 and T7) are unsure of whether IK involves scientific skills such as doing experiments, observation, inferential, as part of its nature. This does not mean that they do not understand IK; they are likely not experienced regarding its scientific processes just like the teachers who answered 'No'. However, T5's inability to tell whether there is experiment in IK could be because he believes that experiment in IK is mostly 'trials and errors' and were mostly tried on humans. This could also be because of the issues mentioned by Vhurumuku (2010) regarding teachers' beliefs, ideas and assumption about IK, or it could also be because of the philosophical controversies mentioned by (Ogunniyi, 2012).

Teachers' Views about IK

The responses from these teachers are proof of their awareness of IK and its relationship with the nature of Science. It is an indication that teachers view IK as a scientific way of knowing which involves experimental processes, although, it might have different approaches as compared to western approaches (Bishop, 2012). Just like nature of Science, IK is tentative, it is not cast on stone as new knowledge, ideas, and invention can arise, making the former knowledge timeworn (De Beer & Mothwa, 2013). From the Westernized Science perspective, Barnhardt and Kawagley (2005) talked about the scepticism of knowledge in Westernized Science, where nothing can be said to be the 'truth'. All knowledge can be refuted and replaced by new theories and ideas, as long as it can be proven, this is a case of paradigm shift by Khun (1962). This calls for perseverance, honesty, inquisitiveness and being open minded for new discovery. The tentativeness of IK confirms its scientific nature, therefore, Hewson and Ogunniyi (2011) explained how this knowledge have stood the test of time by being in existence for a very long time till date, and as its traditions improve and change constantly, making it flexible and transformative (Cronje et al., 2015). According to the study conducted by Aikenhead and Huntley (1999) and De Beer & van Wyk (2012) Science teachers viewed nature of Science and IK as two conflicting ideas, but similar in paradigms. Ogunniyi (2004) and Le Grange (2007) are both of the views that as experiments are carried out in western Science as a sub-culture; same is done in IK as a sub-culture of Science. Although, Westernized Science undergo scientific processes and procedures (Mazzocchi, 2006), however, traditional healers rely on the outcome of the mixed medication or herb on the sick person. The Westernized Science is validated and documented, which enhances its generalizability and replication of found knowledge (Mazzocchi, 2006), unlike the IK which is not documented but can be validated as

stated by Aikenhead and Ogawa (2007). As stated by the participants of this study, IK also involves experimenting, observation, validation of new findings through constant use of the medicine. The indigenous people were also able to cure ailments by identifying medicinal plants according to their healing abilities (Hens, 2006). The problem-solving skills of the indigenous people have been used to heal ailments, solve community issues on sustainability as well as enrich the youths (Iaccarino, 2003; Odora-hoppers, 2004). It is evident in the results found in this study that teachers who participated in this study all agreed that IK is Science and it is similar to the Westernized Science in the sense that it formed the bases for scientific ways of knowing. For the indigenous people, skills and knowledge application is a well-known cultural practice in a community. With reference to Kawagley and Barnhardt (2005) skills and procedures involves local verification, making direct and indirect verification, doing practical experiment, empirical observation and pattern recognition as a way of knowing Science. This reveals a common ground or relationship between IK and Westernized Science. Although, Westernized Science and IK are made up of different knowledge pathways, both worldviews are rooted in the same reality (Mazzocchi, 2006).

Findings from both questionnaire and interview responses shows that teachers view IK as a cultural knowledge embedded with Science and that IK also involves scientific procedures and ways of knowing just like Westernized Science. Most teachers in this study do not think IK is different from Westernized Science because they believe Westernized Science emanated from IKS. However, Mazzocchi (2006) opined that Westernized Science has its roots from the philosophy of the ancient Greece and other traditional systems and beliefs. Therefore, the indigenous people have used this knowledge to interpret and understand their natural environment (Iaccarino, 2003). This study shows that teachers are aware of their IK and they

share a view that IK and Westernized Science are both worldviews that have common ground in relation to its scientific nature. However, this study also revealed that some teachers do not believe that there is science in IK, hence, they view IK as a knowledge of the past which is not documented and cannot be assessed at school in comparison to Westernized Science. This findings show that if teachers do not believe that there is Science in IK, they will not consider the idea of integrating it with Science. It is also evident in this study that most teachers are traditionalist, that is, they have strong belief in their culture and tradition, but few of them are not aware of the need to bring in their cultural knowledge into the classroom. The reason could be that the curriculum did not explicitly state how teachers could integrate IK and Westernized Science in their classrooms as revealed in the policy document analysis.

Research Question 3: What Are Teachers' Experiences on the Possibilities of Integrating IK and Life Sciences concepts To Promote Science in the Classroom?

The curriculum (NCS 2002 and CAPS 2012) for Life Sciences mandated teachers to integrate IK with Science in their classrooms; however, teachers have different views regarding the possibilities of integrating IK with their Science teaching. Teachers have given several reasons why they could and could not integrate IK in various research conducted by different Science educators. Similarly, for this study, teachers have different perspectives on the possibilities of integrating both IK and Westernized Science in the classroom. The data collected from teachers led to the formation of two themes. These two themes are based on knowledge and identity. The last theme in figure 4 is identity, although it is not part of the common ground, but it reflects the embodiment of knowledge that the indigenous people have due to their unique cultural practices.

Theme 4: Knowledge- Indigenous Ways of Knowing

The theme that emerged from the analyzed responses from the data collected was 'knowledge' as seen in figure 4. In Kawagley and Barnhardt's (2005) analysis of what constitutes knowledge as a common ground for IK and Westernized Science, their idea was that IK is an integrated everyday knowledge involving subsistence traditional practices, the authors posited that it involves the knowledge of plants and animal behaviors, cycles, habitat needs, materials, and objects. From the participants' perspectives, IK is the;

> Knowledge about Science as seen or known and practiced in different cultures or racial groups, including breakthrough in the use of medicinal plants in treating ailments and disorders……. Yes, it needs to be tested like any other hypotheses that are testable. (T5)

The responses received from the participants of this study revealed how well informed they have regarding IK. T6 described IK as an "Information that has rooted from cultural background of authentic tribes, that defines diversified people according to their original traditions." Similar idea is shared by T7, and the following statement was made, that IK is a "Knowledge systems, and worldviews of the natives of a geographical area." To back it up, T9 described it as a "Knowledge that exist within a specific cultural context that has been acquired through a series of informal experiments and intimate understanding of the environment."

The questionnaire responses from teachers are an indication that teachers understand and are aware of their IK. Teachers understand that IK is a conglomerate of various indigenous

cultural practices that defines a community. An interview was set up with these teachers to further elicit their understanding of IK the following responses ensued.

> Like the western Science, you may have a problem of comparing our Indigenous Knowledge system with their school system. But ours was always there before we learned that. And then, although I don't know it, because I'm a modern man, I was taught the modern version of Science. I will only hear about Indigenous Knowledge as transmitted by our parents from orally, to say they would be able to cure this with that. And then when I think of their medicine, I'll be thinking of the 'Iyangas', how this has helped people and they are still potent because of their way of doing things. Their culture, their way of doing this, it still helps, it still cures diseases and now, but now their transmission, how was it transmitted? I think it was transmitted through being initiated by someone, though at times it was transmitted like, there must be what is now known as community of practice whereby there is more experienced one and then there will be others who will be learning from there, and then it is like socializing, to a new way of doing things, I think that's how it was transmitted. (T7)

> So my understanding of Indigenous Knowledge is that, um, this is the knowledge that is cultural and it's local and it's, um, it's intimate. It's, knowledge that is developed by elderly members of a community and it's sustained and passed on to generations by them. So, um, my understanding of this knowledge is that, yeah. So I think basically that would be the knowledge that we grew up developing. As you are growing up to know about the environment that you grew up in. Yeah, I mean, its knowledge that has sustained our forefathers for many years. So I think, yeah, that would be my understanding of Indigenous Knowledge. (T9)

Responses from teachers indicate that they view IK as a traditional and cultural knowledge that defines diversity and can be found within a cultural context which involves informal experiments. In this study, most teachers view IK as being informal in its nature of experimenting ideas and the need to formulate hypothesis even though it is not done as in Westernized Science. The theme 'knowledge' was generated to answer research question three, which deals with teacher's experience and their views on the possibility of integration. For the participants, IK is a form of knowledge found in different cultural groups and their everyday lived experience. They are of the opinion that it is a body of knowledge that deals with plants that are used for medicine to treat ailments. The curriculum has a section on medicinal plant and environmental sustainability for Life Sciences concepts. With this knowledge of IK, teachers could incorporate such knowledge with Westernized Science to make Science more accessible to learners in the classroom. T7 is of the opinion that issues could emanate while comparing IK and Westernized Science during teaching practice. He mentioned that he is not familiar with integrating IK and Westernized Science, and the reason is because he was taught in a Eurocentric way during his teacher education program. Although, he believes that IK does exist and can be transmitted from one generation to another through socialization. If T7 and some other teachers do not integrate IK with Westernized Science, there is every possibility that the knowledge could be lost to modernization as the years goes by. This means that the learners at schools are more likely not to experience the cultural practices that are part of their IK in their communities. If this knowledge is lost to modernization, what IK will be made accessible to learners in the classroom and then passed down to the next generation? Therefore, in the formal classroom situation, a

teacher like T7 can help learners to exchange ideas from their diverse cultural practices through collaboration and then bring in examples from his IK to make Science accessible to all learners.

Teachers believe that IK is cultural knowledge which can be learned at school, however, Ogunniyi (2004) and Le Grange (2007) stated that, as hypotheses are carried out in Westernized Science, indigenous traditional healers also carry out hypothesis on herbs or any other natural phenomenon they use in healing the common people. Experiments and observations of their environment such as the plants, sea, weather, galaxies and earth and so on, are part of their way of living. Responses from teachers are indication that IK is also inquiry based, just like in Westernized Science. The responses from these teachers mostly indicate that there is a common ground between IK and Westernized Science. From a biodiversity point of view, the indigenous people were also able to identify and classify plants according to their physical and healing characteristics, way beyond the Linnaean classification system (Hens, 2006). This means that, the indigenous people also classified various plants by considering not just their physical appearance, but also according to their efficacy in healing ailments. However, the Linnaean classification considered mostly the similarities organisms share. Findings from this study show that teachers have IK, and this is an indication that the possibilities of being able to bring this knowledge into the Science classroom are positive. The responses from the participants of this study revealed that IK is traditional knowledge, holistic and embedded in different cultural and traditional practices. It is the knowledge that is found in a particular geographical area and every individual from that community is embodied with its systems and practices.

Possibilities of Integration

The South African classrooms are multicultural in nature; however, it is an imperative that all learners should have access to Science, by making Science accessible to all, irrespective

of their culture. This study tries to understand teachers' IK relevant to Science and the possibilities of integrating such knowledge in the Science classroom. To be able to understand this, teachers who participated in the study were asked several questions regarding integration, questions 9 and 10 on the questionnaire were posed to understand this and interview questions were asked to further elicit more ideas teachers have regarding integration. The theme 'knowledge' was generated to buttress the point on the integration of both worldviews. Here are some of the responses teachers gave regarding the possibilities of integrating IK with their Life Sciences teaching and learning in a scientific way. In the questionnaire, when asked if IK can be integrated with their Life Sciences teaching, all the teachers agreed. T4 said "Yes, because, some concepts have the knowledge that is only cultural and traditional." For T4, there are some concepts which are culturally inclined, and they should be linked with IK. However, T6 also said "Yes, Indigenous Knowledge and Life Sciences are both based on nature, hence they correlate." With the response from T6, IK and Life Sciences are similar in their underpinnings and both can be linked to make Science accessible to learners in the classroom. T7 agreed to this statement given by both teachers, and further answered by saying "Yes, as a means to help learners learn how to evaluate evidence in light of advanced claims." Similarly, T9 also responded by saying "Yes, examples from home can help learning of Life Sciences effective." T9 is of the opinion that learner's prior knowledge be used as a link to teach Life Sciences in the classroom. T11 also agreed and gave some examples of the IK ideas that can be easily linked to Life Sciences concepts. In agreement, he said "Yes, in a topic respiration, Indigenous Knowledge such as bread making and Umqombothi (African beer) can be used to demonstrate the importance of IK." T12 opined that there are concepts that can be linked with IK and such concepts are deeply rooted in

IKS. T12 said **"**Yes, most concepts in Life Sciences we know have a rich history in tradition, which western Science has modified to the Science we know today (e.g, fermentation)."

Teachers who participated in this study opined that IK and Westernized Science both have Science and they share similarities and therefore, can be integrated in the Science classroom. The evidence above shows that teachers revealed the possibilities of integrating both worldviews by citing concepts that can be used as example while teaching Life Sciences. The idea of teaching respiration by making reference to the reaction of yeast cells during baking, and local beer brewing by T11 is a way of integrating both worldviews and making Science accessible to all learners in the classroom. This could be a way of demonstrating the idea of Science in the IKS. Also, T12 believes that Life Sciences is rooted in history and traditional knowledge, and the possibilities of integration is not farfetched. For example, fermentation can be taught using the local beer brewing as an example from IK. To further elicit more ideas from these teachers, an interview was held with T9 and T4, and the following statements ensued.

> Yeah, there are possibilities of integrating Indigenous Knowledge, definitely…… I've always taught and tried to integrate Indigenous Knowledge even when I was still doing my practical, but I thought I was wrong. So it's something that I would do, when I'm alone, and there is no teacher in the class, and try to just integrate it here and there to make learners understand. But I didn't know there was something that was actually required by the curriculum. I did it because personally for me, when I was a learner, I knew very much that if someone is to link this with my everyday life, then it made me understand. But I didn't know that it's something that the curriculum required. I did it, but you know I did it in secret because I thought I was doing the wrong thing. (T9)

> If maybe you are teaching and there is an example that is both cultural and indigenous. We can use such, for example, the African potato plant, the people, the black people ancestors, they used to see some medication that can treat them cancer, right, and cramps, also have Westernized medication. So in such situations, it applies both indigenous and the rest. (T4)

These teachers believe in the integration of IK due to its level of empowering teachers and learners' skills in Science just like the curriculum mandated (DBE, 2011). From their responses, some of the teachers believe that the indigenous culture learners bring to the classroom can be used to provide them with adequate 'entry point into the scientific world (De Beer and Mothwa, 2013). They believe that since Science is embedded in IK, they can be linked to each other in the classroom by making examples from the cultural knowledge learners bring to the classroom with them. Although one of the teachers said that she was not aware of the mandate to include both worldviews in her teaching, but she has always done so and continued to do so after she became aware of it in the curriculum. She mentioned that she integrates both worldviews in her class by making reference to learner's prior knowledge. This study intends to be an eye-opener for the teachers to discover that they can teach Science from a different perspective as they participate in this study. Most of the teachers are familiar with teaching medicinal plants with IK due to their cultural background and its explicit explanation in the curriculum. The concept of fermentation was also mentioned by most teachers, could this be because of their familiarity with the local beer brewing? Some of these teachers noted to teaching learners Science by referring them to their everyday lives, and they indicated that learners are familiar with the local beer 'Umqombothi' as indicated by T11. This local beer has been a source of merriment by indigenes of South Africa, as they use this beer to entertain their

guests in many social and cultural gathering. With the responses given by the participants of this study, it can be deduced that learners are exposed to the Science within their environment. This could draw the attention of learners to the fact that there is Science within their environment, and Science is not just a subject you learn at school alone.

Indigenous Knowledge and how it can be Integrated with Life Sciences Teaching

To answer the research question on how teachers could integrate IK with Westernized Science in their Life Sciences teaching, teachers were engaged in a one on one conversation, following their responses in the questionnaire. One of the major challenge teachers face with integrating IK with their Science teaching have been traced to the 'how' it should be integrated. For this study, teachers were probed on how Life Sciences can be taught using IK and the following response ensued. T1 opined that;

> Indigenous Knowledge is inextricably linked to a global sustainability. Indigenous Knowledge has valuable insights to implementing efficient uses of our land and spiritual relationships with nature. Students can be taught to sustain life and protect our planet, not to exploit it. Conservation of energy and resources and learning about sustainability is essential (T1).

Although, the curriculum did not indicate how teachers should integrate IK with Life Science, but, some teachers have an idea of what could be done in the Science classroom. T3 stated that "Using traditional technology. The health values of common garden herbs, such as, rosemary and thyme, both powerful antiseptic and tonics". Are good examples she uses in her Science classroom to integrate both worldviews. However, T4 mentioned that "Brewing of traditional beer is used widely in African countries which in turn can be used to explain the

behaviour of micro-organism, and also the concept of respiration". For T4, learners prior IK is a determinant to enable a smooth teaching and learning practice in the science classroom. This could be done by referring to learners' lived experience and local knowledge. According to T6, "Indigenous plants such as devil's claw and African potato; also rooibos are used as home base knowledge. Healing flu for instance and are taught during Life Sciences and also passed through generations to generations".

From the questionnaire responses, it is obvious that teachers are aware of what IK they are expected or should bring into the classroom. But, are they explaining 'how' (procedural knowledge) they could integrate this knowledge in practical sense? This prompted a further probe on the issue of 'how' the activities are been done in the classroom, but only two teachers (T3 & T9) were able to give a detailed description of how they bring IK into the classroom in its practicality. The other teachers only explained how they integrate IK using stories of the past, situating the knowledge been taught and learners' prior knowledge. T1 explained the link between IK and Westernized Science by making reference to global sustainability and how it can make learners to value their natural world. He further explained that when teaching sustainability, learners can be exposed to the need to sustain their environment and place value on their cultural resources within their community. For T1, learners should be made responsible for sustaining and protecting the planet through teaching and learning. T3 and T6 are of the opinion that the use of traditional technology (cultural artifacts) can be used to integrate both worldviews in the Science classroom. This can be done by exposing learners to the common herbs that they are used to within their environment. Learners can be made to understand that their IK can be valued and passed down from one generation to another generation. Although, the 'how' IK should be integrated during teaching and learning was not explained by this

teacher. The possibilities of integrating IK and Westernized Science and the aspect of 'how' both worldviews can be integrated are what this study focuses on. However, some teachers believe that IK and Westernized Science can be integrated in the classroom by probing learners' prior knowledge.

Learners' Prior Knowledge as a Way of Integrating Indigenous Knowledge

In the case of the teachers who participated in this study, some said that they tend to use learners' prior knowledge to integrate IK in their Science classroom teaching. For example:

> Because with Science, I believe that if Science can be taught using analogies, examples of the, what learners know in their daily lives you see, based on their cultures, it will go a long way in addressing the misconceptions and the misunderstandings that learners have. I mean in subject like Sciences and so forth, because they look at Science as a subject which is somewhere there, and then which is closely, which is in fact western in all. So, they take a long time to relate themselves to Science, whereas if Science could be taught from an angle of ennn, I mean from Indigenous Knowledge that will be easy for them to relate to the concept……And then I also, for example, when I introduce the topics like work in Science, we use what they know; their prior knowledge will be based on their everyday use of the word 'work'. Like their aunties would say, I'm going to work or I am working, I've worked too much. I went to the field and ploughed, I worked too much today, but here within the context of Science that will have a different meaning. So as a way of introducing, instilling a bit of Indigenous Knowledge, their background, so that they know that things that they are familiar with and they relate to, it helps to deliver the topic. (T2)

Another teacher stated clearly that;

> Yes, let's talk about organic chemistry. You find out that in organic chemistry, we talk about some compounds called Esters, and learners interact with esters every day in the house, and they don't know that they are interacting with Esters. What are Esters? Esters are organic compounds that brings out a very nice attractive smell, the smell of flower, the smell of perfumes, right? From there, even the juice that we have been taking in the house, some of the drinks we normally buy from the shops are not having original, natural fruits like oranges, but they smell like oranges, naartjies but they smell like naartjies, bananas they smell like bananas. So those are just chemicals that we can claim and we merge in the lab and people will put sugar there to make it a drink. So starting from there, you can always talk about the drinks that they buy from Shoprite, how the drink smells, then you start telling them that there is no banana, right? Then you start telling them that this smell, the aroma, whatever there, fruit or orange, there is no orange there, it is just chemicals. So, you drive them with what they interact with in the home first. Talk with vernacular if you talk very fluently, from there, you bring them to Science, from there you take a practical from there they smell the banana, after this will be like [inaudible], and you see there is an alcohol and mixed with ascetic acid. If you do those ones, heat all those things, you get to perfect banana smell. People can even hate you for not giving them bananas at that time because they will say, we smell bananas here and where are the bananas. Exactly, so you can take them from home and get the activities. And even when they smell the bananas in the house, they will think it is a real banana, it's not a real banana, and then you start

teaching them about Esters and esterification. It is very possible, that's one point that we normally bring learners from home to school. I'm trying to think of another one now. Um, we also do what? Um, uh, what is this? Yeah, there are some examples that we normally do. We talk about gravitation, gravitation is a day to day activity, not necessarily football, just from personal experience of the learners, what do you understand as gravitation, what does it do? When you jump what happens, when you throw a stone, what happens? You will be talking some mechanisms, just from what they do every day. When you drop a plate, why does your plate drop straight from the sink down to the floor? Why not taking some [inaudible], okay, fine, is it because there is only air, is there no pull? Then we start talking from there. Those are just day to day activities when they are at home, or with friends or something, but they know that if a ball is kicked upwards it has to go down so you can take it from there. They bring it to the classroom now, this is what is happening, then you start introducing the force to gravity. You start to go deep with it, if you go to the moon, where the force and gravity is much less, about one sixth of that of the earth, you'll discovered that yes it would drop, but the speed of dropping now is less because the acceleration that is dropping it is less on the moon compared to the earth. Now you are going deeper into the topic, but already, you are talking about their day to day experiences whether at home, with friends or their school environment. So, there are some chapters you can start from home, and you start talking about soccer and everything. That is how I teach normally, because I always want them to link their day to day Science, to the Science they do theoretically, practically and even

> laboratorial. It is very easy and it is very understandable, learners will always remember those examples even when in exams, like all the examples, then you come, oh now we are here. This is how deep I actually operate, exactly. (T10)

The statement above is a response from a teacher who believes in the possibilities of integrating IK and Westernized Science in the Science classroom. Just like other teachers, T2 opined that Science can be taught in the classroom by using analogy and making reference to learner's everyday knowledge. He opined that learners see Science as a western culture; therefore, they might not show much interest in learning it. He emphasized that learners come from different culture, therefore based on that, their misconception of certain concepts can be addressed. This means that learners' culture plays an important role in the way they learn Science in the classroom. He emphasized the need to incorporate a bit of IK, learners' background in Science teaching. T2 suggested that Science should be taught from the IK perspective; it could help learners to relate easily with Science and cross the borders of the classroom with ease. He gave an example of how he integrates IK and Westernized Science using learner's everyday knowledge of the concept being taught.

T10 gave an explicit example of how he integrates IK with his teaching in the classroom. From his explanation, he understands that learners come to the classroom with some funds of knowledge which they are exposed to within their immediate environment. He reiterates the need to take advantage of their prior knowledge to teach them certain concepts. For this teacher, integrating learner's IK with Science in the classroom will enable them have access to school Science. He gave an example of using learner's general knowledge of fruits, perfumes, juice and flowers to teach Esters as a concept. Learners are used to the smell of perfumes, juice, fruits, to mention a few, therefore the teacher can make reference to such idea by making them aware that

such smell are caused by esters. He mentioned that because learners interact with some of these items on everyday basis, they will be able to relate with the concept being taught. The teacher is of the opinion that you need to stimulate their prior knowledge of fragrance and scents first, and then link to Science teaching in the classroom. He said in order to make it more efficient, he could communicate with them using their local knowledge. This I believe will give the learners some sense of belonging and increase their interest in Science learning. He also opined that after a teacher must have explained and linked learner‘s IK and Westernized Science, then they should go ahead to teach the practical aspect of it through demonstration. Another example given by this teacher is on the concept of gravity. He opined that teaching this concept in the classroom by making reference to learner's everyday knowledge and football activity within their environment helps them to learn Science. This teacher did not only probe learner's prior knowledge by mentioning learner's everyday activity like he did in the previous example above, he used the strategy of using leading questions and answers to probe their prior knowledge. He opined that as learners answer the questions been asked, he then introduces the concept and links their prior knowledge to the concepts being taught in the classroom. The teacher reiterated that this is how he teaches Science in his classroom, that is, he moves from theory and then practical for accessibility. He explained that when he adopts these methods during his teaching, learners tend to understand the concepts better and remember the all that they were taught. With the explanation given by this teacher, I can say that this teacher understands how to integrate IK and Westernized Science to make Science more accessible to learners in his classroom. He made explicit the possibilities of integrating both worldviews.

These two teachers are from the same school in the semi-urban region where they teach Life Sciences and Physical Sciences. They reiterated the need to include IK with their Science

teaching. It is said by Science educators that probing learners' prior knowledge of events is a good learner-centered strategy to introduce the concept to be taught in the Science classroom. This is evident in the findings of this study on the use of prior knowledge. From their point of views, there are possibilities of integrating both worldviews during teaching and learning process, but one could see that the 'how' they integrate such knowledge is not practical. This could be because the curriculum did not provide the 'how to integrate' explicitly. Irrespective of the fact that the curriculum did not explain how both worldviews should be integrated, these teachers could still find a way of introducing such strategy in their Science classroom by situating the concepts in different contexts.

Situating Life Sciences Concepts in an Indigenous Knowledge Context

The concept of situated learning as proposed by Lave and Wenger (1991) involves teaching and learning taking place in an authentic context to promote Science learning. This concept laid more emphasis on teacher-student interaction with a focus on learner-centered approach as opined by socio-constructivists such as Piaget, Bandura and Vygotsky. Some of the teachers who participated in this study during a one on one conversation with them narrated how they situate IK within cultural context while trying to integrate it with Westernized Science. The following statements were made by some teachers:

> The concept that we normally use in terms of diversity, we firstly indicated that we come from different places and the nation of a person coming from a certain place. Therefore, is not the same. They may be coming from the eastern hemisphere whereby the temperatures are high, and the northern hemisphere were the temperatures are low and that therefore affect the growth of plants and it may even affect your own adaptation as you as a human being. We just say it is

adaptation. You may go to Tanzania, people in Tanzania see the life that they live as been normal. Some of them, you may see that life is being abnormal because you are from different environment, but then as soon as you can be there for a longer time, you tend to adapt and then as you adapt, you must simply know the environment is then starting to be affecting you. Then obviously you're starting to change for you to survive. ….We therefore asking question, why is it that so many black people from West Africa, such as Nigeria, [inaudible] mainly tend to grow taller and larger. Why is it we therefore make a research? They normally eat raw Nigerian food and that then makes their body to adapt to that and their genes are getting much stronger and dominant hence they growing to a point where they grow. So, I do correlate Indigenous Knowledge within the classroom. (T6)

Plant diversity, um, learners are exposed to different plants every day, so they know these plants. Um, so when you teach plant diversity, I think you can always take it back to their communities, because they can identify these plants, they know exactly that we have different types of plants. So I think when you teach that you just bring it back to home and they can just go and identify their different types of plants in their environment and they know the different uses of these plants. These learners can actually tell you that this plant is used for this and is used for that, can cure this and it can cure that. So I think when you teach plants diversity and you can just allow the learners to explore and maybe, yeah, let them tell you about different types of plants that they know and they grew up being exposed to and then you would link it back to the classroom that this is exactly what we are referring to, the different types of plants. Maybe they can tell you

> why they're different because they also know the differences and then yeah, you can then put on the, I don't know, scientific explanations. (T9).

> Yes, even the one for tonsils, but here at school there is one tonsils cure, Roseberry, can you see, is like a flower, it is a lot…. You pluck, bring to the classroom and show them, then if they have tonsil, therefor they just chew it, you see maybe three times per day after three days gone, tonsil is gone….(T3)

The three cases presented above by these Life Sciences teachers is an indication that IK is indeed a cultural knowledge and the teachers emphasized the need to incorporate it in their classroom to make Science learning meaningful. T6 indicated that his learners learn Science better when it is situated within meaningful scientific context like their surroundings or environment. He gave an example of how he integrates IK with Science while teaching adaptation, and the example he gave was on the food learners eat every day for growth. He also, referred to how the food people eat in different context could contribute to their growth and wellbeing by making reference to another African country. This teacher tried to make his lesson culturally relevant by making sure that learners from different race or cultural background do not feel left out. This could also make learners to understand that there is Science in their cultural knowledge. This method of integrating IK with Life Sciences could be an indication that learning Science in its actual sense could reduce the fear learners have regarding Science learning. T9 explained how she integrates IK with Life Sciences in her classroom by referring to learners' everyday knowledge. She gave an example of how she teaches plant diversity in her classroom by making learners identify the various plants within their communities. She mentioned that learners are familiar with different types of plants that they are being exposed to within their locality and they are able to explain their various uses. She opined that learners in her classroom

are aware of the medicinal value and healing power of these plants around them. Therefore, when teaching plant diversity or medicinal plant as a concept in the curriculum, learners should be allowed to share their various ideas or knowledge of these plants during the teaching and learning process. Probing learners' prior knowledge or IK in the classroom is likely going to help teachers to link both IK and Westernized Science and this could help them to cross the borders of Science in the classroom. T3 also share same opinion with T9 on the ideas of situating Life Sciences in its natural context. She opined that when she is teaching medicinal plants she allows her learners to explore the plants around them, by asking them to pluck a plant and bring to the classroom during teaching. This is like asking the learners to bring a real teaching aid to the classroom, and it can help learners to make meaning of the concept being taught. This type of teaching strategy could also help the teacher to easily integrate IK and Life Sciences during her teaching and learning process. The perspectives these teachers hold regarding teaching plant diversity is that learners are fully aware of the plants within their environment and this could be used as bases to teach them Science and make learners understand that Science can be found within their environment. From their responses, teachers are familiar with indigenizing Science by involving learners in the learning process as a strategy to make it more meaningful in the classroom.

Issues of Integrating Indigenous Knowledge in the Science Classroom

Despite the call to integrate IK with Science in the curriculum by policy makers, many teachers still find it difficult to integrate IK with Westernized Science in their classroom. Some of the teachers who participated in this study shared the distress they face on how they integrate IK with Science. For example, in the questionnaire, a teacher was asked whether the curriculum

says anything about what and how IK should be integrated and he answered 'No'. To further elicit his reasons during an interview, he said;

> CAPS, they're trying to introduce Indigenous Knowledge because it is there, but the information that they have is not enough…..they do not give teachers enough information because, you cannot say you want to introduce the Indigenous Knowledge to Life Sciences, but only two paragraphs that is in the entire textbook, do you understand? Because you are just touching it, you brush part, it must be part of each and every topic, if possible, each and every topic needs Indigenous Knowledge, it must be part of each and every topic….. (T4)

Some other teachers who also responded to this question reiterated that the curriculum did not state how IK should be integrated with Life Sciences. T7 said, "No, CAPS document predominantly elaborates on the teaching of western Science content knowledge." While T8 opined that "It is stated on CAPS document, but implicit because it does not guide a teacher on how to implement indigenous knowledge in the classroom." To emphasize further, T12 also said "No, it does not. It does state that we should implement and use indigenous knowledge in teaching. This is found under section B of the general aims, page 4 of the curriculum document." This is an indication that, some of the teachers who participated in this study could be familiar with the curriculum, and they are willing to integrate IK with Life Science.

Finding from this study shows that, teachers are not well equipped with the 'how' to teach IK in the curriculum. T4 made emphasis how he is not able to integrate IK at will, due to lack of the knowledge of integration. This teacher is passionate about teaching Life Sciences and believes he would do more to uphold the cultural heritage of South Africa by integrating IK with

Science. T4 opined that the policy makers introduced IK in the CAPS document; however, the information provided are not enough for teachers to know how to integrate both worldviews during their teaching practice. He further explained that the intention to implement this integration does not correlate with the information provided, which can only be found in few paragraphs of the document. In order to achieve that which was mandated, IK should be part of every concept in the document, instead of having a bit of it. T7 opined that there is more of Westernized Science in the curriculum compared to the IK found in it. The information provided by these teachers could be true because, during the analysis of the CAPS document, more of nature of Westernized Science was found in the document compared to IK content. The IK was more implicit than explicit in the curriculum. T8 reiterated that the amount of IK information found in this document is not enough to guide a teacher on how to integrate IK and Westernized Science. Hence, this could pose a threat on how teachers integrate both worldviews and could thereby cause conflict of both ideas. If the call to integrate both worldviews during teaching is to uphold the cultural heritage as well as make Science accessible to all learners, then, IK should be found in every concept in the document. What IK teachers need to integrate and how they should integrate such knowledge should be provided in the document. Teachers are interested in the integration of both worldviews, but they are discouraged by the little or no information provided as seen in the statements above. Therefore, guidance should be given to teachers in form of a workshop to expose them to 'how' they should integrate these worldviews during their Science teaching. This will enable them to make Science accessible to all the learners in their classroom. However, T4 recommended that;

> They must have researchers that are working with people that have Indigenous Knowledge, they must work together, you must go places, you must research

> because, if you want curriculum developer and you want to take it up in the textbook for instance, you must go to places for research, go away for three years or four years, find enough information that will help the learners or help the teachers to help the learners, you understand. Not just, because, when curriculum developers develop a curriculum, is just a cut and paste like they do with that curriculum, what if they start a new curriculum from scratch that will work for everyone. Because, the Indigenous Knowledge can work if we have more information, so in order to get more information, the indigenous part and the western part, they must cooperate together and work together because, you can find out that there's a certain knowledge that you know in the indigenous aspect, and certain knowledge that they know on the western aspect. Then, because they are not joining together to form one group, the knowledge disappears. It becomes unknown. You find out that we have this knowledge, but it is just a developing child. They can make this knowledge and they can make it a fully fleshed program for education. So I think research is important, but so far South Africa is still struggling with research. (T4)

T4 opined that, for the call to integrate IK with Westernized Science be implemented, more research needs to be done regarding it. Research should be conducted on how to improve the policy documents, and policy makers should work with teachers and other policy holders on how to improve the curriculum. He further explained that, the research should be extended to other cultural contexts for years in order to have vast IK and to help teachers and learners to have a good classroom experience. T4 reiterated that a new curriculum should be developed to provide more information on IK and Westernized Science. Research could be done by eliciting

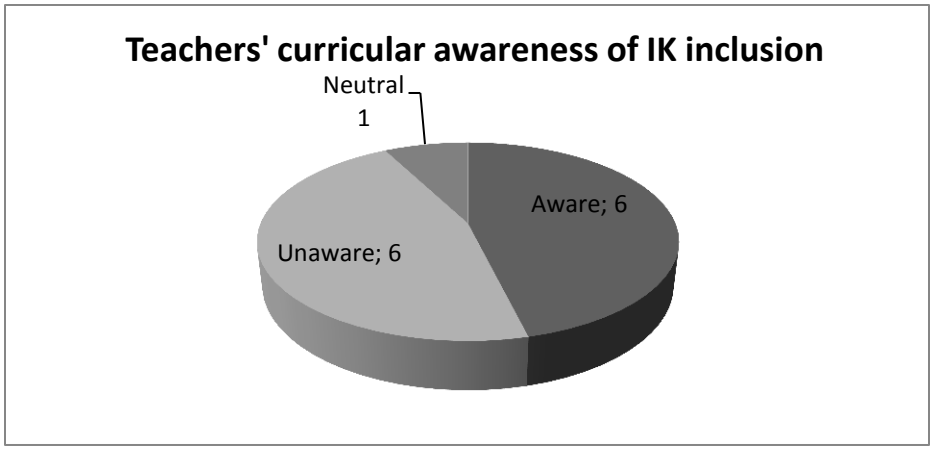
views from people from different races and cultural contexts; this will enable policy makers to have vast idea of what IK content should be integrated, and the how it should be integrated. This level of guidance from research will enable teachers to integrate both worldviews in their Science classroom. There are ongoing researches that have been done regarding IK implementation, yet the gap on how IK should be integrated is yet to be filled. The response from T4 who is a Life Sciences teacher from one of the schools in the peri-urban region is an indication of the inadequate IK information provided in the curriculum, as well as some other teachers who participated in this study. This is evident in the results from the document (NCS 2002 & CAPS 2012) analysis, 'how teachers should integrate IK with Westernized Science was not stated in the documents. T12 seems to be one of the teachers who are well informed with the details of the curriculum. The teachers' passion about upholding the cultural heritage of the country was very intriguing, because he says that he is aware that he is teaching future scientist, therefore, he thinks it's the best way to help learners become scientist without bias. The inadequacy of information in the curriculum as to how teachers should integrate IK can be an impediment to most teachers who teach Sciences and would like to make it more interesting than the usual way they were taught. This is causing so much concern for some of the teachers who participated in this study, hence they hope for the curriculum to be modified to accommodate IK as intended by the policy makers. Could it be that teacher's inability to integrate IK and Westernized Science in their Science classroom is because they are unaware of the mandate to integrate such knowledge? Or could it be as a result of inadequate IK content in the curriculum?

Teachers' knowledge of the inclusion of Indigenous Knowledge in the curriculum

For every Science teacher, knowledge of the curriculum is an imperative factor; therefore, Science educators and policy makers expect teachers to immerse themselves in the knowledge of the curriculum, especially for the subject they teach. This knowledge of the curriculum is what Shulman termed as curricular knowledge. The figure below shows the percentage of teachers who were aware of the need to integrate IK and Westernized Science in the curriculum and those who were not aware; from the questionnaire responses and it could also be the problem of awareness of whether to integrate both worldviews in their Science classroom. Below is a chart (figure 5) showing the number of teachers who are aware and unaware of the mandate to integrate IK with Westernized Science in the classroom?

Figure 5

Teachers' Knowledge of the IK inclusion in the curriculum



The figure 5 above is the value of teachers who are aware and unaware of the need to incorporate IK into their Science teaching. Unaware (6) represent teachers who do not have the idea of the inclusion mandate, aware (6) represents teachers that are aware of the mandate, while neutral (1) represent the data for teachers who are not sure of the mandate. I used aware and unaware to

make the data more explicit and direct for easy interpretation. The participants who indicated that they were aware of the mandate in the curriculum explained that although, they are aware of the mandate, but the IK content was not explicitly explained and how teachers should integrate IK and Westernized Science was not explained in the CAPS document. The participants who indicated that they were not aware of the mandate were definite about their response in respect to the absence of IK in the curriculum. When some of the teachers were interviewed regarding this, they opened up saying that they do not use the curriculum because, the Annual teaching plan (ATP) document has been made available to them, hence they resulted in using the ATP document. However, the aim of providing the ATP for teachers is to unpack the policy document, to help them in their pacing and sequencing of specific subjects during their teaching and learning practice per term. Teacher's unawareness of the mandate and the use of ATP could affect teacher's implementation of the IK mandate in the curriculum. ATP is more subject-specific and breaks down the concepts to be taught in Life Sciences. However, the policy document is broader in terms of its scientific content. If teachers use the ATP to teach Life Sciences, and there are no IK embedded in it, there could be a missing gap on the integration of IK with Westernized Science. This means that learners might not be exposed to scientific ideas that are culturally inclined to their knowledge. These learners might not understand the Science in their IK and therefore, they could lose interest in Science. Therefore, policy makers, principals and head of departments should ensure that teachers use the curriculum alongside the ATP to have a culturally inclusive classroom and make Science accessible to all learners. There should be adequate and explicit IK in the ATP, and the ATP should have some forms of IK for teachers. However, policy makers should also ensure that teachers use the curriculum with the ATP together, to teach Life Sciences. This will enhance their knowledge of the curriculum (curricular

knowledge). Teachers need curricular knowledge to be able to teach effectively, therefore, encouraging them to use the curriculum is imperative. This study found that most teachers are not aware of the requirement to integrate IK with Life Sciences in their Science classroom because of their inability to use the curriculum to prepare for their lessons. The implication of this on Science teaching is that, teachers will not be able to implement the mandate to integrate IK and Westernized Science; hence the idea of a culturally relevant classroom will not be achieved.

Theme 5: Identity

Although identity was not part of the Barnhardt and Kawagley's (2005) knowledge synthesis model, but we cannot talk about IK without mentioning the identity of the indigenous people, because it portrays their unique way of life and how it affects and defines an individual. The Venn diagram above (Figure 4) was adapted from Barnhardt and Kawagley's (2005) knowledge synthesis and was used to analyze teacher's views of IK. Teacher's view of IK is evident in the Venn diagram above (Figure 4). When the teachers who participated in this study were asked about their views of the values of IK, most of them stated that IK helps one to know their cultural identity. For example, in the questionnaire T8 responded that; "It reflects to the characteristics of a community's cultural and social identity and cultural heritage and are maintained, used and practiced." Similarly, T12 responded by saying that "Indigenous Knowledge practices are mostly unique to particular groups. How these are practiced and valued says a lot about the community, such as performing rituals, respecting adults, dressing a particular way, etc".

Responses from these teachers above are an indication that every individual identifies with a cultural group within a community. This cultural identity is what makes them unique and

differentiates them from other communities. T8 explains how a community has its own indigenous characteristics and how a social group nurtures their cultural heritage and identifies themselves within their socio-cultural context. On the other hand, T12 also confirms the uniqueness of a social group because of their IK and how this knowledge is being practiced within a community. These practices range from respecting the elders of the community, performing rituals, their way of dressing. These practices are peculiar to people of a tribe or ethnics, for example the Zulu tribe dress differently from Xhosa tribe in South Africa. Members of a tribe or communities are identified according to the way they dress and their language. In my opinion, I believe that every tribe or ethnics have a way of life which distinguishes them from other ethnic groups. This is what makes them unique and they can be identified with these cultural practices. Every individual also has a uniqueness which differentiates them from other people or their peers. Findings from this study show that teachers are aware of their IK and they understand how tribes or social groups differ from each other in their ways of life or cultural practice. This means that, if teachers have their unique way of life and understands the values of IK, the possibilities of integrating IK and Westernized Science could be high, and this could affect how they integrate IK with Life Sciences in their classroom to promote learning. However, teachers who participated in this study were engaged in a one on one conversation to elicit more information about the values of IK, and they had this to say;

> I think it has a great value in the sense that I identify myself as a Shangani…From my identity, and whenever I go and talk to my ancestors, I would be calling myself Shangani [inaudible], so we still believe in them because we saw our fathers doing that, we saw our grandfather doing that, and then it's just now, it is a believe which we now need to come up and proof that it is really what it is. We

> know quite a lot that uh, that there are witches and all of that, but we have never seen one and I will always say it in my class, to say, it is not only with our faith, we have never seen the witches, even you the scientist you have never seen an atom, but you believe in it. So, in that way we, we have to build it from there. As I wanted to say because of these witches, I have to go to a Sangoma to protect myself from these witches, to protect me from them. And then, the medicine to use is the chemistry part of it. (T7)

> I think we are who we are because of the culture, you know, somehow like it shaped us, you know, like built and shaped us. So, it forms our beliefs, um, almost everything, you know. So, I think, yeah, it is very important. Honestly I think your culture or the tradition is still here because you know, like it forms a very big part of us, you know, in terms of how we view life, you know, in terms of how we do things, how we, you know, how we behave, yeah **(**T8)

T7 identified himself as a Shangani, that is, a spiritualist from the Zulu tribe. He believes that with his identity, he is able to access the metaphysical aspect of IK. He reiterates that, one could communicate with their ancestors with his status as a Shangani and he believes so much in such powers. He explained that such practice was passed down to them from their ancestors and because they believe in it, it will remain so for the younger generation. He also explains that this metaphysical or spiritual practice can be compared to the idea of atom in Westernized Science. He said that, we have not seen atoms before, yet we believe so much in them, therefore, same goes for his status as a traditionalist. He sees the need to visit a Sangoma (spiritualist) who helps them to communicate with their ancestors to seek for protection. This means that this teacher strongly believes in the metaphysical aspects of their traditional knowledge (IK). In my opinion,

this kind of knowledge is likely not to trend in the classroom because, some learners in the classroom have different belief and religion and this could cause chaos in the classroom. **T8** opined that our culture makes us who we are and the indigenous values help us to form certain beliefs and mold us to become a better person and also help us to identify with our culture. He explains that IK is very important for the growth of an individual because it forms our beliefs. He further explains how IK play an important role in the way we view life, that is, we create a particular worldview because of our experience with culture and tradition. I am of the opinion that this experience with culture influences teacher's belief and how they teach Sciences in the classroom. However, there have been studies which presents how teacher's beliefs and worldviews affect the way they teach Sciences in the classroom. In this case, it is expected that teachers' idea of IK will affect how they teach Life Sciences by integrating it with IK. T3 identified herself as a traditionalist, and she further explained that she inherited this passion for medicine from her mother who was a Sangoma (Spiritualist). The responses from these teachers regarding IK cultural values are all indication that culture influences our beliefs and how we live. This is a true indication that humans are all products of culture, and culture influence individual's cognitive development from childhood which also influence beliefs and worldviews people have. The teacher who identified herself as a traditionalist was very proud of whom she is and from her responses to the one on one conversation, it was observed that it affected her choice of teaching Life Sciences and how she teaches the subject.

PART THREE: Integrated Discussion

Integrating IK and Life Sciences for Knowledge Promotion in the Classroom

The three research questions posed for this study to investigate teachers IK and the possibilities of integrating such knowledge were answered and the following findings were

made. In order to investigate teacher's IK and the possibilities of integration, there was need to understand what was stated in the curriculum. The policy documents (NCS & CAPS) were analysed to find out why teachers were mandated to integrate IK with Westernized Science, what IK teachers need to integrate and how they should integrate such knowledge. The analysis done on the CAPS document revealed that the curriculum mandated teachers to integrate indigenous and western worldviews during teaching by specifying why and what IK should be integrated. However, teachers were not provided with the how-to integrates this knowledge (Ogunniyi, 2007a). The Life Sciences curriculum content for Grades 10, 11 and 12 had little or no adequate information regarding IK. Also, it was found that most teachers were not using the curriculum to teach; instead, they use an alternative document (Annual teaching planning) to teach in their Science classrooms. This could also mean that some teachers could be lacking curricular knowledge. Curricular knowledge is the awareness teachers have about the curriculum generally. Curricular knowledge is:

> Represented by the full range of programs designed for the teaching of particular subjects and topics at a given level, the variety of instructional materials available in relation to those programs, and the set of characteristics that serve as both the indications and contraindications for the use of particular curriculum or program materials in particular circumstances" (Shulman, 1986, p. 10).

However, if some teachers do not use the curriculum to teach, then how can they be aware of the mandate to use IK in the classroom? Nonetheless, findings from this study show that some teachers are not aware of the mandate to integrate IK with Westernized Science, hence their inability to integrate both worldviews. After finding out what was indicated in the curriculum, the views of the teachers were sought regarding IK, and it was found that teachers

are embodiments of IK and they are aware of their knowledge (Ogunniyi, 2007a). This is in resonance with Zhou and Brown (2015) that every individual is an embodiment of culture, and since the teachers are a product of culture, it is imperative to empower them on how to use their IK to teach Science in the classroom. This is also because, the act of learning is known as culture acquisition (Aikenhead, 1996) and it is naturally influenced by learners' culture. As constructivists would say' teachers are the facilitators of learning, both within and outside the classroom (Vygotsky, 1978; Moll, 2001). Therefore, they are the most competent in the teaching and learning process (Zhou & Brown, 2015). It is known that since IK is known to cover all spheres of life, teachers should incorporate those aspects that are scientifically relevant to the concept being taught, such as medicine, agriculture, climatology, sustainability, fishing, forest, and so on (Hewson, 2012). However, integrating IK in the Life Sciences classroom could help the learners to acknowledgement their social identities (Cronje et al., 2015) thereby making teaching and learning a worthwhile experience to enhance change (De Beer & Whitlock, 2009). Also, Coe, Aloisi, Higgins and Major (2014) encouraged teachers to adopt the right teaching strategies to make Science accessible in the classroom. IK should be integrated with western Science in the classroom, to improve the growth of scientific literacy in the classroom, considering the multicultural nature of the South African classroom (Diwu & Ogunniyi, 2012; (Driver et al., 1994). According to teacher's responses to questionnaires and interviews under the theme 'knowledge', the use of different approaches to teach Science is known to be that of the integrationist approach (Naidoo & Vithal, 2014).

The study carried out by De Beer and Mothwa's (2013) on how to use ethnobotany with scientific rigor to teach Life Sciences in the classroom without introducing pseudo-Science is an example of the use of a different teaching strategy (situated learning) to teach Life Sciences in

the classroom. Situated learning involves learning that takes place in its original field where it is applied (Lave & Wenger, 1991). In this case, the teachers situated their learning within the school context, which is the social context where learning as a social activity takes place (Bourdieu, 1994). Lave and Wenger explained that situated learning happens in communities of practice, for example in the classroom as a social context. It appeared that most of the teachers in this study are familiar with teaching plant diversity and medicinal plants with IK (De Beer & Whitlock, 2009); this could be because of their experience with culture and their environment, or perhaps it could be the idea of humans been the product of their culture as stated by constructivists (Zhou & Brown, 2015).

With the responses from teachers, it means that IK can be integrated using prior knowledge and lived experiences of learners (Ramirez & Ross, 2019). This is because learners do not come into the science classroom as empty slate (Bonomi 2019). However, prior knowledge involves the thought processes of an individual, and it is an organizing factor for learners' thought processes (Meyer, 2004). As learners lived experiences are brought into the classroom, it enables them to connect new experience that is about to take place in the classroom with prior experiences and bridge the space between their lived life and what they learn in school (Fránquiz & Ortiz 2018; Ramirez & Ross, 2019). This according to Ackerson et al. (2000) allows the learners to establish the basis in which interpretation is made regarding new and future events, and thereby maintaining a healthy and stable worldview. From the responses above, teachers understand the need to create a balance between the two worldviews (Indigenous Knowledge and Westernized Science) to avoid conflicting ideas among learners (Cronje, et al., 2015) and also to ensure an effective teaching and learning using their experiences. They believe that this also can be achieved with the cultural experience learners bring from their various

cultural backgrounds to the classroom, since they are all products of a culture (Zhou & Brown, 2015). According to De Beer and Mothwa (2013) "A true constructivist teacher will realize the importance of building new knowledge on learner's existing prior knowledge" (p. 453). How IK is integrated in the Science classroom is imperative to how learners understand Science. Therefore, the onus is on the teachers to make Science accessible to all learners of different colors and races in the classroom, by adopting the right teaching strategies (Coe et al., 2014). For teachers to be able to implement the mandate there is need for them to change their teaching strategy. This includes the use of cultural artifacts and relating the classroom Science with learner's prior knowledge or cultural knowledge before linking both to the classroom Science (Roschelle, 1997; Strangman & Hall, 2004; Fakoyede & Otulaja, 2019). According to O'Donoghue and Neluvhalani (2002) the use of the constructivist approach to teach Science in the classroom by introducing learner's IK and prior knowledge is encouraged by the curriculum. This involves linking learner's lived experiences (Ramirez & Ross, 2019) and helping them to engage with each other, thereby making the curriculum to offer a more culturally relevant learning challenge. Jegede and Okebukola (1991) posited that the implication for this is that teachers should start their lessons by probing learner's prior knowledge to establish learner's worldviews regarding the concept to be taught. According to Ogunniyi and Ogawa (2008) the integration of IK with Westernized Science in the Science curriculum permits teachers to be innovative with the use of teaching strategies. For example, the constructivist approach of using learner's prior knowledge to probe their understanding of the concept before introducing them to the new concept; ensuring the use of a holistic approach; making sure that classroom discussion is extended to other ways of knowing; involving learners in classroom problem solving activities and bringing IKS experts/practitioners to the Science classroom (Ogunniyi & Ogawa, 2008).

Finally, when these teachers' views regarding their experience and the possibilities of integrating both worldviews in the classroom was probed, it was found that; the teachers were positive about the integration of IK and they displayed positive interest in its integration with Westernized Science. However, they indicated that the problem lies with the way IKS is represented in the curriculum. Teachers opined that the curriculum does not explicitly explain how they could integrate IKS and Westernized Science, hence their inability to implement the mandate (Ogunniyi, 2007a). Most of the teachers opined that integrating IK with Westernized Science enables them to make Science more accessible to learners in the classroom. Findings from this study revealed the possibilities of integrating both worldviews in the Science classroom. However, teachers opined that if they are well equipped with cultural artefacts (Fakoyede & Otulaja, 2019) and indigenous information on how to teach in the curriculum, the possibilities of integrating both worldviews will be positive, and they will be able to integrate both worldviews and make Science teaching more meaningful in the classroom.

Summary of Findings for This Study

This study was conducted in four South African peri-urban schools, and it involved Life Sciences teachers with different teaching experiences. This study aims at understanding teacher's IK and the possibilities of integrating such knowledge with Sciences in the classroom. Three research questions were posed to investigate this research: to understand how IK was represented in the curriculum; to elicit more views from teachers regarding their understanding of IK and how IK can be integrated with Science to enhance teaching and learning of Science in the classroom as mandated by the policy documents.

Answering Research Question 1: How is Indigenous Knowledge Represented in the Grade 10, 11 and 12 Life Sciences curriculums in South Africa?

The South African Life Sciences policy documents (NCS 2002 & CAPS 2012) mandates teachers to integrate IK with Science in their classroom to promote the cultural heritage of the society and enhance Science learning in the multicultural classroom. To understand teachers IK, first there is need to understand what the curriculum portrays regarding this knowledge. Therefore, to answer this research question, the contents of both policy documents were broken down into codes and were analyzed using three themes: Why IK should be integrated with Life Sciences in the classroom; what indigenous knowledge to be taught in the content; and how to teach by integrating indigenous knowledge? Details of the analysis can be found in the part 1 section of this chapter. These three themes summarized the content of the policy documents. It was found that the curriculum did mandate teachers to integrate IK and the reason (why) for this was given as described in the part 1 of this chapter. Also, what content to be integrated were also given, although not explicit for all the concepts in the curriculum, but in few cases as analyzed earlier, but 'how' it should be integrated with Science was not given to teachers as indicated in the analysis in part 1. Teachers who participated in this study indicated that they do not know what IK is appropriate for their Life Science teaching and how they could integrate it with their classroom teaching, hence, most of them resulted only to the use of learner's prior knowledge and situating their teaching within learner's environment. It was also revealed that the schools did not provide teachers with the cultural artifacts needed to integrate IK and Life Sciences in their classrooms or within the school context; this is because the school is unaware of the necessity of this integration policy. Findings also show that 50% of the teachers who participated in this study were not aware of the mandate to integrate IK and Westernized Science during their

classroom teaching practice. It was revealed in this study that the teachers' unawareness of this stance in the curriculum is as a result of the use of an Annual Teaching Plan (ATP) document provided for teachers instead of the use of the curriculum itself. Findings also show that teachers' inability to use the curriculum could lead to lack of curricular knowledge; hence, this could also be an impediment to the implementation of this policy. Findings from this analysis are an indication that although IK was mandated to be integrated with Science, the importance of Westernized Science in the curriculum over IK of the people was more pronounced in the document and schools. Hence, the goal of promoting the cultural heritage of South Africa by integrating IK with Westernized Science and making Science accessible to all learners in the multicultural classroom is likely not to be met.

Answering Research Question 2: What Perception do Teachers have about Indigenous Knowledge?

The themes, organizing principles, habits of mind, skills and procedures, and knowledge were analysed to answer research question 2. Findings from this analysis revealed that some teachers who participated in this study understand that Westernized Science and IK are both worldviews that have common ground as to its scientific nature. They are of the view that both worldviews are holistic in nature due to their principles and historical underpinnings in Science. Also, teachers have a strong perception that IK has Science; therefore, it helps to promote the culture of Science using language as a tool in crossing the cultural borders in the classroom. Although, some do not believe that there is Science in IK. They also indicated that IK formed the basics of the education that is in existence now, hence, it upholds the cultural values of the people. Teachers opined that Westernized Science has its roots in IK, that is, the Western people explored and colonized IK to create their Western knowledge. Teachers' view of IK indicated

that teachers are aware of their IK and the possibilities of integrating such knowledge in their Life Sciences classroom were emphasized. The reiteration of the scientific nature of IK heightened teachers' to integrate both knowledge views during their teaching practice. Few teachers are of the view that since IK is a body of knowledge, it should be allowed in the classroom teaching and no part of it should be left out. Findings from this study show that teachers reiterated that every concept in the curriculum should have IK ideas, so as to improve learners' knowledge construction. From teachers' views, it can be deduced that they understand that every individual is an embodiment of their culture, which forms their identity and give them a sense of belonging. Therefore, this answers the research question on teachers' perception of IK.

Answering Research Question 3: What Are Teachers' Experience on the Possibilities of Integrating IK and Life Sciences Concepts to Promote Science in the Classroom*?*

The curriculum (NCS and CAPS) for Life Sciences mandated teachers to integrate IK with Science in their classrooms; however, teachers have different views regarding the possibilities of integrating IK in their Science teaching. From the analysis done on teachers' responses regarding IK, it was found that some teachers have been practicing integration of both worldviews, but some are sceptical about it because, they do not know how to integrate both. Teachers who integrated IK with Westernized Science gave varieties of examples on concepts and how they teach them using IK. From the analysis, it is evident that teachers indicated that to help learners to understand Science better, they relate the concepts to their prior knowledge and lived experiences. Some explained that they situate such concept within a scientific context that learners are yet to or have experienced. Also, some teachers indicated that some Life Sciences concepts have rich history in tradition, for example, 'fermentation', which can be related to the

local African beer brewing that most learners are familiar with. Teaching learners the concept 'immunity' by referring to the 'African potato' which is used to cure several ailments and strengthening the immune system, and many more. They further indicated that integrating both worldviews will enable learners from different multicultural context to learn Science effectively. Findings indicated that, although the curriculum does not explain the how to integrate both worldviews, but some teachers are able to break through the barrier. Some teachers were able to state how they integrate IK with their Life Sciences teaching through situated learning, others indicated that theirs is through story-telling and prior knowledge. There is also an indication that most teachers do not integrate both worldviews and their reasons were that the curriculum did not give how they should integrate IK with Westernized Science. Another reason given by some teachers is the issue of time constraint; they reiterated that they do not have enough time to incorporate certain teaching strategies using IK. This is because there is no adequate time allocated to the teaching of these concepts in consideration of the activities involved. Teachers believe that IK in its totality is cultural knowledge and they emphasized the need to incorporate it in their classroom to make Science learning meaningful. These findings help to answer the research question 3 on teacher's experiences on the possibilities of integrating IK and Life Sciences concepts to promote Science learning in the classroom.

Summary

The mandate to integrate IK with Westernized Science in Science classrooms has paved way for the use of various teaching strategies for teaching Science. This study aims at understanding teachers IK and the possibilities of integrating such knowledge with Science. The main research question posed for this study is: How can IK be used as a tool to promote Science teaching and learning in the South African classroom context? However, various sub-questions

were used to answer this question which aims at solving the issue of integration found among Science teachers in the Science classroom today. Findings from this study show that teachers are embodiment of Indigenous Knowledge and this knowledge can be used as a tool to bridge the gap in Science learning and making Science accessible to all learners from different context. There is possibility of integrating IK and Westernized Science in the classroom using different teaching strategies, however, the curriculum needs to emphasize more on how this needs to be done.

Chapter Six

Overview, Limitations, Recommendations and Conclusions

In this chapter, I present the summary of the findings on teachers' IK and the possibilities of integrating such knowledge in some selected peri-urban schools in Gauteng province. The overview of the research is discussed, and the research questions are mentioned to contextualize the study. The limitations of the study and contribution of the research to Science education is discussed as well as the recommendations for further study, classroom practice and curriculum reform.

Overview of the Study

This study was conducted to understand, describe, and analyze teachers' IK and compare the findings with what the curriculum requires regarding the integration of IK in four selected peri-urban high school in Gauteng province of South Africa. The South African Life Sciences policy documents (NCS 2002 & CAPS 2011) requires teachers to integrate IK with Science in their classroom practice, but there are still issues of integration found among teachers in schools. This is becoming alarming because of the rate of failure of Life Sciences in South Africa. The mandate emphasizes the requirement for teachers to include IKS in their Science teaching by helping learners to understand "the relationship between Indigenous Knowledge and Science". For this to happen "Learners should understand the different cultural contexts in which Indigenous Knowledge systems were developed" (DoE, 2003; DBE, 2011, pg. 17). The Specific Aim 3 further stated that teachers should ensure that "examples of Indigenous Knowledge that are selected for study should, as far as possible, reflect different South African cultural groups. They should also link directly to specific areas in the Life Sciences subject content" (DBE, 2011,

pg. 17). In this case, the teacher is the more knowledgeable other and facilitator (Vygotsky, 1968) of the classroom room activity, as the learners are known to transform from being passive learners to active participants of the teaching and learning process. The aim of this study was to understand teachers' IK and the possibilities of integrating such knowledge with Life Sciences in the Science classroom. To achieve this, the following research questions were posed to understand what IK teachers have and how it can be used as a tool to solve Science literacy issues in the classrooms. How is IK represented in the grade 10, 11 and 12 Life Sciences curriculum in South Africa? What perception do teachers have about Indigenous Knowledge? What are teachers' experience and the possibilities of integrating IK and Life Sciences concepts to promote Science in the classroom? To ensure achievement of credibility and trustworthy answers to the research questions posed for this research, the study adopted a qualitative case study research design.

Limitations of the study

Some of the limitations of this study were considered and taken into account.

Firstly, qualitative data were collected for this study. Participants of this study were teachers, but there were limitations in terms of language, and this could be because most of the teachers who participated in this study speak English as their second language. There could have been a language barrier while filling the questionnaire, and during the interview. However, the teachers could have expressed themselves more clearly and confidently by speaking their own mother tongue (isiXhosa, Ndebele, isiZulu, etc). However, there was code switching which occurred during the interviews and therefore sometimes the participants spoke in their native language and thereafter interpreted what they meant to me in the form of English so that I can understand what they have said. Perhaps, this might have taken away the meaning that they intended to pass

across during the interview through code switching, that is, the meaning must have been diluted when they spoke in their language and then interpreted it.

Secondly, to ascertain how teachers explained that they integrate both worldviews in their Life Sciences classroom, it would have been valuable to observe their lessons during teaching and learning practice. However, teachers' views were more pertinent in this study because, their IK and their views of the possibility of integration, and their awareness of the mandate to integrate such knowledge with Science was the main focus of this study. Due to time constrain as well as the COVID 19 restrictions, I could not go to schools to gather more evidence from their classrooms.

Implication of the study to Science Education

Findings from this study reveal that the integration of IK and Westernized Science is not as successful as it should have been in some classrooms in the Gauteng province, considering the mandate of implementation in the curriculum. However, the qualitative data analyzed show different levels of integration in the classroom, eleven teachers implement the integration policy while two teachers did not implement it. The reason behind teachers' different attitude towards implementation could be as a result of varying factors such as, lack of resources, language barrier, time management, the use of the right strategy to teach certain concepts, inadequate information in the curriculum on how they should integrate both worldviews, unawareness of the mandate to integrate both worldviews, and so on.

Findings from this study also show that it could be as a result of the conflicts between IK and Westernized Science experienced by Science teachers in the classroom (Cronje et al., 2015). The integration of both worldviews could be problematic for teachers as Battiste (2002) surmised

"Creating a balance between two worldviews is the great challenge facing modern educators" who has the intention of incorporating IK and Westernized Science in their Science classroom (p. 202). Although, some teachers do not view both worldviews as different, therefore, they believe that both knowledge systems can be integrated while teaching Life Sciences in the classroom. This also resonate with the studies conducted by De Beer and van Wyk (2012) and Barnhardt and Kawagley (2005) that IK and Westernized Science can be synthesized.

Based on the conversations with the teachers, it appears that some teachers do not view IK as important since it is not well documented and is not assessed in schools. Nevertheless, most of the teachers view IK as a very important worldview that can be used to create access to Science for all learners in the classroom because of its scientific nature. Although, some scientists do not acknowledge IK as being 'scientific in nature' because they believe it is bias and superstitious in nature (Snively & Corsiglia, 2001; Horsthemke, 2004), while some believe that IK is scientific in nature. Some teachers who participated in this study revealed that IK is relevant because of its contribution to "educational relevance and to redressing past colonizing hegemony" (Keane, 2008: 588).

Findings from the qualitative data analysed also revealed that some teachers do not believe that IK is validated while most of them believe that IK is validated and experiment is conducted by the indigenous people through trial and error and consistent practice. However, educators such as Semali and Kinchelo (1999), Odoro Hoppers (2002) and Moodie (2003) suggested the need for IK to be validated or legitimized, but Horsthemke (2004) termed this as 'tautologies' because, "Considering the centrality of justification, knowledge is necessarily valid, legitimate, warranted. There simply could be no other knowledge, i.e. knowledge that is invalid, illegitimate or unwarranted. It would not be knowledge then" (p. 38).

Findings show that the issue of integrating both worldviews in the Science classroom is as a result of teachers not using the curriculum or not knowing how to integrate both worldviews. However, findings from this study revealed that teachers have problems with refining their practice in relation to 'HOW' to integrate IK with their Life Sciences teaching. This could also be seen from the analysis of the curriculum in the previous chapter, i.e. the why and what IK to be taught in the classroom were visible in the curriculum, however, how teachers should integrate both knowledge views were not explicitly stated in the policy documents (NCS & CAPS). This could be linked to why most teachers from this study complained that the Life Sciences curriculum did not state clearly what and how to teach Science using IK, hence the struggle. This resonates with the studies conducted by Taylor and Cameron (2016) and De beer and Mothwa (2013) regarding teachers' ability to know-how to integrate IK with Science. Hence most of the teachers recommended the need to review the Life Sciences curriculum to accommodate IK.

Recommendations for Further Studies

Findings from this study have revealed that teachers are embodiments of their culture (IK) and have the potential of integrating such knowledge with Science. However, due to certain impediments and lack of awareness, some teachers are not able to integrate IK and Westernized Science in some classrooms in Gauteng province. Based on these findings, some recommendations can be made on how to improve teacher's classroom teaching practice, policy and teacher educators.

Teaching practice

As issues regarding the implementation of IK with Westernized Science in the classroom keep rising, there are several researches conducted on how to curb these issues by. This study also investigated teachers' IK and the possibilities of integrating such knowledge with Westernized Science. This study focused on the mandate given to teachers to integrate IK with Science by considering the reason it should be integrated, what is to be integrated and how it should be integrated. The need to make the Science classroom more culturally relevant is imperative due to the multicultural nature of the classroom. A culturally relevant classroom considers learner's everyday lived experience by enabling them to be actively involved in the classroom teaching practice for meaning making (Clarke & Ramahlape, 1999). For this study, the teachers who participated in the interviews were from different cultural backgrounds (Xhosa, Zulu, Sesotho, to mention a few), just like their learners. One of the teachers made reference to the use of the context of some students from another country to teach Science. This shows that teachers are aware that their learners are from a diverse cultural group. Since the teachers are the facilitators of their classroom activities, they explained how they help learners to construct their own knowledge using their experience (prior knowledge) both within the classroom and outside the classroom. According to Meyer (2004) "Prior knowledge is the organizing factor of individuals' thought processes "(p. 971). For some of the teachers in this study, probing learners' prior knowledge as a basis to teach Science was a better way they could integrate IK with their Science teaching to promote meaning making in the classroom. However, teachers are encouraged to adopt useful teaching strategies to make the learning context conducive enough for learners. These teaching strategies could involve using the right teaching resources and introducing cultural knowledge (IK) ideas and encouraging learners to exchange ideas amongst

themselves. IK is a local knowledge (Ogunniyi, 2011) that is socially constructed by learners from their lived experiences, so also is scientific knowledge viewed as socially constructed which involves the individual and the social processes (Driver et al., 1994). These social processes which take place during teaching and learning between the social actors (teachers and learners) in the classroom teaching practice might promote meaning making in the classroom.

Resources to Teach Indigenous Knowledge

Irrespective of the teachers' willingness to integrate IK and Westernized Science (Ogunniyi, 2007b; Naidoo, 2010), findings from this study also revealed that teachers do not have enough access to IK in the textbooks they use in teaching Life Sciences. For teachers to be able to implement the policy of integrating IK and Westernized Science there is need to introduce IK in the textbooks used for teaching Life Sciences, to create a culturally relevant learning environment and make Science accessible to all learners in the classroom. Most teachers rely on the use of textbooks in the classroom; therefore, lack of IK in the textbooks could be a hindrance or lead to their inability to integrate both worldviews (Shizha, 2007). However, textbooks with IK content should include diverse cultural ideas for inclusivity, but more emphasis should be made on the culture of the local community to avoid bias and oppression like the Eurocentric textbooks. Findings from this study revealed that teachers do not integrate IK and Westernized Science due to the lack of cultural artifacts to enhance their integration of IK. According to Fakoyede and Otulaja (2019) cultural artifacts are mediating tools teachers can use in facilitating Life Sciences concepts. If this is lacking, how then can teachers make Science learning accessible to this learners from township schools. According to the authors, teachers' emotions were elated when they realized that they could teach their learners the abstract topic of molecules using bead works (cultural artefacts). Interviews had with teachers, show that teachers

are aware of their IK and are willing to integrate IK with their Life Sciences teaching, but the resources to do that are not provided. Moreover, if teachers are not given the 'how-to integrate IK' in the curriculum, even if they have the artefacts, they might still not be able to integrate IK with their Life Sciences teaching. Teachers' inability to apply the how-to might give them the impression that they are not doing enough and this can affect their emotions negatively. The teacher in the classroom is seen as the more knowledgeable other (MKO) because s/he is has the higher ability and understanding of the task to be done/achieved during the teaching and learning processes. Vygotsky's emphasis on this MKO shows that a learners' understanding of a concept in the Science classroom is as a result of the teacher's, intervention and mediation in the classroom. However, their ability to get resources and utilize them while teaching different concepts in the curriculum could make learning Science more attractive to learners.

Integrating Indigenous Knowledge with Life Sciences Concepts in CAPS Document

With the discussions had with the teachers who participated in this study, teachers mentioned a few concepts they believe they can integrate IK with. The following concepts were mentioned by different teachers at different intervals; filtration, fermentation (African beer brewing), distillation, thermodynamics, medicinal plants, biodiversity, sustainability, behaviour of micro-organisms, immunity, conservation of energy and resources, human evolution, respiration and water purification. As a researcher, I would also recommend some of the concepts that teachers could integrate with IK in their science classroom, such concepts are; saponification (soap making), the skeletal system, classes of food (food that are indigenous to learners could be used to classify different sources of food), nutrition (indigenous food can be classified as a source of different nutrients such as, carbohydrate, protein, fat and oil, etc.), and so on. However, the analysis done on the policy documents does not have IK on some of these

concepts, except for a few as outlined in my findings section in the previous chapter. In this study, it was also found that teachers do not use the curriculum as they are supposed to use it; this is because they focus more on the ATP provided for them. The ATP provided the foundation to what is presented on the CAPS document. It provides the teachers with what to teach weekly and for how many hours they have to teach a particular topic. The ATP is closely aligned with the contents in the CAPS document; therefore, my analysis was focused on the CAPS document. However, the teachers seem to rely mostly on the ATP, so this needs to be taken into consideration in terms of the way IKS is presented on the ATP as well. This could be the reason some of the teachers are not aware of the mandate to include both worldviews in their Science classroom. Teachers are interested in the integration of both worldviews, but are unable to do so due to different reasons mentioned earlier. Although the curriculum mandated teachers to integrate both worldviews, teachers are not provided with 'how' they should integrate IK with Life Sciences; hence they struggle with implementing this policy. The role a teacher plays in the curriculum change is by implementing the information that has been set by curriculum designers and the policy makers. Therefore, teachers play a very important role in making sure that learners have access to the knowledge intended for them to construct in the classroom teaching practice. Kirk and Macdonald (2001) posited that if teachers are not involved in the policy reform, the reform might not succeed in its intended policy. However, Jansen and Christie (1999) surmised that C2005 failed because the roles teachers play in curriculum reform and implementation was underrated. Findings from this study revealed that teachers are interested in transforming their teaching practice; therefore, they should be nominated to participate extensively in policy reform. Teachers should not be ignored because they have a first-hand

experience and access to learners, and therefore can understand what works and do not work in the classroom teaching practice.

Crossing the Cultural Borders of the Science Classroom

The Science teachers who participated in this study come from different cultural background, although most of them live in the townships. This means that teachers are embodiments of culture, just like the learners they teach in the classroom, and Vygotsky is of the opinion that culture influences the transformation that takes place in the classroom through language formation and symbolism. Bourdieu's' theory of habitus deals with physical embodiment of cultural capital, disposition and skills and habits that are deeply rooted because of individuals' (teacher) experiences of everyday life, however, teachers are viewed as the key actor in the classroom dynamics (agency) that takes place during teaching and learning.

The teachers cross the borders of their home to the classroom where the sub-culture of Science is to be taught to learners who have also crossed the borders of their home to engage in learning the sub-culture of their classrooms. Judging from the findings of this study, how can the teachers help learners to understand the sub-culture of Westernized Science if they do not understand how learners view their own world from their everyday lived experiences? "If only we could understand how students make sense of their natural world, we could design a Science curriculum so that Science makes sense to all students" (Aikenhead, 1996, p. 3). This however means that teachers need to be equipped with the necessary resources to help learners understand Science in a more subtle way at school. If learners every day cultural experience is in harmony with the sub-culture of Science in the classroom, the students' worldview will be supported by Science (Aikenhead, 1996). This means that the learner have been enculturated into the sub-culture of Science which requires border crossing. To achieve a successful border crossing in the

classroom, there is need for teachers to integrate IK and Westernized Science in the classroom. However to achieve this, the curriculum need to be explicit with the information on how teachers should integrate IK and Westernized Science in their teaching practice.

Professional Development for Teachers

Many teachers were trained in a Eurocentric way (Ogunniyi, 2004) and this could be one of the reasons they are not able to integrate IK and Westernized Science. However, most teachers start teaching immediately after their teacher training program, therefore, they are not exposed to how they can integrate IK and Westernized Science in their classroom practice (Shizha, 2007). This can be found with the response from T7 in the discussion chapter. Findings from this study also revealed that the curriculum did not instruct the teachers on 'how they can integrate IK with their Life Sciences teaching in the classroom. Therefore, the need to organise seminars and workshops as a professional development like most teachers in this study recommended is imperative. Professional development is said to be an activity that enhances the skills, expertise, knowledge and other characteristics of an individual as a teacher (Organization for Economic Cooperation and Development, OECD, 2009). It can be referred to as a tool that can be used to empower teachers, helping them with the capacity necessary for managing the changes that occurs in the school curriculum, as well as promote effective teaching in the Science classroom. The OECD believes that teacher development can be made available in various forms, that is, it ranges from the formal to informal. It could be made available by inviting external expertise as a workshop, courses, collaboration between teachers from different schools or within, and so on. Luft and Hewson (2014) posited that professional development for teachers, is an on-going experience for cognitive growth to take place, and it is influenced by curriculum policy statements as well as concerns regarding learners' cognitive growth. From the findings of this

study, teachers are yearning for a proper workshop and seminar to be organized, so that they can have more knowledge of IK and how to integrate IK and Westernized Science in their Science classroom. Teachers are interested in the integration of both worldviews because they mentioned its relevance to their Science teaching in the data collected for this study. However, Mogari et al. (2016) posited that teachers should be responsible for their own professional development since they are also members of a community and should endeavour to join in the effort of creating a solution to the problems arising in the learning community.

For this study, teachers were not involved with a formal professional development for IK awareness and integration. However, during data collection for this study, the researcher as the participant observer was able to take note of most of the ideas teachers have of IK and its integration. After the questionnaire and interview responses have been analysed, the researcher was able to communicate with the participants based on their responses, after which teachers were made aware of how to better use their IK to promote meaning making for all learners in the classroom. This practice awakened teachers' interest in integrating IK with their Life Sciences teaching, and will help inform their classroom practice because, when teachers change their form of practice, it affects the way learners construct new knowledge in the classroom.

Teachers' Recommendation of Indigenous Knowledge Inclusion in the Curriculum

This study looked at teachers' Indigenous Knowledge and the possibilities of integrating such knowledge with Life Sciences. The document analysis done for this study revealed that the curriculum mandated teachers and informed them of why they should integrate IK and what IK to integrate, but the how-to integrate such knowledge was not stated in the curriculum. However, this is causing some issues of implementation in the Science classroom. Also, the teachers who participated in this study are of the opinion that IK is Science and stated its importance in

teaching Science. Teachers thereby recommended ways in which their IK integration as mandated by the curriculum can be enhanced, thereby informing teaching and practice. Teachers from this study are of the opinion that IK workshops be held quarterly, to enhance their ability to integrate IK with their Science classroom. An example can be traced to the work of Fakoyede and Otulaja (2019) on the need to work with teachers by setting up a small group of workshop on teaching them how to create cultural artefacts by themselves. As Rogan (2004) opined about issues of implementation, he said teachers are lacking in the aspect of innovation and initiative in Science classroom teaching and learning, which eventually leads to different views of seeing the curriculum as intention and as a practice. Also, teachers suggested that every concept in the curriculum should be linked to IK, by so doing; they will be able to uphold their cultural heritage as proposed by the curriculum. The teachers also suggested that the textbook used for teaching should have substantive IKS content in it to enable them to integrate both worldviews.

Contributions of the Study to Science Education

This study investigated teachers' IK and the possibilities of integrating such knowledge with Westernized Science. In the drive to investigate teachers' IK and the attempt to find out the possibilities of integrating IK and Westernized Science, the following contributions were made from the data collection process to the findings of the study.

Awareness of Indigenous Knowledge and its pedagogy

Findings from the study revealed that most teachers are embodiment of IK (socially and culturally), but they are unaware of the need to utilize this knowledge to enhance their teaching practice. Hence, during the process of data collection (interviews), teachers were made aware of their IK and how they can integrate it with Life Sciences in the classroom. From the teachers'

perspective, they did not know that they could bring IK into the classroom as a factor in making Science accessible to all learners in the classroom, thereby, encouraging a culturally inclusive classroom teaching practice. Also, some of the teachers who participated in this study were not aware of the mandate to integrate IK with their Life Sciences teaching and learning in the classroom. However, my interview with them helped them to be aware of these mandates, and this could change their views of IK to improve teaching practice in the classroom.

Transformation of practice

The awareness teachers have of the mandate to integrate IK and Westernized science could be a positive influence to their teaching practice. This could change how teachers teach Science in the classroom. Teachers developed interest in the curriculum and they indicated that they would implement the mandate, in order to improve learners' interest in science learning. Teachers' interest in changing their teaching method (how) will enhance what they teach learners in the classroom to promote meaning making. Since teachers are part of the curriculum reform or policy making, they can inform curriculum change through their ideas because, they have a first-hand experience with learners. According to Ogunniyi (2013) when teachers are engaged with the process of curriculum development, they become emancipated and obtain technical and practical knowledge as they own and implement the curriculum. Therefore, they can advise the policy makers on how to improve on the IKS content in the policy document and make it accessible to teachers for easy implementation. After the brief conversation held with individual teachers on the awareness of the mandate to integrate IK with Life Sciences and how to enhance their science teaching through integration, the teachers became equipped with more cultural knowledge to make their classroom more culturally relevant. The member-check process with teachers also, heightened teachers' interest because they perused through their own interview

responses and it stimulated new ideas they could explore to improve their classroom teaching practice. When teachers' practice changes, it could influence learners' attitude towards science, and scientific literacy could be improved, thereby, making the aim of science education achievable in the science classroom.

Conclusion

This study aimed at understanding teachers' IK and the possibilities of integrating such knowledge with Life Sciences teaching in four selected peri-urban schools in the Gauteng province. This research was conducted to investigate how IK is represented in the curriculum and Science teachers' views of how they integrate IK with Life Sciences in the classroom. Literature was reviewed on the integration of IK and the constructivism theory was used to unpack the research questions. This study adopted a qualitative, interpretive case study approach to investigate the phenomenon under study. In this chapter, I further discussed the overview of this study and the research approach used to carry out this research. I stated the objectives of the study in relation with the research questions posed for this study. Recommendations were made based on the findings of this study, as well as teachers' recommendation. I discussed the implications of this study to Science education in South African context. I discussed the limitation of this study and recommendation for further research. It was recommended that teachers' classroom practice be improved by providing them with the resources need for an effective Science teaching and learning. I discussed the contribution of this study to science education. This study has established that the curriculum mandated teachers to integrate IK with Life Sciences, but how they should go about it was not explicitly stated; teacher's view of IK and Westernized Science is that both worldviews are ways of knowing and they both share common grounds as to their scientific nature; teachers' view of IK indicated that teachers are aware of

their IK and the possibilities of integrating such knowledge in their Life Sciences classrooms were emphasized. Therefore, there is need to ascertain that all Life Sciences teachers in South Africa, especially in the township schools receive support from policy makers in their pursuit to integrate IK with Life Sciences.

References

Abdi, A. A. (2003). Apartheid and Education in South Africa: Select Historical Analyses. *Western Journal of Black Studies*, *27*(2).

Abrams, E., Taylor, P. C., & Guo, C. J. (2013). Contextualizing culturally relevant science and mathematics teaching for indigenous learning. *International Journal of Science and Mathematics Education*, *11*(1), 1-21.

Adams, A., & Cox, A. L. (2008). Questionnaires, in-depth interviews and focus groups.

Agrawal, A. (1995). Dismantling the divide between indigenous and scientific knowledge. *Development and change*, *26*(3), 413-439.

Aikenhead, G. (2001). Integrating Western and Aboriginal sciences: Cross-cultural science teaching. *Research in Science Education*, *31*(3), 337-355.

Aikenhead, G. S. (1996). Science education: Border crossing into the subculture of science.

Aikenhead, G. S., & Ogawa, M. (2007). Indigenous knowledge and science revisited. *Cultural studies of Science education*, *2*(3), 539-620.

Aikenhead, G., & Huntley, B. (1999). Teachers' views on Aboriginal students learning western and Aboriginal science. *Canadian Journal of Native Education*, *23*(2), 159-175.

Akerson, V. L., Abd-El-Khalick, F., & Lederman, N. G. (2000). Influence of a reflective explicit activity-based approach on elementary teachers' conceptions of nature of science. *Journal of Research in Science Teaching: The Official Journal of the National Association for Research in Science Teaching*, *37*(4), 295-317.

Ali, S., Li, D., Congbin, F., & Khan, F. (2015). Twenty first century climatic and hydrological changes over Upper Indus Basin of Himalayan region of Pakistan. *Environmental Research Letters*, *10*(1), 014007.

Alistair, B. (1976). The Afrikaans medium Decree & the Soweto Uprising. Retrieved from https://www.thoughtco.com/student-uprising-soweto-riots-part-1-43425, on 13th August 2018.

Alsubaie, M. A. (2015). Examples of current issues in the multicultural classroom. *Journal of Education and Practice*, *6*(10), 86-89.

Altheide, D. L., & Johnson, J. M. (1994). Criteria for assessing interpretive validity in qualitative research. In N. K. Denzin & Y. S. Lincoln (Eds.), *Handbook of qualitative research* 485–499. Sage Publications

Alvi, M. (2016). *A manual for selecting sampling techniques in research*. Munich Personal RePEc Archive.

Angaama, D., Fatoba, A. F., Riffel, A. D., & Ogunniyi, M. B. (2016). Harnessing Indigenous knowledge for science teaching: The voices of learners. In *Proceedings of the 2nd International Conference of the African Association for the Study of Indigenous Knowledge Systems*. 23-32.

Anderson, J., Horton, L., Kendrick, M., & McTavish, M. (2017). Children's funds of knowledge in a rural northern Canadian community: A telling case. *Language and Literacy*, *19*(2), 20-32.

Anwar, A. (2011). African indigenous knowledge systems: Challenges and opportunities. *Africa Insight*, *40*(4).

Austin, K., Orcutt, S., & Rosso, J. (2001). How people learn: Introduction to learning theories. *The Learning Classroom: Theory Into Practice–A Telecourse for Teacher Education and Professional Development*.

Avery, L. M. (2013). Rural science education: Valuing local knowledge. *Theory Into Practice*, *52*(1), 28-35.

Babbie, E. R. (2010). The practice of social research. Wadsworth: Cengage Learning. *International Edition* 530.

Bada, S. O., & Olusegun, S. (2015). Constructivism learning theory: A paradigm for teaching and learning. *Journal of Research & Method in Education*, *5*(6), 66-70.

Baker, T., & Nelson, R. E. (2005). Creating something from nothing: Resource construction through entrepreneurial bricolage. *Administrative science quarterly*, *50*(3), 329-366.

Baker, T., Miner, A. S., & Eesley, D. T. (2003). Improvising firms: Bricolage, account giving and improvisational competencies in the founding process. *Research policy*, *32*(2), 255-276.

Barnes, C. J. (2006). Preparing preservice teachers to teach in a culturally responsive way. *Negro educational review*, *57*.

Barnes, T. J. (2006). Situating economic geographical teaching. *Journal of geography in higher education*, *30*(3), 405-409.

Barnhardt, R. (2008). Creating a place for indigenous knowledge in education: The Alaska native knowledge network. *Place-based education in the global age: Local diversity*, 113-133.

Barnhardt, R., & Oscar Kawagley, A. (2005). Indigenous knowledge systems and Alaska Native ways of knowing. *Anthropology & education quarterly*, *36*(1), 8-23.

Bartlett, L. (2007). Bilingual literacies, social identification, and educational trajectories. *Linguistics and Education*, *18*(3-4), 215-231.

Basit, T. N. (2010). *Conducting research in educational contexts*. Bloomsbury Publishing.

Battiste, M. (2002). *Indigenous knowledge and pedagogy in First Nations education: A literature review with recommendations*. National Working Group on Education Ottawa.

Battiste, M., & Youngblood, J. (2000). *Protecting Indigenous knowledge and heritage: A global challenge*. ubc Press.

Bell, R. L. (2008). *Teaching the nature of science through process skills: Activities for grades 3-8*. Allyn & Bacon.

Bennett, M., Barrett, M., Karakozov, R., Kipiani, G., Lyons, E., Pavlenko, V., & Riazanova, T. (2004). Young children's evaluations of the ingroup and of outgroups: A multi-national study. *Social development*, *13*(1), 124-141.

Bhouraskar, S. (2020). Teaching multicultural students. Retrieved from https://www.accreditedschoolsonline.org/education-teaching-degree/multicultural-students/ on 21st of July 2020.

Bogdan, R., & Biklen, S. K. (1997). *Qualitative research for education*. Allyn & Bacon Boston, MA.

Bohensky, E. L., & Maru, Y. (2011). Indigenous knowledge, science, and resilience: What have we learned from a decade of international literature on "integration"? *Ecology and Society*, *16*(4).

Bonomi, M. (2020). Mi (s) Lengua (s): educational paths for Hispanic students within Italian school. *Journal of Multilingual and Multicultural Development*, *41*(1), 45-58.

Botha, L. R. (2010). Indigenous knowledge as culturally-centred education in South Africa. *Africa Education Review*, *7*(1), 34-50.

Botha, L. R. (2012). Using expansive learning to include indigenous knowledge. *International Journal of Inclusive Education*, *16*(1), 57-70.

Bourdieu, P. (1971). Systems of education and systems of thought. *Knowledge and control: New directions for the sociology of education*, 189-207.

Bourdieu, P. (1994). Theory of symbolic power. *Culture/power/history: A reader in contemporary social theory*, *155*.

Bowen, G. A. (2009). Naturalistic inquiry and the saturation concept: a research note. *Qualitative research*, *8*(1), 137-152.

Boyce, C., & Neale, P. (2006). Conducting in-depth interviews: A guide for designing and conducting in-depth interviews for evaluation input. Pathfinder International. *Monitoring and Evaluation*, *2*, 1-12.

Brandon, A. F., & All, A. C. (2010). Constructivism theory analysis and application to curricula. *Nursing education perspectives*, *31*(2), 89-92.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative research in psychology*, *3*(2), 77-101.

Braun, V., & Clarke, V. (2013). *Successful qualitative research: A practical guide for beginners*. Sage.

Brayboy, B. M. J., & Castagno, A. E. (2008). How might Native science inform "informal science learning"? *Cultural studies of Science education*, *3*(3), 731-750.

Breakwell, G. M., & Rose, D. (1995). Theory and method. *Research methods in psychology*.

Byrnes, R. M. (1996). *South Africa: A country study*. Federal Research Division.

Cannon, L. W. (1990). Fostering positive race, class, and gender dynamics in the classroom. *Women's Studies Quarterly*, *18*(1/2), 126-134.

Chesworth, L. (2016). A funds of knowledge approach to examining play interests: listening to children's and parents' perspectives. *International Journal of Early Years Education*, *24*(3), 294-308.

Churchill, R., Ferguson, P., Godinho, S., Johnson, N. F., Keddie, A., Letts, W., & Vick, M. (2012). *Teaching: Making a difference*. John Wiley and Sons. Milton, Qld

Clark, J., & Ramahlaphe, K. (1999). Stepping out into the world of lightning with the science through applications project (STAP). In *Proceedings of the 7th Annual Conference of the Southern African Association for Research in Mathematics and Science Education Conference* 100-115.

Cobern, W. W. (1991). Contextual constructivism: The impact of culture on the learning and teaching of science. *A paper presented at the Theoretical Bases for Science Education Research symposium at the Annual Meeting of the National Association for Research in Science Teaching*, Lake Geneva, Wisconsin

Cobern, W. W. (1998). *Socio-cultural perspectives on science education: An international dialogue 4*. Springer Science & Business Media.

Cobern, W. W. (2000). *Everyday thoughts about nature: A worldview investigation of important concepts students use to make sense of nature with specific attention to science* 9. Springer Science & Business Media.

Cobern, W. W., & Aikenhead, G. (1997). Cultural aspects of learning science. *Scientific Literacy and Cultural Studies Project. 13*.

Coe, R., Aloisi, C., Higgins, S., & Major, L. E. (2014). What makes great teaching? *Review of the underpinning research*.

Cohen, L., Manion, L., & Morrison, K. (2004). *A guide to teaching practice*. Psychology Press.

Cohen, L., Manion, L., & Morrison, K. (2017). *Research methods in education*. Routledge.

Corbin, J., & Strauss, A. (2008). Strategies for qualitative data analysis. *Basics of Qualitative Research. Techniques and procedures for developing grounded theory, 3*.

Cortes, C. E. (1981). The societal curriculum: Implications for multiethnic educations. *Educations in the 80's: Multiethnic education. National Education Association*.

Creswell, J. W. (2012). Educational research: planning. *Conducting, and Evaluating*.

Creswell, J. W. (2014). *A concise introduction to mixed methods research*. SAGE publications.

Creswell, J. W., & Creswell, J. (2003). *Research design*. Sage publications Thousand Oaks, CA.

Creswell, J. W., & Creswell, J. D. (2017). *Research design: Qualitative, quantitative, and mixed methods approaches*. Sage publications.

Cronje, A., De Beer, J., & Ankiewicz, P. (2015). The development and use of an instrument to investigate science teachers' views on indigenous knowledge. *African Journal of Research in Mathematics, Science and Technology Education*, *19*(3), 319-332.

Darling-Hammond, L., & Berry, B. (2006). Highly qualified teachers for all. *Educational leadership*, *64*(3), 14.

De Beer, J. J., & van Wyk, B.E. (2012). Indigenous knowledge in the life sciences classroom: Science, pseudo-science or a missing link? *Suid-Afrikaanse Tydskrif vir Natuurwetenskap en Tegnologie*, *31*(1), 5.

De Beer, J., & Mothwa, M. (2014). *Indigenous knowledge in the science classroom: science, pseudoscience, or a missing link*?

De Beer, J., & Van Wyk, B.-E. (2011). Doing an ethnobotanical survey in the life sciences classroom. *The American Biology Teacher*, *73*(2), 90-97.

De Beer, J., & Whitlock, E. (2009). Indigenous knowledge in the Life Sciences classroom: put on your De Bono hats! *The American Biology Teacher*, *71*(4), 209-216.

De Jong, T., & Ferguson-Hessler, M. G. (1996). Types and qualities of knowledge. *Educational psychologist*, *31*(2), 105-113.

Dekkers, P., & Mnisi, E. (2003). The Nature of Science—Do teachers have the understandings they are expected to teach? *African Journal of Research in Mathematics, Science and Technology Education*, *7*(1), 21-34.

DeMarrais, K. (2004). Qualitative interview studies: Learning through experience. *Foundations for research: Methods of inquiry in education and the social sciences*, *1*(1), 51-68.

Denscombe, M. (2008). Communities of practice: A research paradigm for the mixed methods approach. *Journal of mixed methods research*, *2*(3), 270-283.

Denzin, N. K., & Lincoln, Y. S. (2005). Introduction: The discipline and practice of qualitative research.

Denzin, N. K., & Lincoln, Y. S. (2005). Introduction: The discipline and practice of qualitative research.

Denzin, N. K., & Lincoln, Y. S. (2011). *The Sage handbook of qualitative research*. Sage.

Department of Education. (2003). *Revised National Curriculum Statement Grades R-9 (schools) Policy: Natural Sciences*. Pretoria, South Africa: Government Printers.

Department of Basic Education. (2011). *Curriculum and Assessment Policy Statement (CAPS) Life Sciences: Grades 10, 11 and 12*. Pretoria: Department of Basic Education.

Department of Education. (2009). Report of the task team for the review of the National Curriculum Statement. *Final report handed to the Minister of Education*. Pretoria, South Africa: Government Printers.

Department of Basic Education (2019). Life Sciences: National Senior Certificate Diagnostic Report Part 1. *https://dbedashboard.co.za/School-Improvement/problem-solving/nsc-subject-diagnostic-reports/*

Diwu, C. T., & Ogunniyi, M. B. (2012). Dialogical argumentation instruction as a catalytic agent for the integration of school science with Indigenous Knowledge Systems. *African Journal of Research in Mathematics, Science and Technology Education*, *16*(3), 333-347.

Driver, R., & Oldham, V. (1986). A constructivist approach to curriculum development in science.

Driver, R., Asoko, H., Leach, J., Scott, P., & Mortimer, E. (1994). Constructing scientific knowledge in the classroom. *Educational researcher*, *23*(7), 5-12.

Duymedjian, R., & Rüling, C.-C. (2010). Towards a foundation of bricolage in organization and management theory. *Organization Studies*, *31*(2), 133-151.

Dziva, D., Mpofu, V., & Kusure, L. (2011). Teachers' conception of indigenous knowledge in science curriculum in the context of Mberengwa district, Zimbabwe.

Ekborg, M. (2005). Student-teachers' Learning Outcomes during Science Subject Matter Courses. *International Journal of Science Education*, *27*(14), 1671-1694.

Fakoyede, S. J., & Otulaja, F. S. (2019). Beads and beadwork as cultural artifacts used in mediating learners' agentic constructs in science classrooms: a case for place-based learning. *Cultural studies of Science education*, 1-18.

Farnsworth, V., Kleanthous, I., & Wenger-Trayner, E. (2016). Communities of practice as a social theory of learning: A conversation with Etienne Wenger. *British journal of educational studies*, *64*(2), 139-160.

Fataar, A. (1997). Access to schooling in a post-apartheid South Africa: Linking concepts to context. *International review of education*, *43*(4), 331-348.

Flick, U. (2014). Challenges for qualitative inquiry as a global endeavor: Introduction to the special issue. *In SAGE Publications Sage CA*: Los Angeles, CA.

Fránquiz, M. E., & Ortiz, A. A. (2018). *Coeditors' introduction: Ensuring the success of dual language programs through alignment of research, policy, and practice*. 215-220

Freire, P. (1972). Pedagogy of the Oppressed. 1968. *Trans. Myra Bergman Ramos. New York: Herder*.

Garroutte, E. M. (1999). American Indian science education: The second step. *American Indian Culture and Research Journal*, *23*(4), 91-114.

George, J. M. (2013). 'Do You Have to Pack?'—Preparing For Culturally Relevant Science Teaching in the Caribbean. *International Journal of Science Education*, *35*(12), 2114-2131.

Gilbert, N. (1999). Simulation: A new way of doing social science. *American Behavioral Scientist*, *42*(10), 1485-1487.

Graham-Jolly, M. (2003). The nature of curriculum. *Coleman, M. Graham-Jolly M. & Middlewood, D.(Eds.). Managing schools in South Africa: Managing curriculum in South African schools. London: Commonwealth Secretariat*, 3-16.

Guba, E. G., & Lincoln, Y. S. (1994). Competing paradigms in qualitative research. *Handbook of qualitative research*, *2*(163-194), 105.

Guba, E. G., & Lincoln, Y. S. (2001). *Guidelines and checklist for constructivist (aka fourth generation) evaluation*. In.

Halme, M., Lindeman, S., & Linna, P. (2012). Innovation for inclusive business: Intrapreneurial bricolage in multinational corporations. *Journal of Management Studies*, *49*(4), 743-784.

Haneda, M. (2006). Classrooms as communities of practice: A reevaluation. *Tesol Quarterly*, *40*(4), 807-817.

Hart, M. A. (2010). Indigenous worldviews, knowledge, and research: The development of an indigenous research paradigm. *Journal of Indigenous Social Development, 1*(1A).

Hens, L. (2006). Indigenous knowledge and biodiversity conservation and management in Ghana. *Journal of Human Ecology*, *20*(1), 21-30.

Hewson, M. G. (2012). Traditional healers' views on their indigenous knowledge and the science curriculum. *African Journal of Research in Mathematics, Science and Technology Education*, *16*(3), 317-332.

Hewson, M. G., & Ogunniyi, M. B. (2011). Argumentation-teaching as a method to introduce indigenous knowledge into science classrooms: Opportunities and challenges. *Cultural studies of Science education*, *6*(3), 679-692.

Horsthemke, K., & Schafer, M. (2007). Does' African mathematics' facilitate access to mathematics? Towards an ongoing critical analysis of ethnomathematics in a South African context. *Pythagoras*, *2007*(65), 2-9.

Iaccarino, M. (2003). Science and culture: Western science could learn a thing or two from the way science is done in other cultures. *EMBO reports*, *4*(3), 220-223.

Isserles, R., & Dalmage, H. (2000). Cultural capital as rules and resistance: Bringing it home in the introductory classroom. *Teaching Sociology*, *28*(2), 160-165.

Jadama, L. M. (2014). Impact of subject matter knowledge of a teacher in teaching and learning process. *Middle East and African Journal of Educational Research*, (7), 20-29.

Jansen, J. D. (2001). Image-ining teachers: Policy images and teacher identity in South African classrooms. *South African journal of education*, *21*(4), 242-246.

Jansen, J. D. (2001). Image-ining teachers: Policy images and teacher identity in South African classrooms. *South African journal of education*, *21*(4), 242-246.

Jansen, J. D., & Christie, P. (1999). *Changing curriculum: Studies on outcomes-based education in South Africa*. Juta and Company Ltd.

Jansen, J., & Taylor, N. (2003). *Educational change in South Africa 1994-2003: Case studies in large-scale education reform*. The World Bank.

Jayanthi, S. (2017). Sustaining the Identity of the Indian Woman in a Multicultural Realm "Mrs. Sen" in Jhumpa Lahiri's Interpreter of Maladies. In *Journal of English Language Teachers' Interaction Forum.* (8), 16

Jegede, O. J. (1999). Science education in nonwestern cultures: Towards a theory of collateral learning. *What is indigenous knowledge*, 119-142.

Jegede, O. J., & Okebukola, P. A. (1991). The effect of instruction on socio-cultural beliefs hindering the learning of science. *Journal of Research in Science Teaching*, *28*(3), 275-285.

Jonsen, K., & Jehn, K. A. (2009). Using triangulation to validate themes in qualitative studies. *Qualitative Research in Organizations and Management: An International Journal*.

Kallaway, P. (1984). *Apartheid and education: The education of black South Africans*. Ravan Pressof South Africa.

Kaya, H. O., & Seleti, Y. N. (2014). African indigenous knowledge systems and relevance of higher education in South Africa. *International Education Journal: Comparative Perspectives*, *12*(1).

Keane, M. (2008). Science education and worldview. *Cultural studies of Science education*, *3*(3), 587-621.

Kibirige, I., & Van Rooyen, H. (2006). Enriching science teaching through the inclusion of indigenous knowledge. *Teaching science in the OBE classroom. Braamfontein, South Africa: Macmillan*.

Kincheloe, J. L. (2011). Describing the bricolage: Conceptualizing a new rigor in qualitative research. In *Key works in critical pedagogy* 177-189. Brill Sense.

Kincheloe, J. L., & Steinberg, S. R. (2008). Indigenous knowledges in education: Complexities, dangers, and profound benefits. *Handbook of critical and indigenous methodologies*, 135-156.

Kirk, D., & MacDonald, D. (2001). Teacher voice and ownership of curriculum change. *Journal of curriculum studies*, *33*(5), 551-567.

Kuhn, T. S. (1962). Historical structure of scientific discovery. *Science*, *136*(3518), 760-764.

Kuzel, A. J., & Like, R. C. (1991). Standards of trustworthiness for qualitative studies in primary care. In P. G. Norton, M. Stewart, F. Tudiver, M. J. Bass, & E. V. Dunn (Eds.), *Primary care research: Traditional and innovative approaches* 138–158. Sage Publications, Inc.

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge university press.

Le Grange, L. (2007). Integrating western and indigenous knowledge systems: The basis for effective science education in South Africa? *International review of education*, *53*(5), 577-591.

LeCompte, M. D., & Schensul, J. J. (2010). *Designing and conducting ethnographic research: An introduction 1*. Rowman Altamira.

Lederman, N. G. (2007). Nature of science: Past, present, and future. *Handbook of research on science education*, *2*, 831-879.

Lederman, N. G., Lederman, J. S., & Antink, A. (2013). Nature of science and scientific inquiry as contexts for the learning of science and achievement of scientific literacy. *International Journal of Education in Mathematics, Science and Technology*, *1*(3).

Lee, O. (2001). Culture and language in science education: What do we know and what do we need to know? *Journal of Research in Science Teaching: The Official Journal of the National Association for Research in Science Teaching*, *38*(5), 499-501.

Lee, V. S. (2011). The power of inquiry as a way of learning. *Innovative Higher Education*, *36*(3), 149-160.

Letts, L., Wilkins, S., Law, M., Stewart, D., Bosch, J., & Westmorland, M. (2007). Guidelines for critical review form: Qualitative studies (Version 2.0). *McMaster university occupational therapy evidence-based practice research group*.

Lévi-Strauss, C. (1966). The Savage Mind, trans. *J. Weightman and D. Weightman. Chicago: University of Chicago*, *15*.

Lewis, S. (2015). Qualitative inquiry and research design: Choosing among five approaches. *Health promotion practice*, *16*(4), 473-475.

Lichtman, M. (2013). *Qualitative research for the social sciences*. SAGE publications.

Liu, C. C., & Chen, I. J. (2010). Evolution of constructivism. *Contemporary issues in education research*, *3*(4), 63-66.

Longstreet, W. S., & Shane, H. G. (1992). *Curriculum for a new millennium*. Pearson College Division.

Luckett, K. (2009). The relationship between knowledge structure and curriculum: A case study in sociology. *Studies in Higher Education*, *34*(4), 441-453.

Luckin, R., Logan, K., Clark, W., Graber, R., Oliver, M., & Mee, A. (2008). Learners' use of Web 2.0 technologies in and out of school in Key Stages 3 and 4.

Luft, J. A., & Hewson, P. W. (2014). Research on teacher professional development programs in science. *Handbook of research on science education*, *2*, 889-909.

MacMillan, J., & Schumacher, S. (2006). *Research in education–Evidence-based Inquiry . International Edition.* In: Boston: Pearson Education Inc. Pergamous Press.

Malcolm, C., & Keane, M. (2001). Working scientifically in learner-centred ways. *6th International History, Philosophy and Science Teaching Conference.*

Maodzwa–Taruvinga, M., & Cross, M. (2012). Jonathan Jansen and the curriculum debate in South Africa: An essay review of Jansen's writings between 1999 and 2009. *Curriculum Inquiry*, *42*(1), 126-152.

Maxwell, J. A. (2012). *Qualitative research design: An interactive approach 41*. Sage publications.

Maxwell, J. A. (2013). Applied social research methods series: Vol. 41. *Qualitative research design: An interactive approach*, *3*.

Mazzocchi, F. (2006). Western science and traditional knowledge: Despite their variations, different forms of knowledge can learn from each other. *EMBO reports*, *7*(5), 463-466.

McCown, R., Driscoll, M., & Roop, P. (1996). Facilitating student motivation. *Educational psychology*, 278-309.

McMillan, J. H., & Schumacher, S. (2006). *Research in Education: A Conceptual Introduction Addison Wesley Longman*: New York.

McMillan, J. H., & Schumacher, S. (2010). Research in Education: Evidence-Based Inquiry, MyEducationLab Series. *Pearson*.

Merriam, S. B., & Tisdell, E. J. (2015). *Qualitative research: A guide to design and implementation*. John Wiley & Sons.

Mertens, D. M. (2018). Ethics of qualitative data collection. *The SAGE handbook of qualitative data collection*, 33-48.

Meyer, H. (2004). Novice and expert teachers' conceptions of learners' prior knowledge. *Science education*, *88*(6), 970-983.

Michel, H., & Neumann, I. (2014). Nature of Science and Science Content Learning: Can NOS Instruction Help Students Develop a Better Understanding of the Energy Concept? *National Association of Research in Science Teaching (NARST), Pittsburgh, Pennsylvania*.

Miles, M. B., Huberman, A. M., & Saldaña, J. (2018). *Qualitative data analysis: A methods sourcebook*. Sage publications.

Mogari, D., Kriek, J., & Atagana, H. (2016, January). Designing a teacher development programme for improving the content knowledge of grade 12 mathematics and science teachers. *SAARMSTE Conference Proceedings*.

Moll, L. C. (2001). Through the mediation of others: Vygotskian research on teaching. *Handbook of research on teaching*, *4*, 111-129.

Moodie, G. (2003). The missing link in Australian tertiary education: short-cycle higher education. *International Journal of Training Research*, *1*(1), 44-63.

Mortimer, E., & Scott, P. (2003). *Meaning Making In Secondary Science Classroomsaa*. McGraw-Hill Education (UK).

Mosimege, M. (2005). National priorities in Indigenous Knowledge Systems: implications for research and curriculum development. *Indilinga African Journal of Indigenous Knowledge Systems*, *4*(1), 31-37.

Moulaison Sandy, H., & Bossaller, J. (2017). Providing cognitively just subject access to indigenous knowledge through knowledge organization systems. *Cataloging & Classification Quarterly*, *55*(3), 129-152.

Mpofu, V., Otulaja, F. S., & Mushayikwa, E. (2014). Towards culturally relevant classroom science: a theoretical framework focusing on traditional plant healing. *Cultural studies of Science education*, *9*(1), 221-242.

Msimanga, A., Denley, P., & Gumede, N. (2017). The pedagogical role of language in science teaching and learning in South Africa: A review of research 1990–2015. *African Journal of Research in Mathematics, Science and Technology Education*, *21*(3), 245-255.

Mthethwa-Kunene, E., Onwu, G. O. & de Villiers, R. (2015). Exploring Biology Teachers' Pedagogical Content Knowledge in the Teaching of Genetics in Swaziland Science Classrooms. *International Journal of Science Education*, *37*(7), 1140-1165.

Naidoo, P. D. (2010). *Teachers' interpretation and implementation of the policy on indigenous knowledge in the science national curriculum statement*

Naidoo, P. D., & Vithal, R. (2014). Teacher approaches to introducing indigenous knowledge in school science classrooms. *African Journal of Research in Mathematics, Science and Technology Education*, *18*(3), 253-263.

Naidoo, V. (2007). Research on the flow of international students to UK universities: Determinants and implications. *Journal of Research in International Education*, *6*(3), 287-307.

Nakashima, D., Prott, L. and Bridgewater, P. (2000) Tapping into the worlds' wisdom, *UNESCO Sources*, 125, 12. Retrieved 30th June 2018.

Nieuwenhuis, J. (2007). Analysing qualitative data. *First steps in research*, *2*, 104-130.

Nilsson, P. (2013). What do we know and where do we go? Formative assessment in developing student teachers' professional learning of teaching science. *Teachers and Teaching, 19* (2), 188-201.

Nisbett, R. (2004). *The geography of thought: How Asians and Westerners think differently... and why*. Simon and Schuster.

Nola, R., & Irzik, G. (2006). Philosophy, science, education and culture 28. *Springer Science & Business Media*. 175.

Nystrand, M., Wu, L. L., Gamoran, A., Zeiser, S., & Long, D. A. (2003). Questions in time: Investigating the structure and dynamics of unfolding classroom discourse. *Discourse processes*, *35*(2), 135-198.

Ocampo, M. L. (2004). A brief history of educational inequality from apartheid to the present. Seminar paper from Global Perspectives on Human Language: The South African Context. Retrieved July 2020 from *http://www.stanford.edu/~jbaugh/saw/Lizet_Education_Inequity.html*

O'Donoghue, R. and E. Neluvhalani. 2002. *"Indigenous knowledge and the school curriculum: a review of developing methods and methodological perspectives*". 121-134. In E. Janse van Rensburg, J. Hattingh, H. Lotz-Sisitka and R. O'Donoghue (eds.) EEASA *Monograph: Environmental Education, Ethics and Action in Southern Africa.* Pretoria: EEASA/HSRC

O'Leary, D. E. (2014). Knowledge management: An empirical analysis of reuse and productivity. *Journal of decision systems*, *23*(3), 249-265.

Odora Hoppers, C. A. (2001). Poverty Power and Partnerships in Educational Development: A post-victimology perspective. *Compare: A Journal of Comparative and International Education*, *31*(1), 21-38.

Odora Hoppers, C. A. (2002). Indigenous knowledge systems, sustainable livelihoods and the intellectual property system: A peace action perspective. *Journal of Peacebuilding & Development*, *1*(1), 106-112.

Odora Hoppers, C. A. (2005). *Culture, indigenous knowledge and development.*

Odora Hoppers, C. A. (2006). Centre for African renaissance studies, the academy, the state and civil society: Methodological implications of transdisciplinarity and the African perspective. *International Journal of African Renaissance Studies*, *1*(1), 33-52.

Odora Hoppers, C. A. (2009). Education, culture and society in a globalizing world: Implications for comparative and international education. *Compare*, *39*(5), 601-614.

Odora Hoppers, C. A. (2009). Education, culture and society in a globalizing world: Implications for comparative and international education. *Compare*, *39*(5), 601-614.

Odora-Hoppers, C. (2004). The cause, the object, the citizen: Rural school learners in the void of intersecting policies and traditions of thought. *Quarterly of Education and Training in South Africa*, *11*(3), 17-22.

Ogunniyi, M. (2004). The challenge of preparing and equipping science teachers in higher education to integrate scientific and indigenous knowledge systems for learners: the practice of higher education. *South African Journal of Higher Education*, *18*(3), 289-304.

Ogunniyi, M. (2006). Using a practical arguments-discursive science education course to enhance teachers' ability to implement a science-indigenous knowledge curriculum. *Proceedings of the Southern African Association for Research in Mathematics, Science and Technology Education*, 117-127.

Ogunniyi, M. (2007a). Teachers' stances and practical arguments regarding a science-indigenous knowledge curriculum: Part 1. *International Journal of Science Education*, *29*(8), 963-986.

Ogunniyi, M. (2007b). Teachers' stances and practical arguments regarding a science-indigenous knowledge curriculum: Part 2. *International Journal of Science Education*, *29*(10), 1189-1207.

Ogunniyi, M. (2012). Re-focussing discourses in indigenous knowledge systems. Proceedings of Systematic Review of South African-Mozambican Published Research on Indigenous Knowledge Systems Conference,

Ogunniyi, M. B. (2011). The context of training teachers to implement a socially relevant science education in Africa. *African Journal of Research in Mathematics, Science and Technology Education*, *15*(3), 98-121.

Ogunniyi, M. B., & Hewson, M. G. (2008). Effect of an argumentation-based course on teachers' disposition towards a science-indigenous knowledge curriculum. *International Journal of Environmental and Science Education*, *3*(4), 159-177.

Ogunniyi, M. B., & Hewson, M. G. (2008). Effect of an argumentation-based course on teachers' disposition towards a science-indigenous knowledge curriculum. *International Journal of Environmental and Science Education*, *3*(4), 159-177.

Ogunniyi, M., & Ogawa, M. (2008). The prospects and challenges of training South African and Japanese educators to enact an indigenised science curriculum. *South African Journal of Higher Education*, *22*(1), 175-190.

Okeke, C., & Van Wyk, M. (2016). *Educational research: an African approach*. Oxford University Press Southern Africa.

Onwu, G., & Mosimege, M. (2004). Indigenous knowledge systems and science and technology education: A dialogue. *African Journal of Research in Mathematics, Science and Technology Education*, *8*(1), 1-12.

Opie, C. (2004). *Research Procedures Doing Educational Research. A Guide to First Time Researchers.* In: Sage Publications, London.

Osborne, J., Simon, S., & Collins, S. (2003). Attitudes towards science: A review of the literature and its implications. *International Journal of Science Education*, *25*(9), 1049-1079.

Patton, M. Q. (2015). *Qualitative research & evaluation methods: Integrating theory and practice.*

Perso, T. (2012). Cultural responsiveness and school education: With particular focus on australia's first peoples; *A review & synthesis of the literature*.

Preissle, J., & Grant, L. (2004). Fieldwork traditions: Ethnography and participant observation. *Foundations for research: Methods of inquiry in education and the social sciences*, 161-180.

Probst, B., & Berenson, L. (2014). The double arrow: How qualitative social work researchers use reflexivity. *Qualitative Social Work*, *13*(6), 813-827.

Ramirez, P., & Ross, L. (2019). Secondary dual-language learners and emerging pedagogies: The intersectionality of language, culture, and community. *Theory Into Practice*, *58*(2), 176-184.

Ramorogo, G., & Ogunniyi, M. (2010). Exploring teachers' conceptions of the rainbow using an argumentation-based intervention. *African Journal of Research in Mathematics, Science and Technology Education*, *14*(1), 24-35.

Rata, E. (2012). The politics of knowledge in education. *British Educational Research Journal*, *38*(1), 103-124.

Rogan, J. (2004). Out of the frying pan…?: Case studies of the implementation of Curriculum 2005 in some science classrooms. *African Journal of Research in Mathematics, Science and Technology Education*, *8*(2), 165-179.

Rogoff, B. (2008). Observing sociocultural activity on three planes: Participatory appropriation, guided participation, and apprenticeship. *Pedagogy and practice: Culture and identities*, 58-74.

Rollnick, M., & Mavhunga, E. (2015). The PCK summit and its effect on work in South Africa. *In A. Berry, P. Friedrichsen & J. Loughran (Eds.), Re-examining Pedagogical Content Knowledge in Science Education* 135-146. London: Routlege.

Roschelle, J. (1997). *Learning in interactive environments: Prior knowledge and new experience*. Citeseer.

Russell, B. (2005). *Analysis of mind*. Routledge.

Scholtz, Z., Watson, R., & Amosun, O. (2004). Investigating science teachers' response to curriculum innovation. *African Journal of Research in Mathematics, Science and Technology Education*, *8*(1), 41-53.

Scott, P. (2008). Talking a way to understanding in science classrooms. *Exploring talk in school*, 17-36.

Scott, P. (2008). Talking a way to understanding in science classrooms. *Exploring talk in school*, 17-36.

Seale, C. (1999). Quality in qualitative research. *Qualitative inquiry*, *5*(4), 465-478.

Semali, L. M., & Kincheloe, J. L. (2002). *What is indigenous knowledge?: Voices from the academy*. Routledge.

Senanayake, S. (2006). Indigenous knowledge as a key to sustainable development.

Shenton, A. K. (2004). Strategies for ensuring trustworthiness in qualitative research projects. *Education for information*, *22*(2), 63-75.

Shizha, E. (2005). Reclaiming our memories: The education dilemma in postcolonial African school curricula. In *Issues in African Education* 65-83. Springer.

Shizha, E. (2005). Reclaiming our memories: The education dilemma in postcolonial African school curricula. In *Issues in African Education* (pp. 65-83). Springer.

Shizha, E. (2005). Reclaiming our memories: The education dilemma in postcolonial African school curricula. In *Issues in African Education* (pp. 65-83). Springer.

Shizha, E. (2007). Critical analysis of problems encountered in incorporating indigenous knowledge in science teaching by primary school teachers in Zimbabwe. *Alberta Journal of Educational Research*, *53*(3).

Shizha, E. (2008). Globalization and indigenous knowledge: An African post-colonial theoretical analysis: An African Post-colonial Theoretical Analysis. In *Education and social development* 37-56. Brill Sense.

Shizha, E. (2010). The interface of neoliberal globalization, science education and indigenous African knowledges in Africa. *USA) Chairperson of the Foreign Language*, *1*, 26.

Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational researcher*, *15*(2), 4-14.

Siniscalco, M. T., & Auriat, N. (2005). Questionnaire design. *Quantitative research methods in educational planning*, *8*.

Sjøberg, S., & Schreiner, C. (2010). The ROSE project. *An overview and key findings*, 1-31.

Snively, G., & Corsiglia, J. (2001). Discovering indigenous science: Implications for science education. *Science education*, *85*(1), 6-34.

Snively, G., & Corsiglia, J. (2001). Discovering indigenous science: Implications for science education. *Science education*, *85*(1), 6-34.

Spady, W. G. (1994). *Outcome-Based Education: Critical Issues and Answers*. ERIC.

Stake, R. E. (2005). Qualitative case studies.

Stears, M., Malcolm, C., & Kowlas, L. (2003). Making use of everyday knowledge in the science classroom. *African Journal of Research in Mathematics, Science and Technology Education*, *7*(1), 109-118.

Strangman, N., Hall, T., & Meyer, A. (2004). Background knowledge instruction and the implications for UDL implementation. *Retrieved october*, *23*, 2006.

Stroupe, D., Moon, J., & Michaels, S. (2019). Introduction to special issue: Epistemic tools in science education. *Science Education*, *103*(4), 948-951.

Su, S.-W. (2012). The Various Concepts of Curriculum and the Factors Involved in Curricula-making. *Journal of language teaching & research*, *3*(1).

Sumranwanich, W., & Yuenyong, C. (2014). Graduate students' concepts of nature of science (NOS) and attitudes toward teaching NOS. *Procedia-Social and Behavioral Sciences*, *116*, 2443-2452.

Sumranwanich, W., & Yuenyong, C. (2014). Graduate students' concepts of nature of science (NOS) and attitudes toward teaching NOS. *Procedia-Social and Behavioral Sciences*, *116*, 2443-2452.

Taber, K. S. (2011). Models, molecules and misconceptions: a commentary on "secondary school students' misconceptions of covalent bonding". *Journal of Turkish Science Education*, *8*(1), 3-18.

Taherdoost, H. (2016). Sampling methods in research methodology; how to choose a sampling technique for research. *How to Choose a Sampling Technique for Research (April 10, 2016)*.

Taliaferro, K., & Scholar, M. (2003). Multicultural education: using Penn state's teacher education performance framework to help education students develop a multicultural perspective. *Penn state mcnair journal*, *10*(4), 7-15.

The glossary of education reform (2016). Content Knowledge. Retrieved from *https://www.edglossary.org/content-knowledge/*

Tracy, S. (2013). Qualitative research methods, handbook of research methods in tourism: Quantitative and qualitative approaches. *Wiley-Blackwell, West Sussex, UK. doi*, *10*, 9781781001295.

Urick, J. (2020). How Can Educators Use Multicultural Materials to Create a More Inclusive Classroom Community?

Van Teijlingen, E., & Hundley, V. (2002). The importance of pilot studies. *Nursing Standard (through 2013), 16*(40), 33.

Vhurumuku, E. (2010). Using scientific investigations to explain the nature of science. *Teaching scientific investigations. Johannesburg: Macmillan*.

Vhurumuku, E., & Mokeleche, M. (2009). The nature of science and indigenous knowledge systems in South Africa, 2000–2007: A critical review of the research in science education. *African Journal of Research in Mathematics, Science and Technology Education*, *13*(1), 96-114.

Vygotsky, L. (1986). *Thought and Language*. Cambridge: The Massachusetts Institute of Technology. In: MIT Press.

Vygotsky, L. S. (1968). *Thought and language (newly revised, translated, and edited by Alex Kozulin).* In: Cambridge, MA: MIT Press.

Vygotsky, L. S. (1978). Mind in society: The development of higher mental processes (E. Rice, Ed. & Trans.). In: Cambridge, MA: Harvard University Press.(Original work published 1930, 1933 ….

Walther, J. (2014). Understanding interpretive research through the lens of a cultural Verfremdungseffekt. *Journal of Engineering Education*, *103*(3), 450-462.

Wenger, E. (2011). Communities of practice: A brief introduction.

What Caused a Student Uprising in Soweto in 1976? (2019, July 3). ThoughtCo. https://www.thoughtco.com/student-uprising-soweto-riots-part-1-43425

Yin, R. K (2009). Case study research: Design and methods . Thousand Oaks, CA: Sage. *The Canadian Journal of Action Research*, *14*(1), 69-71.

Yin, R. K. (2015). *Qualitative research from start to finish*. Guilford publications.

Zain, A. N. M., Rohandi, R., & Jusoh, A. (2010). Instructional congruence to improve Malaysian students ‘attitudes and interests toward science in low performing secondary schools. *European Journal of Social Sciences, 13*(1), 89-100.

Zhou, M., & Brown, D. (2015). *Educational learning theories*.

Appendices

Appendix 1: Ethics Clearance

Research Office

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

CLEARANCE CERTIFICATE	**PROTOCOL NUMBER: H18/10/02**
PROJECT TITLE	Teachers' indigenous knowledge and the possibilities of affording integration of indigenous knowledge in Life Science teaching and learning
INVESTIGATOR(S)	Miss U Ahanonye
SCHOOL/DEPARTMENT	Animal, Plant and Environmental Sciences/
DATE CONSIDERED	19 October 2018
DECISION OF THE COMMITTEE	Approved Permission letters required from the three schools before data collection can commence
EXPIRY DATE	01 November 2021

DATE 02 November 2018 **CHAIRPERSON** J-aright
(Professor J Knight)

cc: Supervisor : Dr F Otulaja, Dr S Dukhan and Dr I Risenga

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 2: GDE Approval Letter

GAUTENG PROVINCE
Department: Education
REPUBLIC OF SOUTH AFRICA

8/4/4/1/2

GDE RESEARCH APPROVAL LETTER

Date:	17 October 2018
Validity of Research Approval:	11 February 2019 – 30 September 2019 2018/328
Name of Researcher:	Ahanonye U.A.
Address of Researcher:	P.O Box 1494
	Buccleuch
	2066
Telephone Number:	084 758 6461
Email address:	ucgold911@yahoo.com
Research Topic:	Teachers' Indigenous Knowledge and Possibilities of Integration into Life Sciences Teaching and Learning
Type of qualification	PhD
Number and type of schools:	Three Secondary Schools.
District/s/HO	Johannesburg East.

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.

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:

23/10/2018

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

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: 23/10/2018

Making education a societal priority

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 3

Teachers' IKS Questionnaire (TIKSQ)

Teachers' Questionnaire

Please answer all items of this questionnaire. We would like to know your views, this is not a test. Your answers will be used for educational research purposes only. Your responses will be treated confidentially: your identity will not be revealed and is known only to the researcher. The researcher may ask you, later, to clarify your answers verbally: for this purpose only, please provide your ID number below.

_____

Kindly answer the questions below to the best of your ability. There is no right or wrong answer to the questions. Feel free to express **your opinion** on the issues regarding indigenous knowledge also known as cultural knowledge. Your assistance is highly appreciated. Thanks

1. What do you understand by the term, indigenous knowledge? Please explain

_____
_____
_____
_____
_____

2. What does indigenous knowledge system mean to you?
   a) As a person?

_____
_____
_____
_____
_____

   b) As a science teacher?

_____
_____
_____
_____
_____

3. Is indigenous knowledge important? ___Yes or ____ No.
   If Yes, why?

_____
_____
_____
_____
_____

   If No, why?

_____
_____
_____
_____
_____

Teachers' IKS Questionnaire (TIKSQ)

4. What makes indigenous knowledge different from other types of knowledge (for example, Science)?

_____
_____
_____
_____
_____

5. Practitioners of indigenous science (e.g. elders, herbalists, traditional healers) observe nature to generate knowledge. Do they do experiments and test in order to verify or validate this knowledge? ___Yes or ____ No
If Yes, how?

_____
_____
_____
_____
_____

If No, why?

_____
_____
_____
_____
_____

6a. How is Indigenous knowledge carried on from one generation to another?

_____
_____
_____
_____
_____

b. Does this knowledge stay same? Yes___No___
If yes explain

_____
_____
_____
_____
_____

If No explain

_____
_____
_____
_____
_____
_____

7. Myths are stories that are told in different cultures by elders from one generation to the next. Do you think myths and rituals play any important role in indigenous knowledge systems? ___Yes or ___No
Please explain with example.

Teachers' IKS Questionnaire (TIKSQ)

8. Does indigenous knowledge reflect the social and cultural values of a people? ___Yes or ___No
If Yes, how?

If No, why?

9. Can indigenous knowledge be used to explain Life Sciences concepts in the school context?
If Yes, why?

If No, why?

10. How can Life Sciences be taught in the classroom using indigenous knowledge?
Please explain and provide examples

11. Does the curriculum explain what and how you should implement indigenous knowledge in the classroom?
Please site an example from the CAPS document.

Teachers' IKS Questionnaire (TIKSQ)

More information regarding Indigenous knowledge and its use in the classroom

Appendix 4: Sample Interview Questions

Possible Sample Interview Questions

1. With your views of what Indigenous Knowledge is, how do you think Indigenous Knowledge can be incorporated with life science in the classroom?
2. The curriculum mandates that Indigenous Knowledge be incorporated with science in the classroom, how could teachers do this?
3. When did you become aware of this mandate in the science curriculum?
4. How have you tried to incorporate Indigenous Knowledge with science in your teaching of science? Please explain your response
5. How do you think Indigenous Knowledge can be used to teach life science?
6. What are the possibilities of incorporating Indigenous Knowledge with science?
7. How could you incorporate Indigenous Knowledge with science when you teach science in the classroom?
8. What concepts in life science do you think can be linked to indigenous Knowledge?

Appendix 5: Participant's Consent Form

School of Animal, Plant & Environmental Sciences

Private Bag 3, Wits 2050, South Africa ·Enquiries: Tel.: +27 (0) 11 717-6403 | Fax: +27 (0) 11 717-6494

Dear Participant.

Participant Consent Form

You have read the Information Sheet about my research with title listed below. For you to fully participate in this study, I am asking you to please complete, sign and return this consent form as soon as possible.

Title of research: Teachers' Indigenous Knowledge and the possibilities of affording integration of Indigenous Knowledge in Life science teaching and Learning.

I, ……., agree to participate in this research project. The research has been explained to me and I understand what my participation will involve.

I agree to participate in this study	YES	NO	(please circle)
I agree that the researcher may use my quotes in her research report	YES	NO	
I agree to participate in interviews and that such interviews can be audio recorded for transcription	YES	NO	

_____ (Name of Participant)

_____ (Participants' Signature) _____ (Date)

Uchechi Agnes Ahanonye (Name of Researcher)

_____ (Researchers' Signature) _____ (Date)

Appendix 6: Letter of Permission from Principal

School of Animal, Plant & Environmental Sciences

Private Bag 3, Wits 2050, South Africa ·Enquiries: Tel.: +27 (0) 11 717-6403 | Fax: +27 (0) 11 717-6494

Ms Uchechi Agnes Ahanonye
Phone: 0847586461
e-mail: 1180216@Students.wits.ac.za

Dear Sir/Ma,

Permission to Conduct Program of Research Study

I am seeking your permission to conduct a program of research study titled **"Teachers' Indigenous Knowledge and the possibilities of affording integration of Indigenous Knowledge in Life science Teaching and Learning."** This program of research study will involve four life science teachers from your school for the period of the research. It is an after school program.

The purposes of this program of research study are 1) To explore teachers' indigenous knowledge and the possibilities of integrating Indigenous Knowledge into multicultural classroom in South Africa, as mandated by the curriculum 2) To generate teachers' awareness of Indigenous Knowledge. This study will run for 6 months, from February 2019 to August 2019, involving two Grade 10 and Two Grade 11 life science teachers.

The reason I have chosen your school is because the school has a diverse teacher and student body from different socio-cultural backgrounds and are mostly black Africans. I am inviting your school to participate in this research which will contribute to the knowledge base for teaching science in Africa.

During this study participant's voice will be recorded on audio devices. Participants will be asked to take part in one-on-one conversations and/or small-group discussions/meetings outside the classroom activities, which will be audio-recorded. There are no potentially harmful risks to participants related to participating in this study.

There is no direct benefit from this program of study to participants. However, as a result of their participation, participants' own awareness about school, indigenous knowledge, science, teaching and learning may be increased. This program of research study will provide participants (student teacher(s), in-service teacher(s), researcher(s), your school, the University and the field of science education with valuable insights into the relevance of integrating indigenous knowledge with science teaching and learning in a multicultural classroom.

Research findings from this study will be presented at local, regional, national and international conferences, in journal articles and in books or book chapters, and at Wits School of Education seminars and professional development for pre-service and in-service teachers.

Participation is completely voluntary and participants may withdraw at any time without any prejudice or penalty against them. Withdrawal from participation or refusal to participate in this study will not in any way affect participants, performance or position in your school or at Wits School of Education. Participants may choose not to participate in this study. If a participant chooses not to participate, no references to him/her will be made in the reporting of this study.

School of Animal, Plant & Environmental Sciences

Private Bag 3, Wits 2050, South Africa ·Enquiries: Tel.: +27 (0) 11 717-6403 | Fax: +27 (0) 11 717-6494

Participants will receive no financial or any other compensation for participating in this study. All information collected in this study will be kept private and participants will not be identified by name. Confidentiality and anonymity will be maintained, as pseudonyms will be used in place of proper names of individuals and location of study. Researcher will keep the audio recordings and data transcriptions from this study in the supervisors' locked filling cabinet. Only the researcher and her supervisor will have access to these and they will be destroyed in three years immediately after this study.

If a participant wishes for further information regarding his/her rights as a research participant, he/she may contact: The University Human Research Ethics Committee (non-medical), telephone +27(0)117171408, email Shaun.Schoeman@wits.ac.za.
If a participant has any concerns or questions about the conduct of this program of research study (project) they should feel free to contact the researcher at location stated above.

By signing this letter, you agree to give permission for this program of research study to be conducted in your school. The purpose, procedures to be used, as well as, the potential risks and benefits of participation have been explained in detail. You or participants can refuse to participate and/or withdraw from this program of research study at any time without penalty. Refusal to participate in or withdrawal from this study will have no effect on participants in any way, whatsoever. You will be given a copy of this consent form after you have signed it for your record.

Name of Principal	Signature of Principal	Date
Ms Uchechi Agnes Ahanonye		
Name of Researcher	Signature of Researcher	Date

Appendix 7: Information Sheet

School of Animal, Plant & Environmental Sciences

Private Bag 3, Wits 2050, South Africa ·Enquiries: Tel.: +27 (0) 11 717-6403 | Fax: +27 (0) 11 717-6494

Dear Sir/Madam

Teacher's Participation Information Sheet

My name is Uchechi Agnes Ahanonye and I am a PhD student in the School of Animal, Plant and Environmental Sciences at Wits University in Johannesburg. As part of my studies I have to undertake a research project, and I am investigating Teachers' Indigenous Knowledge and the possibilities of affording integration of Indigenous Knowledge in Life science Teaching and Learning. The aim of this research is to explore teachers' indigenous knowledge and the possibilities of integrating Indigenous Knowledge into multicultural classroom in South Africa.

As part of this project I would like to invite you to participate with me in this study. By participating, you will be asked to complete a questionnaire after which you may be asked to participate in discussing the content/answers to the questionnaire in a one-on-one interview at a location of your choice; the interview may last up to one hour and there may or may not be a follow-up to the discussion. With your permission, I would audio-record the interview using a digital device so as to accurately capture our discussion for verbatim transcription. The collected data and hard copy of the transcribed data will be member-checked and stored in a locked cabinet in my Supervisor's office and only myself as the researcher and my supervisor will have access to the data for this research purposes only. Any digitized data will be stored in a password-protected computer. Data collected will be destroyed three years after completion of the study.

Confidentiality and anonymity of participants in reporting the results of this study will be maintained. For confidentiality only the researcher and her supervisor will have access to the data collected and stored in a locked or password-protected computer for the purpose of this study. Anonymity will be maintained by using culturally-relevant pseudonyms in place of actual and proper names of participants.

Participants will not receive any compensation for participating in this study, and there are no prejudices or penalties for not participating or withdrawing from this study at any time. However, as a result of your participation, your awareness about Indigenous Knowledge, school science, teaching and learning may be increased. Participants are free to withdraw their participation at any time or may choose to not answer any question if s/he does not want to without any penalty.

Data collected from this study may be used to publish journal articles in addition to my thesis. Data can also be presented at local, national regional and international

School of Animal, Plant & Environmental Sciences

Private Bag 3, Wits 2050, South Africa ·Enquiries: Tel.: +27 (0) 11 717-6403 | Fax: +27 (0) 11 717-6494

conferences, seminars and workshops for training science teachers and for professional development.

If you have any queries, concerns or complaints regarding the ethical procedures of this study, you are welcome to contact the University Human Research Ethics Committee (non-medical), telephone +27(0)117171408, email Shaun.Schoeman@wits.ac.za.

If you have any further questions afterwards about this research, feel free to contact my supervisors at 0117176075 or 0746430133 or by email: femi.otulaja@wits.ac.za.

Yours sincerely,

Uchechi Agnes Ahanonye
ucgold911@yahoo.com
0847586461

Supervisors:

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