EXPLORING INDIGINISING THE UNIVERSITY'S SCIENCE CURRICULUM THROUGH BOTTOM-UP DECOLONISATION:

AFFORDANCES AND HINDRANCES

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By

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DECLARATION

I Chrispen Mutanho (12M5588) declare that this thesis is my original work and has not been submitted in its entirety or in part for examination for a degree to any other university or education institution. Any information that has been obtained from other scholars has been acknowledge by citation and included in the references list.

Signature  Date: June 2021

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In Shona we say *'Kusatenda huroyi'* which literally means 'failure to thank and acknowledge those who helped you is witchcraft'. In the understanding of the Shona people 'only a witch can afford not to be grateful when something good has been done to him/her. It is with this understanding that I would like to thank all the people who contributed to the success of this study in one way or the other.

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DEDICATION

I dedicate this study to my late grandmother Mrs Masekiwa Janet Mutanho (nee Mukasa), whose indigenous knowledge and teachings inspired me to conduct this study. May her spirit continue to live in me and inspire many young souls, to retrieve our wisdom and use it for the benefit of our people to solve the challenges that confront us daily. To her, I would like to say '*Lala ngoxolo makhulu, ngoba indima yakho uyidlalile'* (Rest in peace grandma!' You have played your part!) The ball is now in our court.

ABSTRACT

The integration of indigenous knowledge (IK) in the science curriculum is a spreading phenomenon driven by the need to bring about *relevancy* and *equality* in science education. In South Africa, for instance, the need to integrate IK in science education is part of the global effort to build a democratic state from the debris of apartheid. Henceforth, the integration of IK is backed up by both the National Constitution of the Republic of South Africa (Act 108 of 1996) and the South African Department of Basic Education's (2011) National Curriculum Assessment Policy Statement.

However, the success of this policy seems to be hindered in part by the fact that the teachers who are the implementers of the curriculum changes seem to lack the relevant pedagogical content knowledge (PCK) to integrate IK in their science teaching repertoires. Such a trend is often blamed on their Eurocentric educational background. Interestingly, very little research has been done to explore ways of supporting teachers to develop the relevant conceptual tools and teaching strategies that will enable them to integrate IK in science teaching. It is against this background that an interventionist case study on how to support the Bachelor of Education Natural Sciences in-service teachers in particular to develop exemplar science lessons that integrate IK as easily accessible resources was conducted.

The study is underpinned by three complementary paradigms, namely, the interpretive, the critical, and indigenous research paradigms. While the interpretive paradigm enabled me to understand and interpret descriptive data, the critical paradigm enabled me to take an emancipatory stance and challenge the micro-aggressive elements embedded in conventional research practices; within the indigenous research paradigm, Ubuntu was the relational perspective that informed the researcher-participant relationships in this study. Vygotsky's sociocultural theory was used as an overarching theoretical framework, in conjunction with the cultural historical activity theory. Additionally, the topic-specific pedagogical content knowledge provided the methodological and analytical tools.

Data were gathered through questionnaires, individual face-to-face interviews, focus group interview, participatory observation, and the teachers' reflections. This study established that if teachers are given back the agency to collaboratively resolve the contradictions that confront them in their workplaces, they can generate their own ideas on how to integrate IK in science teaching. The teachers in this study experienced a shift in their agency from a paralysed state of resisting the integration of IK at the beginning of the intervention to an 'I can do it' attitude at the end of the intervention. Thus, it could be argued that this study's major contribution to new knowledge lies in demonstrating possible ways of supporting teachers to integrate IK as easily accessible resources in their science teaching. Additionally, the study also challenged the Eurocentric approach to ethics and offered Ubuntu as a relational perspective that can be used to complement the shortcomings of Eurocentric research paradigms. The study thus recommends that continuing professional development or professional learning communities should afford teachers the opportunity to collaboratively engage with the challenges that they face in their workplaces in order to resolve the contradictions that confront them.

Keywords: University; BEd Science; in-service teachers; science curriculum; scientific knowledge; indigenous knowledge; indigenisation; decolonisation; Ubuntu; transformative learning; socio-cultural theory; cultural historical activity theory

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LIST OF ABBREVIATIONS AND/OR ACRONYMS

BBC:	British Broad Casting Corporation
BEd:	Bachelor of Education
CAPS:	Curriculum Assessment Policy Statement
CHAT:	Cultural Historical Activity Theory
CoP:	Community of Practice
cPCK	Connected Pedagogical Content Knowledge
CPD:	Continuing Professional Development
DBE:	Department of Basic Education
DoE:	Department of Education
DNA:	Deoxynucleic Acid
ePCK:	Enacted Pedagogical Content Knowledge
IBL:	Inquiry Based Learning
IK:	Indigenous Knowledge
IKS:	Indigenous Knowledge Systems
MKO:	More Knowledgeable Other
PCK:	Pedagogical Content Knowledge
PLC:	Professional learning community
pPCK:	Personal Pedagogical Content Knowledge
SAARMSTE:	Southern African Association for Research in Mathematics, Science and Technology Education
TCPD:	Teachers' Continuing Professional Development
TSPCK:	Topic Specific Pedagogical Content Knowledge
WS:	Westernised Science
ZPD:	Zone of Proximal Development

CHAPTER ONE: SITUATING THE STUDY

> There are no simple answers to the decolonisation of the curriculum and therefore the process should be embarked upon thoughtfully but also be open to experimentation from which much could be learned. The decolonisation of the curriculum I suggest that it involves a process of change that does not necessarily involve destroying Western knowledge but in decentring it or perhaps deterritorialising it (making it something other than what it is). ... Decolonising the curriculum has to incorporate rethinking the term curriculum itself (or how it is conventionally understood). (Le Grange, 2016, p. 6)

1.1 Introduction

The call to decolonise the curriculum is a growing phenomenon, not only in Southern Africa but also in many parts of the world. Seehawer (2018) noted that although this debate started a long time ago in countries such as New Zealand, Australia and Canada, it has recently filtered into the Southern African region where it has led to the proliferation of studies on the integration of indigenous knowledge (IK) in science education. In South Africa, it comes at a time when the demand for social justice in education is at its peak. Recently, there was a wave of student protests coined #Rhodes Must Fall started at the University of Cape Town which ended up spreading to all other universities in the whole country. Central to the students' grievances was the call for transformation in higher education institutions which the students alleged to be exclusionary to the majority indigenous learners (Le Grange, 2016; Mbembe, 2016; Oeftering, Davis, Ngcoza & Nhase, 2020; Ogunniyi, 2018). These protests were epitomised by Ayanda Maxwere's action of emptying a bucket of faeces on Cecil John Rhodes' statue as a symbol of defiance against the imperial character of the post-apartheid South African education system. These protests reignited the debate among politicians and academics to decolonise the curriculum (Le Grange, du Preez & Blignaut, 2020).

However, while many agreed with the students' demands, very few went beyond the political rhetoric to provide concrete examples of how the decolonisation should be achieved. It is against this background that this study responded to this call by exploring the decolonisation of teacher education through the integration of (IK). The study specifically explored how to support Bachelor of Education Natural Sciences in-service teachers (BEd Natural Sciences in-service teachers) to develop exemplar science lessons that integrate IK. Although studies on the integration of IK in the science curricula have been conducted before (Hashondili, 2020; Jacobs, 2015; Mothwa, 2011; Shinana, Ngcoza & Mavhunga, 2021; Shizha, 2013), there seems to be a tendency to focus on primary and secondary school science.

The aforementioned studies and many others were necessitated by the observation that science is perceived as one of the most difficult subjects to the majority of indigenous learners (Aikenhead, 1996; Le Grange, 2007). This is largely because science in many African countries is taught in a decontextualised manner (Gwekwerere, 2016). Recounting their own experiences, scholars from different African countries describe their schooling as alienating because it largely contradicted what they were taught at home (Achebe, 1987; Ogunniyi, 2007a; Mukwambo, 2013; Simpson, 2014). In this regard, Simpson (2014, p. 6) reflected that:

> My experience of education, from kindergarten to graduate school, was one of coping with someone else's agenda, curriculum, and pedagogy, someone who was neither interested in my well-being as a kwezens, nor interested in my connection to my homeland, my language or history, nor my Nishnaabeg intelligence. No one ever asked me what I was interested in nor did they ask for my consent to participate in their system. My experience of education was of continually being measured against a set of principles that required surrender to an assimilative colonial agenda in order to fulfil those principles.

Although Africa attained independence from its colonisers, the education systems of many African countries, including South Africa are largely Eurocentric. While the above authors were describing their educational experiences in Nigeria and Zimbabwe, their experiences are a common phenomenon in many African countries including South Africa (Le Grange, 2008). For this reason, and extending on Engeström's (2010) seminal work, in this study I used the Cultural Historical Activity Theory (CHAT) lens so that I would not lose focus of the multi-layered nature of the science education activity system. In this way, I would pay attention to both the observable behaviour and the historicity of science education in the country.

Emphasising the importance of storytelling in research, Carter et al. (2014, p. 362) advised that "researchers need to begin with their own story as they seek to understand the stories of others". Hence, I start by briefly reflecting on my own encounter with the tension between Westernised science and IK. Thereafter, I give a brief background to this study, turn to the purpose of this study, the statement of the problem, significance of the study, and the research questions.

1.2 Does it Matter who We are in Research?

Who we are influences how we go about conducting research (Keane, Khupe & Muza, 2016). This means that a qualitative researcher cannot distance themselves from the research process because as humans, we are subjective beings whose views of the world are influenced by our past experiences. For this reason, Litchman (2010, p. 121) views the qualitative researcher as "the conduit through which all the information flows, for it is through his/her senses that the world is subjectively perceived, interpreted and given meaning". Hence, it is important for a qualitative researcher to declare their position in relation to what they are researching to enable the reader to understand the research through the eyes of the researcher. It is with this understanding that I start by briefly recounting my own experiences of how schooling alienated me from my African identity and indigenous knowledge (IK) as a small child. In doing so, I am declaring my positionality as that of an indigenous researcher with a lived experience of the tensions between IK and science. I also take the assumption that illuminating my background will enable the readers of this thesis to understand how my past experiences might have shaped my world views.

1.2.1 Caught in-between two fighting elephants

In Shona we say "*Panorwa nzou huswa ndiwo hunotsokodzerwa*", which means when elephants fight it is the grass that suffers the worst damage. This saying summarises the hardships that the ordinary citizens went through during the bloody civil war that led to Zimbabwe's independence in 1980. During the liberation struggle, I was a little boy living with my parents in a remote rural area in Zimbabwe. The freedom fighters used what they called 'guerrilla tactics' where they used the 'mass' (ordinary citizens) as human shields. Their motto was "you (the mass) are the sea, and we are the fish". They mingled and lived with us like ordinary citizens and fought the enemy from within. This made it very difficult for the then Rhodesian army to distinguish between the ordinary citizens and their enemies or 'terrorists' as they were called.

Faced with this crisis, Ian Douglas Smith (the then Prime Minister) declared a state of emergency which included a 6am to 6pm curfew (Mushonga, 2005). They closed schools, hospitals, clinics, and shops in many rural areas as an attempt to cut off food and medicine supplies to the freedom fighters. We, as ordinary citizens were caught up in-between what Mushonga (2005) later described as 'the man in the middle'. Although the purpose of the curfew was to help the security forces to deal with the terrorists, the Rhodesian army abused it and used it to indiscriminately kill innocent citizens with impunity. Additionally, most gravel roads in rural areas were closed off to public transport because the freedom fighters planted land mines to make it difficult for the Rhodesian army to travel to the rural areas to fight.

This made life in the rural areas very difficult because people had no access to food, medicines, and other basics from the nearest towns. Our village was not less than 40 kilometers away from the nearest town. This meant that if one were to travel to the nearest shops to buy food, they would have to walk 40 forty kilometers to and from the nearest town in about eight hours between sunrise and sunset and pray that they did not meet the soldiers along the way or get accused by the freedom fighters as a sellout. Put differently, civilians were caught between a hard place and a rock and that made life very difficult for no one dared travel in those conditions.

Faced with these challenges, our communities turned to their indigenous knowledge systems (IKS) and Ubuntu to help one another to deal with the challenges of the war situation. I remember that my grandmother, who was one of the oldest people in our community and was well known for her knowledge of traditional medicines to cure wounds, prevented the spread of diseases (Emeagwali & Shizha, 2016), preserved food (Hashondili, 2020; Shetunyenga, 2020), farmed, understood weather patterns, among others. I can recall very well this other plant which she would ask my mother to put in our drinking water to prevent diarrhea because drinking water was drawn from an unprotected spring (*chisipiti*) near the river. In our case, much of the traditional medicines and IK worked in solving real life problems that we were facing during such a crucial time. Emeagwali and Shizha (2016) confirmed that the traditional plants that were used by traditional healers have healing properties.

Surprisingly, when I entered school soon after the war, IK was not part of our curriculum as reiterated by Simpson (2014) in the above quote. Instead, the school system, especially teachers, tended to push a hidden curriculum that castigated IK. Shizha (2007) confirmed this by pointing out that teachers in Zimbabwe act like gatekeepers who perceive their duty as that of preserving Westernised science and preventing its contamination with indigenous knowledge. Some teachers would even reprimand learners with statements such as "*Sei uchiita sen'anga iwe?*" (Why do you behave like a witch doctor?)

For me, such words were a direct attack on my culture as I grew up with a grandmother who was a well-known herbalist. It embarrassed me because the word *witch doctor* (which was the colonial term for traditional healers) associated my grandmother with *witchcraft*, contrary to her role in society. I felt like I was the child referred to by Grill (2003, pp. 90-91) when he said:

> The Negro children who had the privilege of attending a mission school had the respective norms of civilisation drilled into their heads: individualism, work discipline, rationality and responsibility, bodily hygiene, linear perception of time, literacy. They learned that their parents' religion is mere idolatry, that the transmitted norms and values are primitive, that African culture prevents progress. Thus, vanished the remnants of any feeling of self-worth that may have been left over after the trauma of slavery. The senses, the thinking, the desires of Africans were colonised.

Although I did not have the privilege to learn at a mission school, the curriculum that we received by and large resembled the one described by Grill. The dilemma that this experience created in my life was that I had to live in two worlds in one day. At home I was an African child who was taught to respect Ubuntu and value IK, our elders, ancestors, and nature. At school, IK was treated as primitive, ancestral knowledge that had no scientific basis. In church, it was associated with evil and regarded as demonic. Bombarded with such contradictions, I had to cross what Aikenhead (1996) called the cultural bridge twice a day as I went to and from school. I had to apply Aikenhead and Jegede's (1999) collateral learning strategy to resolve the tension between the two knowledge systems. In other words, I had to divide the seemingly conflicting knowledge systems by holding them separately in my head to avoid confusion. In his Contiguity Argumentative Theory, Ogunniyi (2007a) referred to this as an equipollent cognitive state whereby colliding thought systems co-exist. Arguably, that made me resilient and enabled me to do well in science subjects regardless.

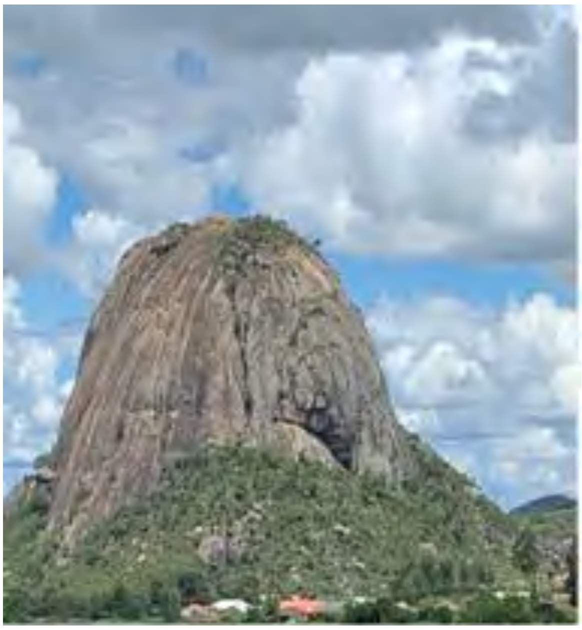
As I grew older, I attended church because the school made it compulsory for every learner to attend church services on Sundays. The pastors also portrayed IK as barbaric and associated it with witchcraft. They even preached that *"vanoita zvehun'anga nekushopera havapinde denga"* (Those who practice or believe in traditional medicines or believe in fortune telling will not enter heaven). This was very sad for me because it literally meant that I could not enter heaven because I lived with a herbalist. Yet, I had no choice but to touch and sometimes use the traditional medicines. In consequence, even though I did well in science at school, I never saw the link to connection between school science and our daily experiences (Gwekwerere, 2016).

If anything, I got the impression that IK was knowledge of the yesteryear that has no significance or relevance in our modern societies that are science driven. Resultantly, even though I grew up with a desire to be a medical doctor (most probably inspired by the good work my grandmother did), I never saw her knowledge of herbs as relevant to my 'dream career'. Somehow, the school stripped us of our identity and sense of being. The school system was the cognitive colonization through its official curriculum and hidden curriculum. Through the official curriculum, the school system taught us to despise IK by systematically campaigning against it or simply ignoring it. One can argue that IK was relegated to the null curriculum because it was not included as part of the curriculum.

Many argue that schools and the churches in post-colonial Africa, continued to play their traditional colonial role of propagating cognitive imperialism (Afonso-Nhalevilo, 2013; Le Grange, 2016; Nyamnjoh, 2016). For learners like me, this presented a huge dilemma as we had to live with two conflicting knowledge systems in our heads. Borrowing from Aikenhead and Jegede (1999), Ogunniyi (2007a) equates his experience of IK and science to crossing the home-school border twice in one day. Further, Aikenhead and Jegede (1999) posited that some learners find this border crossing between school science and everyday knowledge very difficult. Concurring, Le Grange (2007) drew our attention to the challenge of having to reconcile conflicting knowledge systems and argued that it could lead to what he called cognitive dissonance. The net effect of this was that we often dismissed IK at face value as something that was irrelevant and not worth knowing (Emeagwali, 2014).

Interestingly, our elders continued to teach us what they had learnt from their own parents through folk stories, riddles, direct apprenticeship, and many other lesson forms (Chilisa, 2012). Sadly, storytelling was ignored in our school curriculum yet, as Iseke (2013) pointed out, it is the most important traditional teaching method used to transmit intergenerational knowledge. This means that our education system missed the opportunity to connect with us through the teaching method that we were familiar with to enhance our understanding and capture our attention (Iseke, 2013; Kalu, 2018; Kibirige & Van Rooyen, 2006; Roschelle, 1995). In a recent study conducted in Nigeria, Kalu (2018) found out that although oral storytelling was the main teaching method used to pass on intergenerational knowledge among the Ibo people, the school system did not make use of it. While this study was conducted in Nigeria, its findings are applicable to many African countries, including South Africa. What this suggests is that even in the post-apartheid era, IK epistemologies continue to be marginalised.

Interesting storytelling is still being used in many African communities including the one I grew up in. Tzou, Meixi, Suárez, Bell, LaBonte, Starks and Bang (2019) view storytelling as ways of theorising, documenting, and preserving knowledge. A case in point is the story of two bully mountains in our area that are said to have fought a long time ago (see Figures 1.1 and 1.2 below). It is believed that many years ago, Zhombwe Mountain was one of the giant mountains in the eastern districts of the present-day Zimbabwe. It saw Hurungwe Mountain standing like a giant in its present site and became envious and jealous of her majestic prominence. In the spirit of conquest, Zhombwe Mountain traveled all the way from the eastern districts of Zimbabwe to stage a fight. A fierce battle ensued between the two rival mountains which destroyed everything in their way. At the end of the fight, Zhombwe (the aggressor) conceded defeat, receded and stood at its present-day position. Today the two mountains stand 15 kilometers apart facing each other, like two giant wrestlers poised to fight, separated by a deep valley and a river as if to mark their territorial boundaries. Unlike the folktales referred to by Iseke and Kalu above, this story is told like a true account of historical events.




Figures 1.1 & 1.2: Zhombwe Mountain (the bully) and Hurungwe Mountain (the bullied) www.geologicalsociety.org.zw.

A closer look at the two mountains shows very interesting features which might have triggered the fiction. For instance, the Zhombwe Mountain looks old and shattered with cracks and upright stones with some yellowish patches in some places as if rocks fell from its surface. It also has a lot of debris around it. On the other hand, the Hurungwe Mountain looks like the younger and stronger one of the two mountains with a more compact surface. However, on the side facing its alleged rival, it has something that looks like a wound as if something dug into it leaving a more cracked surface and loose stones than the rest of its surface. In this study, the 'wound' on Hurungwe mountain (see Figure 1.2) symbolises the damage caused by colonisation on the indigenous people and their knowledge systems, which then necessitates studies like this to retrieve such knowledge (Smith, 2012).

Notwithstanding, as we grew older and became more 'educated' in science, this story started to sound ridiculous. My most natural reaction was to dismiss it as impracticable and unscientific, for mountains are lifeless landforms. In contrast, however, if one takes a deeper look you would realise that it is quite possible that this story may have originated from a geological event (such as an earthquake, tremor, volcanic vibration and so forth). Possibly, the local people who may have witnessed it packaged this event into a story as an oral record of the geological event that might have taken place many centuries ago (Chilisa, 2012; Mbembe, 2021). Moreover, it is quite possible that this story might have originated from a geographical event like a tremor that could have happened in the area which the people in the area could not understand.

What this story tells us is that the indigenous people observed nature and tried to interpret it in their own way. It then makes sense to understand the commitment from one generation to another to pass on the story to the next generation (Kibirige & Van Rooyen, 2006). Of course, the original story line may have been distorted as it was orally passed down from one generation to another, but what is important is that if my hypothesis is plausible then credit should be given to our elders for their attempt to preserve such precious cultural knowledge that may potentially save lives. Indeed, elders are custodians of customary or cultural heritage.

What I find interesting is that to this day no Zimbabwean geographer that I know of has tried to explain why the mountains are like that, so they still stand as mysteries in the eyes of the indigenous people. This goes to show that the colonial education that we inherited continues to blind us and export our minds. It is no wonder that in our high school geography lessons we were taught about the meandering Mississippi river in America which most of us will never live to see, ignoring the meandering stream just behind our school yard. Such an education system exported our minds and made us less conscious of ourselves. It would be interesting to conduct a multidisciplinary research on this story above to find out what could have happened. Why would a community continuously tell such a *fictitious* story and hold it so dearly in their minds, possibly for centuries?

I believe that concealed in many indigenous stories and practices, lies great wisdom that needs to be tapped into, not only for the sake of Africans and science education but also for the rest of humanity as evidenced in Nuntsu's (2020) study conducted in South Africa. In science education, this story could be a good starting point in teaching about earthquakes, active and dormant volcanoes, and other related geographic phenomena. Instead, we were taught about volcanos in Europe and America which we had to imagine. One wonders if it was even necessary to learn about volcanoes in a region where volcanoes and earthquakes are not a common phenomenon.

The significance of this story to this study lies in that it illustrates the damage caused by colonization to the indigenous people and their knowledge systems, hence the need to heal as recommended by Ogunniyi (2018) and Smith (2012). However, Le Grange (2016) was quick to remind us that colonisation was not the mere act of seizing the indigenous people's territories because it also involved cognitive and spiritual conquest as can be seen in my story. This story also shows how my research interest may have been shaped by my lived experiences of the tensions between Westernised Science and IK. It is with this background, that I mobilised the cultural heritage of the indigenous community experts to explore the possibilities and challenges of an intervention on how to support BEd Natural Sciences in-service teachers to develop exemplar lessons that integrate IK.

As Keane et al. (2016) mentioned in Section 1.2 above, our ontological, epistemological and axiological assumptions are shaped by our past experiences. In my case, even though I conducted my study as a foreigner, I was not a complete outsider because I am able to understand and to speak isiXhosa. As a result, unlike Seehawer (2021) who required a cultural brocker in her study, I did not need an interpreter during the research process.

On reflection, when I first arrived in South Africa in 2008, I could not understand or utter a single word in isiXhosa. When I realised the need to learn isiXhosa, I decided to go and live in the villages among the Xhosa people to learn their language and show respect to their culture. At the village, young children wondered why I was the only Black person in the community who was speaking in English and asked me why I spoke in English – I jokingly told them that I was a Black whiteman.

They were so fascinated to see '*umlungu omnyama'* and they asked me to teach them English while they taught me isiXhosa – a mutual benefit. Within a short space of time, I was the most loved member of that community because I was helping their children with their schoolwork. Meanwhile, I learnt Xhosa very fast, which is the benefit of Ubuntu, central to which is reciprocity. Little did I realise that this background would help me in my PhD studies, as I ceased to be a stranger among the Xhosa people. This reinforces the claim made by Keane et al. (2016) that research is intricately tied to our life stories. Thus, it is important for me to start by looking at my positionality which possibly shaped my onotological, epistemological and axiological assumptions in this study.

1.2.2 My positionality and reflexivity

As alluded to in Section 1.2.1, a researcher cannot totally separate themselves from the study that they are involved in because, as Lichtman (2010) pointed out, the researcher is the one who makes crucial decisions and their perceptions of the world are influenced by their socio-economic, political, and religious backgrounds. As a result, it is important to pay attention to one's positionality in relation to the study. Skelton (2001, p. 89) described positionality as the factors that "impact on the way we do our research and how the people we work with perceive us". In support, Holmes (2020) averred that a researcher's positionality influences the way they see the world, the kind of research questions that they chose to investigate, as well as the research outcomes. Thus, the term 'positionality' can be viewed as one that refers to both the researcher's worldview and the position that they decide to take with regard to the research task at hand (Holmes, 2020).

Accordingly, Lumsden (2012) and Thomas (2013) noted that the qualitative researcher has an unescapable influence over their research. Keane et al. (2016, p. 5) also added that this is because the researcher "either consciously or unconsciously takes a position" that influences their research practices and interpretation of the research outcomes. For this reason, Lichtman (2010) described the qualitative researcher as the conduit through which information is processed. This makes it necessary for the qualitative researcher to declare their positionality.

Taking counsel from this, I positioned myself in this study as an indigenous researcher exploring how to support teachers to develop model lessons that integrate IK. As already mentioned above, I conducted this study with the assistance of my colleagues from our CoP. These were the science lecturer (who is a professor), two colleagues from our CoP (Cirha and MaNdlovu), and MaMngwevu. Our different educational backgrounds automatically created power dynamics that needed to be resolved. However, because none of us was an expert on how to integrate IK in science lessons, we engaged in this study as co-learners. Even though the BEd Natural Sciences in-service teachers, the science lecturer and I were science educators, we were all novices on the practice of making the traditional beverages. This positioned us as the learners.

On the other hand, although one of the community members was not as educated as we were, she and the other community member (who was a master's student) were the MKOs on the making of *umqombothi* and *oshikundu.* This then positioned them as the teachers. Our relationship was symbiotic in that, while we learnt how to prepare the beverages, the community members also had an opportunity to get the scientific explanations behind some of the practices as they prepared *umqombothi* and *oshikundu,* respectively. In this way, all of us could be said to have benefited from one another.

I engaged in this study as an interventionist who is an outsider to the Xhosa culture. Although I am also from the southern African region, I am a Zimbabwean from the Shona tribe whose culture is different from the Xhosa culture. For this reason, I had to seek the assistance of the science lecturer who is also a Xhosa to negotiate consent on my behalf and facilitate learning while I was a participant observer. I also had to seek the assistance of my colleagues from our CoP as explained above. These were MaNdlovu (the community expert who demonstrated how to make *oshikundu*) and Cirha (the interpreter when MaMngwevu demonstrated how to make *umqombothi*). The subjects of this study were the BEd Natural Sciences in-service teachers from various government schools in the Eastern Cape Province. Some of them were older and more experienced in teaching science than me and had a better understanding of science education in South Africa. Additionally, as a foreigner, I was also less knowledgeable about the making of *umqombothi* and *oshikundu*.

Moreover, since this study was informed by the indigenous research paradigm (see Section 4.2.3), the pronoun 'we' is deliberately used to challenge the arrogance embedded in the use of "I" or "the researcher" that characterises the conventional way of writing research reports. As Ndlovu-Gatsheni (2017) advised, we need to challenge the macro and micro aggressive elements embedded in Eurocentric research practices. Thus, I used "we" (whenever necessary) in this thesis, as the more inclusive terminology that acknowledges the immense contributions of all those who participated in my study. Both Smith (2012) and Ndlovu-Gatsheni (2017) reminded us that the language used in research carries the dirty history of research. For instance, it can be seen that both the terms "I" and "the researcher" tend to silence the other participants whose direct words and information were used and exalts the contribution of only one person, the researcher. Such an attitude is both arrogant and exploitative and can be traced to the extractive mentality where the colonisers would loot our resources, including information, to accumulate wealth for themselves at the expense of the indigenous people.

1.3 Contextual Background of this Study

This case study was conducted in South Africa, at a time when the call to decolonise the curriculum was growing louder than before, culminating in the 2015/16 #Rhodes Must Fall student protests which reignited the decolonisation debate among academics, politicians, and the general public alike (Le Grange, 2016; Mbembe, 2016; Nyamnjoh, 2016; Ogunniyi, 2018). At the core of these students' demands was the call to end the social and epistemological injustice perpetuated by South Africa's education system. This makes it imperative for society to rethink about education as recommended by Emeagwali and Shizha (2016) and Govender (2014) who recommended that education in Africa should be recrafted to meet the needs and aspirations of the indigenous people. In a similar vein, Mbembe (2021, p.3) notes that "the centrality of an endogenous knowledge" to the material and psychic emancipation of Africa.

The research was conducted at a former 'Whites-only' university in the Eastern Cape Province of South Africa. Like any other university in South Africa, this university is also faced with the challenge of transforming its curriculum which was modelled along the Oxford-Cambridge style. Commenting on the state of the post-apartheid education system in South Africa, Le Grange (2016) noted that the *epistemicide* and cognitive injustice of the colonial era still persists in education because all the 26 universities in South Africa maintained the Western curriculum which largely excluded indigenous people's knowledge. The university where this study was conducted was no exception. For instance, the university is English medium despite the fact that the majority of learners at the institution are second or third English language speakers. One could argue that the whiteness of the institution is also perpetuated by the fact that the teaching staff is still predominantly White; a trend which Le Grange (2016) said is still prevalent in many former White university.

This study was part of a bigger project conducted by five master's and two PhD students and their supervisors working in a community of practice (CoP) (Lave & Wenger, 1991; Wenger, 1998) to explore how to integrate IK in science lessons in different topics in different grades/levels of the South African science curriculum. While the other students worked on how to integrate IK in the secondary school curriculum, my study explored how to integrate IK in science education at tertiary level. As already mentioned above, while many agree that the tertiary education curriculum should be decolonised, very few offer concrete examples of how the decolonisation should take place, hence the need to explore how to decolonise education by integrating IK in the science curriculum (Le Grange, 2016; Mbembe, 2016; Ndlovu-Gatsheni, 2020).

Admittedly, our interest in the integration of IK is not new. Instead, it is part of an ongoing debate not only in southern Africa but also in many postcolonial states all over the world. Accordingly, Hodson (2009) and Webb (2013), viewed this interest in IK as a common trend that is largely influenced by what they described as politics of recognition. These scholars argued that the integration of IK in the science curriculum is part of the continuous struggle by the indigenous peoples to reclaim their identity (Cocks et al., 2012; Mapara, 2009; Smith, 2012). Cocks et al. (2012) emphasised the need for what they call *cultural revitalisation* and argued that it is through cultural regeneration that the indigenous people will regain the identity that they lost in the midst of the tragedy of colonialism and apartheid. Those who align themselves with this school of thought tend to view the integration of IK in the science curriculum as part of the global socio-economic and political transformation that characterises the post-colonial era in many countries (Cocks et al., 2012; Mapara, 2009; Ogunniyi, 2007a; Vhurumuku & Molekeche, 2009). These scholars viewed social transformation and the need to redress the inequities of the colonial era through the provision of equal educational opportunities as an inevitable challenge that faces many post-colonial states.

In South Africa, the need to provide equal educational opportunities is hindered in part by numerous challenges facing the education system (Jacobs, 2015; Le Grange, 2008; Ngcoza, 2007). These challenges include among other things, the need to undo the cognitive imperialism imposed on the indigenous peoples by the colonial education systems (Battiste, 2005); the need for science education that is relevant and sensitive to indigenous peoples' needs (Mhakure & Otulaja, 2017); poor performance in science (especially among indigenous learners); and the need to make science education accessible to all learners. Such changes call for radical transformation and the reconceptualisation of the science curriculum in terms of both its content and pedagogic practices (Gwekwerere, 2016). Inevitably, such transformation provokes tensions between science and IK and threatens the boundaries of science to include alternative ways of knowing. As Hodson (2009) pointed out, this will not be an easy task as "any challenge to the dominance of Western science in the curriculum carries extensive political baggage as it is also a challenge to the political structures that sustain it" (p. 245).

Notwithstanding, in South Africa the integration of IK in science education is a constitutional requirement supported by the Department of Basic Education (DBE) National Curriculum Assessment Policy Statement (CAPS) (DBE, 2011) which stipulates that teachers should incorporate IK to make science accessible to learners from different socio-cultural backgrounds (Mavuru & Ramnarain, 2017). Commenting on the importance of IK in education, Mawere (2015) argued that it enables learners to understand abstract scientific concepts. This implies that, where possible, science teachers should integrate IK in their teaching to help learners grasp the concepts and construct their own understanding of phenomena.

However, a plethora of literature revealed that many teachers in South Africa find it difficult to integrate IK in their science lessons (Bantwini, 2010; Cronje et al., 2015; Jacobs, 2015; Mothwa, 2011). Mothwa (2011) lamented that teachers seem to lack the pedagogical content knowledge to effectively integrate IK because of their Eurocentric educational backgrounds and inadequate training. Additionally, the CAPS (DBE, 2011) document does not clarify or give proper methodological guidance on how teachers should integrate IK. Instead, it is assumed that teachers will use their own discretion to select the appropriate IK of their choice and integrate it into their lessons as they see fit. As a result, teachers find themselves having to play the roles of curriculum designers, textbook writers, and curriculum implementers at the same time (Bantwini, 2010; Jacobs, 2015).

Loucks-Horsley et al. (2010) argued that the 'expert-novice philosophy' underlying the traditional workshop-based approach to professional development renders the professional development efforts ineffective, for it relegates teachers to passive recipients of information. It fails to recognise teachers as strategic agents of change. In support, Jacobs (2015) also found fault with the top-down cascade model of in-service training used in South Africa whenever curriculum changes and innovations are being introduced which she stated denies teachers the opportunity to test and experiment with the new ideas. As a result, although efforts are made to transform the curriculum, teachers revert back to their old pedagogical practices once they return to their classrooms which results in the tension between the intended and the implemented curriculum identified by Ngcoza (2007).

To Ngcoza and Southwood (2019), effective curriculum reforms require a complete paradigm shift in terms of teachers' knowledge, dispositions, skills, and beliefs. This implies that continuous professional development should not be a once off event or a series of disconnected independent workshops, or a 'one-size-fit-all' programme. Instead, it should be a supportive and empowering programme in which teachers collaboratively engage in reflective practice to explore ways of solving problems they encounter in their teaching. Teachers tend to learn better when they are given opportunities to collaboratively engage in resolving the challenges that they encounter in their workplaces.

Herein lies the importance of this study which sought to explore how to support BEd Natural Sciences in-service teachers on how to develop and enact exemplar lessons that integrate IK. The intervention used the making of *umqombothi*[1] and *oshikundu*[2] to demonstrate how teachers can integrate IK in teaching about fermentation as an enabler and (or) constraint to assist teachers in developing their own exemplar lessons that integrate IK in other topics.

1.4 Statement of the Problem

The integration of local or IK in science education is a requirement sanctioned by both the National Constitution of the Republic of South Africa (Act 108 of 1996), and the DBE's CAPS (DBE, 2011). The aim of this policy is to redress colonial educational imbalances by making

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[1] *Umqombothi* is a traditional beverage among the Xhosa and Zulu tribes in South Africa that is prepared from sorghum, millet, maize flour through the process of alcoholic fermentation.

[2] *Oshikundu* is a traditional beverage among the Oshiwambo people of Namibia. It is also prepared using millet, sorghum, maize flour through the process of alcoholic fermentation.

science accessible to learners from different socio-economic and cultural backgrounds (DBE, 2011). Extending on Vygotsky's (1978) seminal work, Mavuru and Ramnarain (2020) reiterated that science teachers should take into consideration their learners' socio-cultural contexts to make science accessible to learners from poor socio-economic backgrounds. This view is also shared by Le Grange (2007) and (Mukwambo et al., 2014) who postulated that science is one of the most failed subjects in many developing countries because it is taught in a de-contextualised manner. Thus, the integration of IK in science education is viewed as a way to bridge this gap between what Mukwambo et al. (2014) called "science-in-society" and "science-in-school".

However, in South Africa, as Ngcoza and Southwood (2015) pointed out, there is tension between the intended curriculum and the implemented curriculum because teachers, who are the most important agents of any curriculum change are not properly trained or supported to implement such a radical shift in science education. In other words, although the DBE's policy document (DBE, 2011) clearly stipulates that teachers should integrate IK in their science teaching, it does not specify or provide proper guidance on how the integration can be done. Moreover, there are many teachers in South Africa who received Bantu Education which denigrated and side lined IK (Mothwa, 2011). This problem is also compounded by the fact that the in-service training offered by the DBE during curriculum innovation is often insufficient, disjointed, and inconsistent with teachers' needs because it is imposed from above without proper needs assessment (Jacobs, 2015; Jensen, 1998). Herein lies the significance of my study which explored how to support BEd Natural Sciences in-service teachers to develop exemplar lessons that integrate IK using easily accessible resources (Asheela, Ngcoza, & Sewry, 2021) in the form of indigenous practices such as *umqombothi* and *oshikundu*.

1.5 Purpose and Significance of the Study

This study sought to contribute to social justice by exploring how to decolonise the tertiary science curriculum through the integration of IK. This places it in the broader national dialogue on how to redress the socio-political and educational inequalities of the colonial era. As pointed out by Vhurumuku and Molekeche (2009), the integration of IK in science education in South Africa is influenced by both the need to redress the legacy of apartheid and the need to make science education accessible to all learners. For this reason, the outcomes of this study may be potentially important to the university's efforts to transform the teacher education curriculum to make it relevant to the needs of the post-colonial South Africa. The outcomes of this study may be used to improve the BEd Natural Sciences Curriculum. It might also be of value to other institutions grappling with curriculum transformation.

The study is also of significance to the participants as it created opportunities for them to enhance their pedagogical content knowledge (PCK) on how to integrate IK in science lessons (Ogunniyi, 2018; Shulman, 1986). This comes against a background of a plethora of literature that claim that teachers struggle to integrate IK in science lessons (Aikenhead & Jegede, 1999; Jacobs, 2015; Le Grange, 2007; Mothwa, 2011; Shizha, 2007). While these studies rightly identify the inadequacies in the teachers' PCK, very little attention is paid to the role of tertiary institutions that did not equip teachers with enough skills to integrate IK in science lessons. Hence, this study focused on supporting the BEd Natural Sciences in-service teachers to develop exemplar lessons that integrate IK. These developed exemplar lessons may become useful to science teachers who may use the skills acquired during this intervention to develop their own lessons on other science topics. The study also has implications for me as a science teacher as it helped me to improve how I integrate IK in my teaching.

1.6 Research Goal and Research Questions

The main goal of this study was to explore how to support the BEd Natural Sciences in-service teachers to integrate indigenous knowledge and use easily accessible resources in their teaching. This goal was achieved by answering the following research questions:

1) What are the BEd Natural Sciences in-service teachers' attitudes, experiences, and pedagogical insights on the integration of indigenous knowledge in science teaching?
2) What contradictions are embedded in the BEd Natural Sciences in-service teachers' attitudes, experiences, and pedagogical insights on the integration of indigenous knowledge in science teaching?
3) What learning opportunities are created (or not) for the BEd Natural Sciences in-service teachers:
    (a) When co-analysing and discussing the curriculum documents?

(b) During the practical demonstrations by the expert by the [3]expert community members?

4) How can the BEd Natural Sciences in-service teachers be supported in co-designing:
   (a) Science lessons that integrate indigenous knowledge using fermentation as an example?
   (b) Their own exemplar lessons that integrate indigenous knowledge in other science topics?
5) How do the BEd Natural Sciences in-service teachers enact and envision the integration of indigenous knowledge in science teaching?

1.7 Theoretical and Analytical Frameworks

This study is underpinned by Vygotsky's (1978) sociocultural theory in conjunction with Engeström's cultural historical activity theory (CHAT). While the sociocultural theory provided the broad theoretical framework informing this study, CHAT provided the methodological and analytical tools.

1.7.1 Vygotsky's sociocultural theory

Vygotsky's sociocultural theory was founded by Lev Semionovich Vygotsky (1896-1934), who is regarded as one of the earliest modern psychologists to account for the role of culture in human cognition. Vygotsky based his theory on the notion that a learner constructs their own understanding of phenomena through active participation in interaction with their environment (Sedlacek & Sedova, 2017; Verenikina, 2003). In other words, learning is a social process in which a learner acquires knowledge through interacting with their peers and the more knowledgeable other (MKO), who is usually the teacher. In contrast, in the context of my study expert community members are regarded as more knowledgeable others. Thus, Vygotsky recognised both the social and personal origins of learning (McRobbie & Tobin, 1997). He argued that learning takes place within the continuum between what the child already knows and that which they can potentially know if they are assisted by the MKO. Vygotsky described this continuum as the zone of proximal development (ZPD). In support, Wood, Bruner, and

[3] In this study, community members are referred to as experts because they are the custodians of the cultural heritage of making traditional beverages *umqombothi* and *oshikundu.*

Ross (1976) used the metaphor of *scaffolding* to describe the role of the teacher in helping learners to develop new insights on what they are learning.

However, critiques of the sociocultural theory argue that the theory is often misunderstood or misapplied in many educational studies that claim to use it as a theoretical framework. For instance, Palincsar (1998) noted that the ZPD is one of Vygotsky's most misunderstood concepts in educational research. Stott (2016) attributed this misunderstanding to the misinterpretation of Vygotsky's work as it was translated from Russian to English. She pointed out that the use of the ZPD concept outside Vygotsky's intended context often leads to the conflation of the terms learning and development. For instance, while Vygotsky used the ZPD to explain children development, this concept is often used in studies where the focus is on learning (Stott, 2016).

The sociocultural theory also tends to view learning as acquisition of knowledge by the novice learner from the expert teacher (Chaiklin, 2003; Vygotsky, 1978). In this study, the learning outcomes were not known or predetermined by the research or the participants because it was a generative study that explored how to support teachers to teach science by integrating IK and using easily accessible resources. This implies that the envisaged learning in this study was expansive in nature. None of us was an expert on the integration of IK in science lessons so no one could monopolise the position of the MKO. As a result, this position was interchangeable among the teachers, the science lecturer, and the expert community experts who took turns to share their knowledge and expertise as the need arose. On the other hand, while Vygotsky's theory was designed in trying to understand how children learn, the participants in this study were adult, experienced science teachers who could hardly fit into the novice-expert principle underpinning the sociocultural theory. Additionally, the study also involved reconceptualising the science teaching activity through exploring new ways of teaching science. It is these limitations of sociocultural theory to this study that necessitated the use of Engeström's CHAT.

1.7.2 The cultural historical activity theory

Cultural-historical activity theory (CHAT) is a practice-based theory that provides the researcher with conceptual, methodological, and analytical tools (Mukute & Lotz-Sisitka, 2012). This theory was developed from Levy Vygotsky's work by his students and followers and was popularised by Engeström (Nussbaumer, 2012). CHAT is based on the assumption that human behaviour is complicated, multi-layered, multi-voiced, and collective. It is influenced by both contextual and historical factors. As such, it uses the collective lens and views the activity system as the unit of analysis (Engestrom, 1987). In this way CHAT is able to account for the interpersonal interactions between individuals and the community at large.

In this study, CHAT was chosen because it would enable me to dig deep to find the underlying factors influencing the behaviour of my participants. For instance, it enabled me to see how the teachers' responses to questionnaires were influenced by the historicity of science education in South Africa. It broadened my understanding of learning and enabled me to view the learning process as a multi-layered process that is influenced by many factors. In CHAT terms, learning is an expansive process that goes beyond the mere acquisition of new knowledge (Engestrom & Sannino, 2010; Mukute & Lotz-Sisitka, 2012; Sannino, 2015). Expansive learning involves the generation of new ideas which were not known to both the teacher/interventionist and the learners prior to the learning process. It involves some qualitative transformation that takes place in both the individual participants and the collective learning community. For this reason, a CHAT lens enables the researcher to account for both the shift in the participants' ZPD and the qualitative changes that occur during and beyond the intervention. Unlike Vygotsky, whose ZPD concept is limited to the acquisition of new knowledge (that is known to the interventionist prior to the intervention), CHAT scholars view learning as an expansive learning process where learners continuously generate new ideas as they try to resolve the contradictions embedded in their work. As such, contradictions are viewed as the drivers or precursors to learning. From CHAT, I drew the key concepts briefly discussed below.

1.8 Key Concepts Used in the Thesis

In this section, I define the key concepts used in this thesis.

1.8.1 Indigenous knowledge

Indigenous knowledge (IK), also called traditional knowledge, local knowledge, indigenous knowledge systems or traditional ecological knowledge, refers to the indigenous peoples' knowledges that they gathered over generations and is used for their survival (Stevenson, Brody, Dillon, & Wals, 2013). In this study, the term indigenous knowledge (IK) will be consistently used. In the context of this study, IK refers not only to knowledge of the past but also the contemporary IK that people use in their everyday lives. My view of IK in this study is informed by the understanding that IK, like any other knowledge system is dynamic. It is not static because it evolves with time.

1.8.2 Contradictions

According to Engeström (2001), contradictions are historically accumulating structural tensions within and between activity systems which usually arise when new elements, new tools or new ways of doing things are added to an already existing activity system (Haapasaari et al., 2016).

1.8.3 Transformative agency

According to Haapasaari et al. (2016), transformative agency refers to breaking away from the given frame of action and taking the initiative to transform it. This implies that transformative agency arises out of the need to change or transform the existing activity. This view resonates with the purpose of this study, which was intended to explore how to support BEd Natural Sciences in-service teachers to integrate IK. In line with this view, Haapasaari et al. (2016, p. 235) accentuate that "transformative agency develops the participants' joint activity by explicating and envisioning new possibilities". In other words, when workmates collectively engage in finding solutions to the challenges that confront them in their workplaces, they combine their transformative agency thereby increasing the possibilities of finding innovative and novel solutions.

1.8.4 Resistance

Resistance refers to opposition to the intervention which manifests itself as negative expressions and actions such as criticism, questioning, rejection, and opposition (Haapasaari et al., 2016). On the other hand, the term resistance connotes something disruptive and negative. In CHAT it is viewed as an agentive action. This is because, as Engeström (2011) pointed out, resistance opens up opportunities to learn new things as people try to resolve the tension that it causes. In this study, such agentive manifestations could be seen in the participants' responses to the interviews and questionnaires during the explorative phase. Such resistance was taken as manifestations of contradictions that trace their origins to the way science was used to suppress IK in the past.

1.8.5 Explicating

This process involves looking at the activity for potential unacknowledged success stories or practices as sources of new possibilities (Haapasaari et al., 2016). In this study, the teachers started by co-analysing the curriculum documents to explicate aspects of the curriculum that could be integrated with IK. The process of explicating involves co-analysing the current and past practices with the intension of identifying those aspects of the activity that can be improved. Taking a cue from this, the process of explicating involves analysing the *past* and *present* activity to identify aspects that can be improved.

1.8.6 Envisioning

According Haapasaari et al. (2016), envisioning ranges from making preliminary suggestions to presenting models of the activity for the future. The concept of envisioning the future activity in this study was first illuminated when the teachers gave their professional insights during the explorative phase. In other words, envisioning is about conceptualising what the new activity would be like. This concept also emerged in the teachers' reflections and when they presented how they would integrate IK in their lesson planning and teaching. In hindsight, these insights represented what they envisioned as the future of the science education activity with regards to the integration of IK.

1.8.7 Committing to concrete actions to change the activity

According to Sannino (2008), commitment to concrete actions is seen through the use of commissive language. That is, the participants of an intervention start using such statements as "I am going to" or "I will". These statements reflect the participants' commitment to do something in the future. This concept simultaneously surfaced with taking consequential action when the explained they would integrate IK.

1.8.8 Taking consequential actions to change the activity

Taking consequential actions to change the activity refers to putting into practice the new ideas. It involves modelling the desired behaviour or undertaking the new activity. Although taking consequential actions is usually expected to manifest at the end of the change laboratory session (Sannino et al., 2016), my study was designed in such a way that the BEd Natural Sciences in-service teachers would have time to experiment with the new ideas they learnt in each session in their classroom so that would have an opportunity to reflect and correct their mistakes.

1.8.9 Expansive learning

Expansive learning is viewed by many as a learning that expands the object by creating new solutions to problems in response to contradictions embedded in the activity (Engeström, 2001; Haapasaari et al., 2016; Sannino et al., 2016). Its expansive nature implies that it is learning that goes beyond the acquisition of predetermined factual knowledge to exploring new possibilities. Through expansive learning participants reorganise their work and reconceptualise the object of the activity. Accordingly, Sannino et al. (2016, p. 603) describe expansive learning as a creative, "multidimensional movement of learners' ZPD through constructing and implementing a new, wider and more complex object of the activity"

In this study, expansive learning refers to the qualitative transformation that occurred with participants both as individuals and as a collective in their understanding of how to integrate IK in science lessons (Engeström, 2015). Qualitative transformation in this study includes the change in attitudes, perception, and understanding of how to integrate IK. While learning is often understood as the acquisition of factual knowledge, in this study learning is understood as embracing not only these two aspects but also the change in attitudes, skills, and values. It connotes an expanded understanding of how to teach science and how to integrate IK in science lessons.

1.9 Thesis Outline

In this section, I will briefly outline the structure of this thesis. The thesis consists of ten chapters which are outlined below.

Chapter One is an introductory chapter aimed at situating this study. It started with a brief introduction after which I presented my own experience of the tension between IK and Western Science as a child. Thereafter, a contextual background is then presented, highlighting the theoretical gaps that necessitated this study. The chapter then focused on the statement of the problem, the purpose of the study, significance of the study as well as the research questions before turning to the theoretical lenses that guided this study. The chapter ends with a brief presentation of the key concepts to this study, a thesis outline, and a conclusion.

Chapter Two is a literature review in which I focus on the debates around the integration of IK. These debates centre on the benefits and challenges faced by teachers in their attempts to integrate IK, and the different approaches used by teachers as they try to integrate IK. What emerged as a gap in the literature reviewed is that most of the studies I came across focused on the integration of IK in junior and high school levels and very few looked at how IK can be integrated in tertiary science education (Stears, Malcolm, & Kowlas, 2003; Mateus & Ngcoza, 2019). It also emerged that although many advocates of the integration of IK acknowledge that

IK is local knowledge that belongs to communities, none of the studies I came across treated the community members as experts in IK from whom researchers could learn. It is these gaps that this study sought to fill. The main concept in this study is IK which in this study refers to the local knowledge that has been accumulated and passed on from one generation to another over many years and is used as the basis for making decisions and for survival. The chapter also briefly looks at language and the participation of women in science education because these two emerged as crucial aspects embedded in this study.

In **Chapter Three**, I present the theoretical lenses that informed this study. These lenses were the sociocultural theory and Engeström's CHAT. These two were used as complementary theories after it was found that Vygotsky's sociocultural theory alone could not account for the expansive learning that took place in this study. The sociocultural theory was used in a slightly different manner from the way Vygotsky used it, because unlike in Vygotsky's case, the participants in this study were not children. As a result, the novice-expert assumption underpinning the role of the MKO was not applicable in this study because all the participants were experts in some respects and novices in other areas. This is further elaborated in chapter three below.

Chapter Four is the research methodology chapter. The chapter takes a step-by-step explanation of the research process. Because the focus of this study is to explore how to support teachers to integrate IK in their teaching, its unique contribution to new knowledge is the invitation of community experts into the university space, to share their expertise on how to make *umqombothi* and *oshikundu* with university students (who are science teachers) and science lecturers. What makes this new knowledge is that although many studies have been conducted on how to integrate IK in science education, not much research has been done how to on how to tap into community experts' IK. Expert community members are often left out of the IK-Science debate yet they ate the custodians of IK.

Chapter Five presents the ethical dilemmas encountered in the course of conducting this study which left us wondering and asking ourselves "With whose lenses are we viewing ethics?" Initially, we wanted to conduct class visits to observe how teachers would integrate IK in their science lessons. This did not happen because the ethical clearance procedure for working with minors is a cumbersome process that would have delayed the data gathering process. Our target population were a cohort of BEd Natural Sciences in-service teachers who were in the third year of their studies and were left with only one year to complete. Any delays to start the research process would have made it very difficult to conduct this study. Moreover, this study was funded by the National Research Fund, which meant that we had to complete it within the shortest possible time so that we would not run short of funds. The university required consent letters from schools, teachers, parents, and the department of basic education whom it described as gatekeepers. Upon getting to the schools the so-called gatekeepers showed us Ubuntu and contrary to the Eurocentric view of ethics, the gatekeepers in this study were gate openers. This showed us that there is cultural tension between the European and African view of ethics.

We then tested the statement “You can withdraw at any given time if you want” which is one of the statements we are required to include when we negotiate consent, to see how it would be received in the Ubuntu-based African cultures. It emerged that all the participants from different African tribes within southern and west Africa unanimously agreed that it was rude and unacceptable to say to someone who has agreed to participate in your study “You can withdraw from this study at any given moment if you want”. This dilemma made us realise that there is need to be sensitive to people’s culture and be informed about the local interpretation of ethics. For this reason, we chose to use the Ubuntu paradigm as the lens through which we could view this study.

Chapter Six presents the data gathered during the explorative phase of this study. It explores the teachers’ experiences, attitudes, and professional insights with regard to the integration of IK in the science curriculum to unearth the contradictions embedded in science education in South Africa. These contradictions were taken as indicators of the teachers’ learning needs and were considered as the basis of the teachers’ transformative agency in this study. Data were gathered through a questionnaire, focus group interview, and face to face interviews conducted with a few volunteers. The three research instruments were used for triangulation purposes. As such, the questions asked were the same in all three instruments.

Chapter Seven looked at the orientation workshop which served to prepare the teachers for the expansive phase. Data were gathered with the intention of answering question two of this study. The main focus in this chapter was to understand the learning opportunities created when teachers co-analysed the curriculum and explore how to integrate IK using easily accessible resources. This was done through three workshops which co-analysed the curriculum, and explored how to integrate IK in a multicultural classroom using easily accessible resources.

What stands out as new knowledge in this chapter is the co-analysis of the CAPS curriculum using Mavhunga and Rollnick's (2013) topic specific pedagogical content knowledge (TSPCK) components as a translation device. Whereas Mavhunga and Rollnick's (2013) components are used in many studies as a post-teaching rubric to assess teachers' PCK, in this study they were used as a pre-teaching tool to unpack the CAPS curriculum and the Natural Sciences textbooks that the teachers were using in their schools. What this study did differently was to use the TSPCK components as a pre-teaching analysis tool to help teachers build an understanding of the CAPS curriculum by looking at it from different angles. This study revealed that this tool can be used not only to assess teachers' PCK but also to build it. It also emerged that the teachers gained new insights on how to elicit learners' IK in a multicultural classroom.

Chapter Eight presents data gathered during the second stage of the expansive phase which comprised of the demonstration lessons and workshops to draw the links between IK and science. The main focus of this chapter was to answer question 2a of this study which explored the learning opportunities created by this intervention during the practical demonstration lessons by the community members. Data were gathered through observations and reflections from the teachers. What emerged as new knowledge in this chapter is that teachers were able to draw links between IK and science. They generated mind and concept maps and explained the science behind different traditional practices and procedures done during the making of *umqombothi* and *oshikundu*. They also identified in the Grade 8 and 9 Natural Sciences curriculum, the concepts that can be taught from the making of the two beverages. Teachers also conducted experiments with *oshikundu* as an easily available resource.

Chapter Nine's main goal is to understand how the teachers enacted the integration of IK in their teaching. This chapter enabled me to assess the impact of the intervention on the teachers' understanding. It can be considered as an evaluative chapter that is meant to see if there was any transformation in the teachers' understanding of how to integrate IK in science lessons. Ideally, data would have been gathered through class visits and lesson observations, but because of the ethical clearance that is not easy to get (as explained in Chapter Five), we had to opt for lesson presentations. The chapter is divided into three sections namely "How I plan", "How I teach", and "How I envision the integration of IK in my science lessons". The data gathered presented in the first section focuses on how the teachers integrated IK in their co-developed lesson plans. This enabled me to see if the teachers gained conceptual skills and strategies to integrate IK in their teaching.

Chapter Ten is a synthesis chapter and is a reflective space where the researcher looks back at the research process, the challenges encountered, the key findings, and the new knowledge generated in this study. This chapter starts with a brief review of the research context, the research process, and the theoretical lenses used in this study before turning to the key findings and the new knowledge that this study generated. Thereafter, recommendations and a brief conclusion are made.

1.10 Chapter Summary

This chapter introduced this study. It situated it into its historical, political, and theoretical contexts. The chapter began with a brief reflection of my own experiences of the tension between IK and science. It then moved on to give a brief background to the study aimed at problematising the integration of IK. It was argued that while the DBE's policy on IK clearly states that teachers should integrate IK in their science lessons, the policy document does not clarify as to how this IK can be integrated. On the other hand, while many studies have been conducted on how to integrate IK in school science lessons, there is a dearth of literature on how to integrate IK in the tertiary science curriculum. This study sought to fill this gap by exploring how to support BEd Natural Sciences in-service teachers to teach science using easily accessible resources and IK. The study drew insights from the sociocultural and CHAT theories. Lastly the chapter presents the key concepts and the course outline.

CHAPTER TWO: LITERATURE SYNTHESIS

> African Indigenous Knowledge Systems constitute a conglomerate of various disciplines and intersecting epistemologies and value systems, by societies that have developed paradigms and ways of existence in ancestral lands. The accumulated knowledges have emerged out of trial and error experimentation as well as tested empirical practices and paradigms related to ecological, geographical, economic, social and other traditions of existence. Indigenous Knowledges have substantial implications for the curriculum. (Emeagwali, 2020, p. 37)

2.1 Introduction

Hart (2018) reminded us of the need to systematically search and review the accredited sources of information on a particular topic to find out what is already known and what still needs to be known about the topic or problem. In the context of this study, the search process involved synthesising literature on the IK and Westernised Science (WS) debate, the role of language in science education, the role of 'hands-on practical activities' and the gender and science debates. In addition, it turns to continuing professional development where it discusses the advantages and shortcomings of the cascade model that is used in South Africa. The literature synthesis starts with a brief exploration of the debates surrounding the integration of IK in science education before examining the cascade model of continuous professional development that is used in South Africa. The discussion starts with establishing a working definition of IK before turning to the debate on the role of IK in science education where the benefits and challenges and the arguments of both the proponents and opponents of the integration of IK are reviewed.

2.2 Understanding Indigenous Knowledge

Some scholars argue that the term 'indigenous knowledge' (IK) is not easy to define as there is no universally accepted definition for it (Khupe, 2014; Ogunniyi, 2007a). For instance, Khupe (2014) traced the complexity of defining IK to the illusive nature of the terms indigenous and knowledge. She argues that the complexity of defining IK "partly stems from the lack of consensus on who or what qualifies as *indigenous* and also partly from what constitutes *knowledge*" (p. 43). The point that Khupe is making is that without clearly defining these two constructs, it is not easy to come up with a comprehensive definition of IK.

Moreover, different scholars tend to call it by different names such as local knowledge, traditional knowledge, indigenous knowledge, traditional ecological knowledge among others (Aikenhead & Jegede, 1996; Ogunniyi, 2007a). In this study, however, I will consistently call it indigenous knowledge (IK). Taking counsel from this I start by briefly exploring the meanings of the two constructs, indigenous and knowledge.

2.2.1 What is indigenous knowledge?

According to Ogunniyi and Ogawa (2008), something can be referred to as 'indigenous' if it is original or native to a particular place or area. The underlying assumption in this definition is that something is 'indigenous' if it is in its place of origin and has not been moved from one place to another. Scholars who view IK from this perspective tend to classify it as local knowledge that is a cultural heritage of a group of people living in a particular community (Aikenhead, & Jegede, 1999; Van Rooyen, 2006). Closely related to this view is seeing IK as primitive knowledge that has been passed from one generation to the other, a stance which Khupe (2014) views as limiting. To Khupe, calling something *primitive* "conjures up the ideas of 'wild', 'naïve', 'unscientific', 'old' and never changed which is reflective of the power dynamics of the colonial era which led to the denigration of IK prior to independence", whereby non-Western science was regarded as unscientific and not worth knowing, yet it had served the indigenous people for many years.

This view is contested by some scholars who feel that it tends to fossilise IK in an ancient form and treat it as static knowledge that never changes. Concurring, Onwu and Mosimege (2013, p. 2) also averred that knowledge is not static but instead it evolves over time and changes as it adapts to the changing cultural contexts and environments. When these definitions are applied to knowledge which is easily shared, spread, and moved from one place to another as people interact with each other, they are problematic. Van Wyk (2006) argued that it is not easy to trace the exact origins of any piece of knowledge given that humans have always been migrating and interacting with each other. In other words, some of the knowledge that may seem indigenous to a particular community today may be foreign knowledge that has been infused into the knowledge systems of the new area where it has been transported to as people migrate. As time goes on it might become very difficult to distinguish between the original IK of that area from foreign knowledge as it and has become ingrained in the social fabric of the indigenous people over time (Khupe, 2014; Le Grange, 2016).

For instance, in South Africa, the knowledge that the Bantu tribes regard as their IK might be knowledge that they came with as they migrated southwards from the north. History has it that the Khoi and the San people are believed to be the first inhabitants of Southern African as confirmed by Wessels (2012). This suggests that if we go by the above definitions of indigeneity, then much of what the Bantu tribes in South Africa claim to be their IK does not qualify to be regarded as IK since it may be knowledge that they brought as they migrated southwards from North Africa. This begs the question, "Whose knowledge deserves to be called IK in South Africa then?"

Seemingly, this tends to gloss over the finer details of the term indigenous by simply regarding any non-Western knowledge that existed in the country prior to colonisation as IK (Hewson & Ogunniyi, 2011). Similarly, the department of education (DoE, 2003) tends to equate IK with 'African' knowledge that existed in South Africa and has evolved for thousands of years. However, while this definition acknowledges the dynamic nature of IK, its categorisation of IK as African is problematic especially in a multicultural country, for instance, a rainbow nation like South Africa as emphasised by the first and former democratically elected President of South Africa, Dr Nelson Mandela, popularly known as [4]Madiba. Khupe (2014) saw such a view as restrictive and an antithesis to the principle of inclusivity underpinned by the national constitution. Earlier, Moyo (2013) also advocated for an inclusive perspective of IK. Such a perspective would be reflective of all the different IK systems of the people in South Africa. Taking counsel from Moyo, this study also adopted an inclusive view of IK. Indigenous knowledge in this study refers to the knowledges that are cultural heritages of the different people living in South Africa. Similar to Ogunniyi (2018), I therefore positioned myself as an indigenous researcher and an integrationist. In my view, I believe such a stance frees us from the limitations imposed by the above definitions and gives us room to cater for the cultural

[4] Madiba is Dr Nelson Mandela's clan name. In the African context, clan names are used to level power gradients amongst people and to show respect for their culture. For instance, unlike from a European perspective, calling old people by their names is regarded as disrespectful and instead clan names are used.

diversity found in South African classrooms. Having said this, I turn to the contestations around the concept of knowledge.

The above arguments illustrate that it is not easy to arrive at an incontestable definition of indigenous knowledge which will enable us to pin down the meaning of IK. This problem is compounded in part by the fact that the term knowledge is also in itself an equally controversial concept. For instance, there are many debates over what constitutes knowledge and who validates and qualifies it as knowledge. Whose knowledge is included/excluded? This drew Khupe (2014) to conclude that knowledge is an elusive concept whose meaning is often contested by many scholars. Moreover, knowledge is often described as factual knowledge (know-what), procedural knowledge (know-how) and explanatory knowledge (know-why) (Taylor & Cameron, 2016).

As already mentioned above, this lack of consensus on the definition of knowledge makes it a futile exercise to try and find a universally acceptable definition. Instead, it may be helpful to have a working definition through which the meaning of IK can be understood. In the following section, I explore the meaning of IK after which I come up with a working definition of IK that is applicable to this study.

According to Kibirige and Van Rooyen (2006), IK refers to a legacy of traditional wisdom passed on from one generation to another in a particular society. Odora-Hoppers (2002, p. 8) added that it is "the wealth of knowledge in a particular group", which distinguishes it from other groups and is not easily accessible to other groups with different cultural backgrounds. A look at these definitions shows that IK is knowledge that is accumulated over a long period of time by a group of people who have lived together and interacted with their environment and have passed this knowledge on for survival from one generation to another. Accordingly, Emeagwali (2020, p. 37) contends that "African Indigenous Knowledge Systems constitute a conglomerate of various disciplines and intersecting epistemologies and value systems, by societies that have developed paradigms and ways of existence in ancestral lands". Her point is that IK encompasses a wide spectrum of knowledge systems that people use to survive. Odora-Hoppers (2002) also adds that IK is embedded in the cultural practices, history, and ways of living of indigenous people. Such knowledge often forms the backbone of socio-economic and scientific world views. Concurring, Shava and O'Donoghue (2014) summed up this debate by arguing that any definition of IK should contain people, place/context, language, knowledge, culture, practices, and dynamism as these are the key features that are central to IK.

The working definition adopted in this study is that of Onwu and Mosimege's (2013, p. 2) which stated that IK is:

> Local, community-based systems of knowledge which are unique to a given culture or society and have developed as that culture has evolved over many generations of inhabiting particular ecosystems. It is the collective knowledge of an Indigenous people about the relationships between people, habitats, and nature. It encompasses knowledge commonly known within a community or a people as well as knowledge which may be known to a Shaman, tribal elders, a lineage, or a gender group.

What is important in this definition in my view is that it acknowledges both the dynamic and ancient nature of IK. This stance is important in my study which focused on how to support in-service teachers to develop exemplar lessons that integrate IK using [5]*umqombothi* and [6]*oshikundu*. In both the Xhosa (South Africa) and the Oshiwambo (Namibia) cultures, the making of these beverages is a practice that was inherited from their previous generations and is still being practiced to this day. In both cases, the two presenters who are referred to in this study as expert community members, acknowledged that there were some modifications that have been made in the way the two beverages used to be prepared in the olden days. Thus, my adoption of the above definition is influenced by its relevance and appropriateness to my study. The integration of IK in the science curricular is viewed by many as a way of making science accessible to learners from diverse cultural backgrounds (Aikenhead & Jegede, 1999; Mavuru & Ramnarain, 2017). The following section discusses the role of IK in science education.

2.2.2 The role of IK in science education

The integration of IK in the science curricular is a growing phenomenon in many post-colonial states (Vhurumuku & Molekeche, 2009). Advocates for the integration of IK argue that the integration of IK in science lessons facilitates learning (Aikenhead, 1996; Le Grange, 2007; Ogunniyi, 2007a). This is backed by a plethora of studies conducted in southern Africa and

[5] *Umqombothi* is a non-alcoholic traditional beverage prepared from maize malt, maize meal, sorghum malt, yeast, and water through the process of anaerobic fermentation. It is commonly made among the Xhosa and Zulus of South Africa although other variants of the beverage are found among many tribes of southern Africa.

[6] *Oshikunduku* also called *ontaku* is a traditional beverage among the Oshiwambo people of Namibian. It is made from fermented millet (mahangu), and malted sorghum. It can be both alcoholic and non-alcoholic depending on the purpose.

abroad that confirm that integrating IK in science lessons motivates learners and boosts their self-esteem (McKinley, 2005); increases participation (Diwu & Ogunniyi, 2012; Mateus & Ngcoza, 2019; Sedlacek & Sedova, 2017); promotes critical thinking (Msimanga & Lelliott, 2014; Mutanho, 2016; Nyamakuti, 2021); and makes it easier for learners to understand science (Asheela, Ngcoza & Sewry, 2021; Kuhlane, 2011).

Research has shown that integrating IK in science lessons makes science more interesting. For instance, studies conducted by Agunbiade et al. (2017), Aikenhead and Jegede (1996) and Seehawer (2018) have demonstrated that learners become more motivated and engaged if teachers integrate prior knowledge from the learners' everyday experiences including IK. That is, when learners see the relevance of science in their everyday lives they will be interested to know more (Asheela et al., 2021). In a study conducted in South Africa by Mutanho (2016) it emerged that learners showed more interest in the science lessons and engaged with each other at a deeper level by asking more questions, arguing, and discussing issues than they used to do. In other words, learners tend to find more interest in the things that relate to their lives than knowledge that is decontextualised and meaninglessly abstract.

In a similar vein, Mavhunga and Kibirige's (2018) study on the integration of learners' knowledge of playground swings found that learners find it easier to grasp scientific concepts when their IK is integrated into their science lessons. Learners find it easier to understand concepts if the teacher develops concepts from the known to the unknown. Accordingly, Barnhardt and Kawagley (2005) advise teachers to use examples that learners are familiar with.

In light of these debates, scholars such as Keane et al. (2016) and Mhakure and Otulaja (2017) called for culturally responsive pedagogies that integrate learners' world views in science lessons to make it easy for them to understand. To fulfil this role teachers need to be cultural brokers (DBE, 2011; Aikenhead & Jegede, 1999). Their role is to research and integrate IK in their teaching and to draw examples from learners' everyday experiences to make science accessible to the learners as evidenced in Kuhlane's (2011) study. In the same vein, Govender (2014) argued that the exclusion of the African child's IK in the science curriculum is one of the major challenges that makes it difficult for them to understand the abstract scientific concept. The point Govender was making is that many indigenous learners fail science because it is taught in a de-contextualised manner which makes it too abstract, foreign, and irrelevant to their daily lives. Aikenhead and Jegede (1999) elaborated on this by saying that learners fail science because they fail to reconcile the cultural differences between their home and school science.

However, literature revealed that there are many factors that militate against the successful integration of IK in science lessons (Aikenhead & Jegede, 1999; Cronje et al., 2015; Le Grange, 2007; Mothwa, 2011). For instance, a study conducted by Mothwa (2011) revealed that although many science teachers in South Africa are willing to integrate IK in their lessons, they struggle to do so because they lack proper training. Mothwa blamed this lack of training on the Eurocentric education that the teachers received prior to independence, which denigrated and dismissed IK at face value as unscientific. This was exacerbated by the fact that the curriculum of that era followed a top-down approach with little accompanying training (Cronje et al., 2015). As such, the curriculum was not designed to respond to the teachers' learning needs but to satisfy the expectations of the curriculum designers.

Jacobs (2015) argued that the same mind set still prevails in teacher education and professional development to this day. In support, Bett (2016) noted that the cascade model is based on the 'one-size-fits-all' notion where an intervention is designed and imposed from above and is expected to cater for all teachers' learning needs, leaving no room to cater for individual teachers' learning needs. Moreover, many workshops conducted by the department of basic education are fragmented, inadequate, and therefore inappropriate (Jacobs, 2015; Ngcoza & Southwood, 2015). Accordingly, Ngcoza and Southwood (2015) argued that such an approach to continuous professional development does not create enough room for teachers to reflect upon their practices and collaboratively solve the problems and challenges that affect them in their workplaces. Instead, teachers are relegated to what Jacobs (2015) described as technicians whose role is to interpret the curriculum designers' manuscript.

With such poor training, teachers cannot be expected to successfully integrate IK in their science lessons. This was confirmed by findings of studies conducted in southern Africa. For instance, Mothwa's (2011) and Shizha's (2007) studies conducted in Zimbabwe found that although teachers were expected to integrate IK in their science lessons they had negative attitudes towards it. Shizha argued that instead of integrating IK, the teachers in his study acted like gatekeepers protecting WS from contamination by IK. To Botha (2012), this could be attributed to the perceived conflict between IK and WS that are traceable to the ontological and epistemological differences between these thought systems. This conflict manifests itself in part in the teachers' fears of teaching pseudoscience because IK has not been scientifically proven (Botha, 2012; Cronje et al., 2015).

Moreover, IK is also perceived to be in conflict with the mainstream Western religions and the teachers' belief systems (Botha, 2012). In their study, De Beer and Van Wyk (2011) found that many teachers felt that some IK practices conflicted with their Christian and Muslim beliefs. Such views are a barrier to the integration of IK in science lessons (Cronje et al., 2015). As curriculum implementers, teachers are the ones who choose what to teach and what to leave out which makes them the most strategic agents of any curriculum innovation. Thus, if IK does not resonate or is in conflict with their belief systems, they are likely to leave it out in their teaching.

According to De Beer and Van Wyk (2011), this problem is compounded in part by the fact that there are no textbooks or literature to guide teachers on how to integrate IK. On the other hand, the department of education's (DoE, 2011) CAPS document does not clarify how IK should be integrated in science lessons. Instead, it is left to the discretion of teachers to choose which IK to integrate as they see fit. The underlying assumption, therefore, is that the teachers have adequate knowledge of IK. However, Ogunniyi's (2007a) study revealed that teachers were only partially aware of the nature of IK. This finding is a recurring trend which also emerged in Mothwa's (2011) and Cronje et al.'s (2015) studies. This leaves one curious to know how the teachers' understanding of the nature of science and IK influences how they integrate IK in their science classrooms, thus, Section 2.4 briefly looks at literature on the different approaches that teachers use in their efforts to integrate IK.

In light of these challenges, Bantwini (2010) advised that effective curriculum reforms should aim at achieving a complete paradigm shift in terms of teachers' knowledge, dispositions, and skills. This implies that in-service training of teachers should not be a once-off event or a series of disconnected, independent workshops, or a 'one-size-fit-all' programme. Instead, it should be a supportive and empowering programme in which educators collaboratively engage in reflective practice to explore ways of solving problems they encounter in their teaching (Ngcoza & Southwood, 2019). The point that both Bantwini (2010) and Ngcoza and Southwood (2019) were making is that teachers' skills and dispositions do not change overnight. They need a long time of continuous engagement to expand their knowledge and transform their understanding (Engeström, 2001). It is for this reason that the teachers in this study were engaged in an intervention that lasted for 18 months of collaborative work accompanied by reflexive thinking.

2.3 Approaches to Integrating IK

Literature revealed that teachers seem to understand the relationship between IK and WS differently which in turn influences their approaches to the integration of IK in science education (Naidoo & Vithal, 2014; Taylor & Cameron, 2016). For instance, Naidoo and Vithal (2014) argued that teachers' understanding of the nature of science and IK determines the choices they make and the strategies they use in integrating IK in their science lessons. Agreeing to this, Taylor and Cameron (2016) singled out three distinctively contrasting perspectives on the relationship between IK and WS which they called: the *inclusive perspective*, the *exclusive perspective* and the *intersecting perspective* as shown in Figure 2.1 one below.

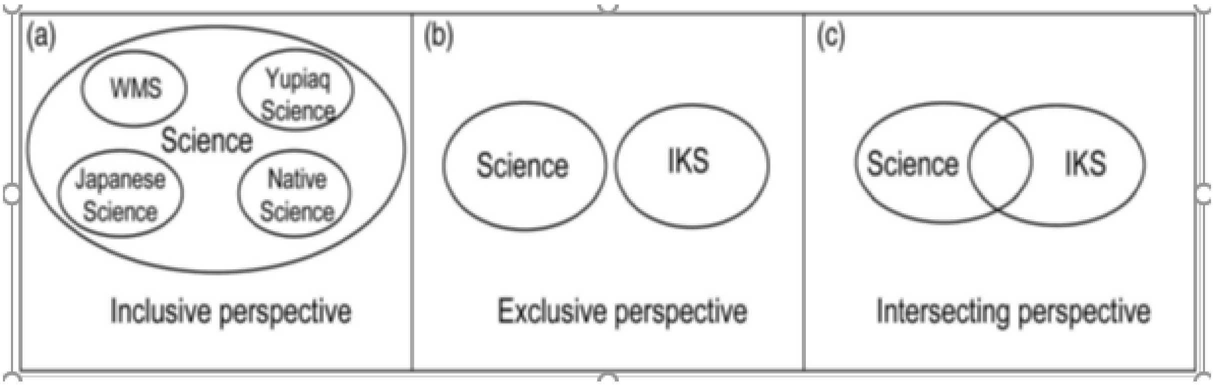

Figure 2.1: The perspectives of the relationships between science and IKS (adopted from Taylor & Cameron, 2016, p. 36)

In their *inclusive perspective*, Taylor and Cameron (2016) argued that "since the term science originates from the Latin 'word' [own emphasis] *Scientia* (knowledge)", then all types of knowledge about nature should be regarded as sciences (p. 36). In other words, since science is knowledge and understanding of nature, then the different knowledge systems about nature should be regarded as sciences, of which WS science is only one of them as illustrated in Figure 2.1(a) above.

On the other hand, the *exclusive perspective* regards IK and WS as completely different knowledge systems that have nothing in common and should be treated separately (Cobern &

Loving, 2001; Hodson, 2009; Horsthemke & Schafer, 2007). Proponents of this perspective advocate for plurality of knowledges in which IK and science are offered as independent subjects. For instance, Hodson (2009) did not see the link between IK and science and he believed that the integration of the two is futile exercise which will ultimately lead to the devaluation and absorption of IK into WS. In his appeal to keep the two knowledge systems, Hodson (2009, p. 5) stated:

> I believe the efforts to be seriously misguided. My position is as follows: to be classified as science or not a form of knowledge must meet the certain criteria for judging whether it is a science or not. There is much of value and benefit in traditional knowledge, and it clearly works well in the context in which it was developed, but it is not science simply because well-meaning people say it is science.

While Hodson acknowledged the legitimacy and value of IK, he does not agree with the idea of juxtaposing it with science. Instead, he argued that calling it science exposes IK to the danger of losing its contextual value and it will not be able to withstand the competition from WS which he feels is epistemologically stronger than IK.

In contrast, advocates of Taylor and Cameron's (2016) intersecting *perspective* (see Figure 2.1c above)), acknowledge that although IK and WS are not the same, they have some common aspects which teachers should exploit in their teaching. These aspects include some factual knowledge (know-what) and procedural knowledge (know-how). This draws scholars such as Seehawer and Breidlid (2021) to recommend a dialogue of epistemologies as the the way to conduct indigenous research in Southern Africa. Drawing insights from this, I take an *integrationist* stance where IK and WS are seen as complementary knowledge systems that can be used to promote the learning of science concepts.

Seehawer and Breidlid (2021) recommended what they coined as *a dialogue of epistemologies* which they viewed as an inclusive approach to conducting research with people from Southern Africa. In this approach both IK and WS are given equal status. Moreover, the differences between IK and WS tend to be reified and exaggerated by those opposed to integration, because it is mainly on the '*know why'* or explanatory knowledge that IK and WS tends to differ. It is on the basis of these explanatory differences that those who support a *separatist perspective* argue that the two knowledge systems should be kept apart (Hodson, 1990; Horsthemke & Schafer, 2007). Admittedly, such views are also common even among teachers as Naidoo and Vithal (2014) have demonstrated.

For instance, research has shown that the teachers' perspectives of the relationship between IK and science influence the approach that they use to integrate IK in science lessons (Naidoo & Vithal, 2014; Taylor & Cameron, 2016). In their study, for instance, Naidoo and Vithal (2014) identified three approaches which they called the *incorporationist* approach, the *separatist* approach and the *integrationist* approach. They argue that the incorporationist approach "embeds an application of a validation process based on scientific criteria that separates the objective from the subjective and from *beliefs*" (p. 258). For instance, a certain teacher in their study selectively used small portions of IK as they best fit into science. In other words, the teacher used IK that made sense scientifically while leaving out that which did not. In this approach, science is used to validate IK (Naidoo & Vithal, 2014).

In their explanation of the exclusive perspective, Taylor and Cameron (2016) borrowed Cobern and Loving's (2001) view which emphasised the differences between IK and WS. Similarly, Hodson (2009) also argued that IK and WS are fundamentally different knowledge systems in terms of their ontological and epistemological orientations, such that they are better treated separately in the curriculum. Ontological assumptions are assumptions about what constitutes reality, while epistemological assumptions refer to how knowledge is acquired (Scotland, 2012). This implies that IK and WS differ in what they consider as knowledge and how such knowledge is acquired, validated, and accepted as real knowledge. This drove Hodson (2009) to argue that merging IK and WS risks making IK extinct as it will not be able to compete against the ontologically and epistemologically more powerful WS which he sees as superior. Likewise, Naidoo and Vithal (2014) also held a separatist view of IK and WS when they argued that IK and Science should be treated as equal but different knowledge systems.

Lastly, both Naidoo and Vithal (2014) and Taylor and Cameron (2016) tended to agree on their intersecting approach which acknowledges that even though IK and WS are different knowledge systems they often share something in common. Taylor and Cameron (2016) succinctly put it when they said that although IK and WS explain phenomena differently they often intersect on procedural knowledge. This resonated with Naidoo and Vithal's (2014) assertion that teachers who use the integrationist approach exploit the knowledge in the intersection between IK and WS (see Figure 2.1 above). These findings point to the need for effective professional development to support teachers to acquire the appropriate skills to integrate IK. These skills include among others, how to unpack the curriculum and how to integrate IK in their science lessons.

However, some proponents of the integration of IK in science such as Ogunniyi (2007a), Afonso-Nhalevilo (2013), Keane et al. (2016), Mukwambo et al. (2014) and Seehawer (2018) cautioned against romanticising IK. Their central argument is that although IK is relevant to the teaching of science, it has its own limitations and may be a source of misconceptions. Besides, not all IK fits into science and would therefore be relevant to science education (Hodson, 2009). In other words, while these authors recognise the relevance of IK in science education, they acknowledge that it is not easy to implement. Accordingly, Ogunniyi (2007a) recommend proper training for teachers to equip them with the necessary PCK to integrate IK. In the context of this study, this was done through a series of change laboratory workshops which covered the following aspects: how to unpack the curriculum, how to draw links between IK and science, how to conduct practical lessons, how to elicit learners' prior knowledge (including IK), and how to tap into expert community members' knowledge fund.

2.4 Hands-on Practical Activities and Visualisation

It is with this understanding that this study explored how to decolonise the curriculum in teacher education by inviting IK expert community members to conduct practical demonstration lessons on how to make *umqombothi* and *oshikundu* to the BEd Natural Sciences in-service teachers at a university in the Eastern Cape of South Africa. Thus, there is need to explore literature on hands-on practical activities and inquiry-based learning (IBL) in science education. According to Shinana et al. (2021), IBL is learning that involves practical hands-on activities where learners investigate scientific phenomena through engaging in hands-on practical activities.

Studies conducted in different parts of the world have demonstrated that involving learners in hands-on, minds-on activities motivates (Kuhlane, 2011; Suarez et al., 2018), improves performance (Kuhlane, 2011) and makes learners more active and more engaged in the science lessons (Correia & Harrison, 2020). In her study in South Africa, Kuhlane (2011) found that her learners became more actively involved in the learning process and were able to ask more questions than in usual lessons. Her findings resonate with the outcomes of many studies conducted in many parts of the world which also found that learners understand better if they learn through practical activities (Cairns, 2019; Husni, 2020; Suarez et al., 2018).

However, Hodson (1990) was quick to caution us against the naïve assumption that practical activities have an intrinsic educational value of their own. Contrary to the claims made by many

Hodson argued that practical activities are loved by many learners because they view them as a way of escaping from the boring classroom situation. In his view hands-on practical activities are counter-productive to learning in many classes because many teachers and their students alike use practical activities as a pass-time. Here in South Africa, this view was confirmed by Ramnarain and Hlatshwayo (2018) study which found that despite their positive attitudes towards science, many teachers find it difficult to conduct hands-on practical activities. For instance, the teachers in their study argued that they struggled to implement IBL because they did not have enough laboratory equipment and were teaching large classes. Earlier on, scholars such as Maselwa and Ngcoza (2003) responded to this challenge of uncritical use of hands-on practical activities by commending what they coined the 'Hands-on, Minds-on, Words-on' approach. To operationalise this, they recommended the 'Predict, Explain, Explore, Observe and Explain' approach where learners start by predicting what they think will happen and give explanations to support their predictions. They then experiment (explore) and observe and compare their initial explanation of the scientific phenomenon and the outcomes of the experiment. Recently, in their study conducted in Namibia, Shinana, Ngcoza, and Mavhunga (2021) extended on Asheela et al.'s (2021) study with the PEEOE approach and found that it is useful in promoting scientific enquiry. Another challenge that is often associated with indigenous learners' failure of science is the use of English as a second language to learn science. Hence, the following section briefly explores the role of translanguaging in science education.

2.5 The role of Language in Teaching Science

Learning in a second language has been singled out as one of the major challenges faced by second language speakers in science lessons. Often such claims associate it with increasing learners' anxiety as well as cognitive load as they grapple to understand both the scientific concepts and the medium of instruction. To alleviate this problem, codeswitching and translanguaging are often offered as solutions. However, the challenge of codeswitching is that it continues to privilege English as the main medium of instruction and allows only a few words to be smuggled into the mainstream instruction.

For this reason, some prefer a more fluid use of all available linguistic resources in a multi-lingual classroom in what has come to be known as translanguaging (MacSwan, 2019). According to Wei (2018), translanguaging can be defined as the simultaneous use of more than one language as a medium of instruction in one lesson, in a manner that transcends language boundaries. It is argued that translanguaging creates a rich learning environment in which learners can freely express themselves in any language of their choice. Charamba (2020) argued that translanguaging creates cognitive access by removing the language barrier. Her argument was that if a teacher allows learners to communicate in their own language they are promoting epistemological access. In her study conducted in Zimbabwe, Charamba (2020) found that translanguaging creates a favourable learning environment and enhances learning and improves understanding.

In the context of this study, translanguaging was used because the expert community member who presented the making of *umqombothi* could not present in English. Teachers also used translanguaging as they discussed in their groups. It is important to note that the majority of participants who actively participated in this study were women, which necessitated a review of literature on gender and science.

2.6 Gender and Science

Women are portrayed as people with no interest in sciences (Simon & Nene, 2018). As a result, many studies conducted throughout the world have revealed that many women who initially show interest in sciences end up dropping out of science, technology, engineering and mathematics (STEM) courses or careers (Harrell, 2016; Simon & Nene, 2018). Accordingly, Simon and Nene (2018, p. 347) pointed out that "sciences are associated with traits understood to be culturally masculine, such as decontextualised analytical thinking, repudiation of emotion, domination of nature, and enthusiasm for designing and implementing weapons of warfare". This association of science and masculinity is thought to be the reason why many women do not find science exciting. In other words, science does not appeal to women because it does not relate to their daily lives.

This is also accompanied by the general stereotypic views that associates science and men. In light of this, Harrell (2016, p. 25) argued that physical scientists are perceived as "solitary, male geniuses, who construct new theories and knowledge by the sheer force of their own personal intellects". He maintained that this stereotypical view tends to discourage women and girls from studying science. Moreover, feminists contend that the science education system is like a leaking pipeline which filters women out leaving men to reach the end.

Additionally, schools and universities also reinforce this stereotyping by presenting a curriculum that is based on masculine thoughts, beliefs, and practices (Clegg, 2001). Rosser (1993) advocated a gender sensitive and gender inclusive science curriculum that focusses less on science experiments that benefits menial careers such as the army, and focusses on experiments located in the domains that are traditionally dominated by women. Similarly, Mhakure and Otulaja (2017) preferred to call such a curriculum a culturally sensitive approach to science education. For instance, the use of *kitchen chemistry*[7] would be one such approach. In their study conducted in Nigeria, Oluruntegbe and Ikpe (2011) found that learners from poor socioeconomic backgrounds who often engage in domestic chores outperformed their counterparts from the higher income families in chemistry. Oluruntegbe and Ikpe speculated that it is possible that the learners who engage in domestic chores learn chemistry from their cooking as they mix different ingredients, the knowledge which they then transfer to school chemistry. In a similar line of argument, Rosser (1993) argued that science does not appeal to girls because both science and technology have been used to destroy humanity in wars, kill animals, destroy the environment, and cause untold suffering and damage to both humans and nature. Seemingly, girls do not find this appealing.

In contrast, Kelly (2016) also noted that boys tend to receive more attention and more encouragement from their science teachers than girls. This includes the teachers' beliefs, attitudes, expectations, and practices that tend to exclude girls. Consequently, there are very few role models for girls to emulate in STEM. These trends are a cause of concern to a developing country like South Africa and have far reaching implications in her efforts to create a democratic society with equal opportunities for everyone. One can argue that this marginalisation of women disadvantages humanity as it side-lines the contributions of the members of society who constitute the majority of the population in most parts of the world.

The above literature failed to distance itself from the masculine stereotype of treating science as a preserve for men by omitting the contribution of women in science. For instance, to argue that there are no female role models which girls can emulate is to dismiss the contribution of many women whose contributions have led to some of the greatest scientific breakthroughs in

[7] Kitchen chemistry refers to the chemistry activities that can be done using common household materials such liquid soap, vinegar, table salt, sugar and so on.

human history. Reporting on BBC, Iqbal (2015) argued that women's contribution to science has always been under-recognised and often ignored or suppressed throughout the history of science (see Appendix B: Table B1).

2.7 Professional Development in South Africa

Teachers' continuing professional development (CPD) is central to any educational reform as it is believed to be a way of improving teacher knowledge of learning and teaching (Geldenhuys & Oosthuizen, 2015; Guskey, 1994; Ngcoza & Southwood, 2015; Ono & Ferreira, 2010). Scholars such as Chauraya and Brodie (2017), Ngcoza and Southwood (2019) preferred to call this a professional learning community (PLC). Central to PLCs is collaborative learning that resonates with the expansive learning emphasised in CHAT. They argued that PLCs help teachers to develop and build their capacities within, between, and beyond their individual selves. For this reason, Guskey (1994, p. 9) saw any attempt to improve schools without improving teachers' knowledge as a futile exercise. He argued that teachers are the most crucial participants to curriculum innovation upon whose shoulders is the responsibility to implement the intended official curriculum". With these words, Guskey reminds us that teachers are in the most strategic position to influence the outcome of any curriculum innovation.

However, the history of education in South Africa reflects that teachers have always been marginalised and excluded when crucial policies such as the integration of IK in science education are being made (Jacobs, 2015; Jensen, 1998; Ogunniyi, 2007a). Walker (1996) traced this trend to the apartheid era. He observed that during the apartheid era South African teachers were denied the opportunity to innovative reflectively and put to use the new ideas that they learnt in professional development programmes. In the post-apartheid South Africa, CPD came against the backdrop of the racially biased apartheid education system that provided little in-service training to Black teachers (De Clercq & Phiri, 2013). They further explained that prior to independence, teachers were treated as labourers with basic technical competencies and were required to follow tightly monitored syllabi handed down by the ministry of education. Concurring, De Clercq and Phiri (2013) added that the curriculum was designed by White experts and handed down to teachers to implement. This suggests that the education system was authoritarian and prescriptive in nature. Hence, the purpose of professional development was to provide little in-service training that mainly focused on administrative issues with very little pedagogical and content matter (De Clercq & Phiri, 2013). Additionally, such training was imposed from above with little consideration of the teachers' needs.

The attainment of independence in 1994 was accompanied with the shift from Bantu Education to an inclusive curriculum. This policy shift imposed the need to realign teachers' knowledge and skills with the demands of the new curriculum (Ngcoza, 2007; Ngcoza & Southwood, 2015). Consequently, many initiatives were put in place to correct the lack of competencies and re-align the teachers' knowledge and skills in line with the new socio-political and economic prerogatives. Pressed with the need to train many teachers to satisfy the demand for skilled teachers, the government resorted to the cascade model (Jensen, 1998; Jacobs, 2015).

Karalis (2016, p. 104) described the cascade model as the CPD model where "a cohort or first generation of trainers is trained in a specific subject and after they are qualified or considered adequate or proficient as trainers in that specific issue, they become trainers of a second cohort or generation" of trainers. This process is often repeated several times until the target population receives training. In this way, information is diffused to the trainees at the lowest levels who in most cases are the teachers. The cascade model is often selected for its cost effectiveness for it allows many teachers to be trained within a short space of time (Dichaba & Mokhele, 2012). Bett (2016) added weight to this by saying that the cascade model is the preferred way of disseminating information in many African countries that find themselves with the need to train a large number of teachers within a short space of time. Such was the challenge that faced South Africa after 1994.

However, despite its benefits, the cascade model is often criticised for being a top-down model that does not allow teachers to actively participate in their learning (Bett, 2016; Dichaba & Mokhele, 2012). Many argue that this model results in the distortion of the initial message as it trickles down from the top to the bottom layers of trainers (Bett, 2016; Dichaba & Mokhele, 2012). In their study, Dichaba and Mokhele (2012) tried to answer the question "Does the cascade model work for teachers training?" by analysing teachers' experiences of in-service training. They concluded that although this model is widely accepted as a way of conducting CPD it "appears to have failed to significantly improve the performance of educators". In essence while a lot of financial resources are spent on in-service training programmes using this model, the classroom realities remain the same (Ngcoza & Southwood, 2015).

In a study conducted in Kenya by Gathumbi et al. (2013) on a three-tier cascade model, it was found that the information was diluted as it trickled down from the initial trainers to the teachers. Similarly, some argue that this inherent weakness of the cascade model is what contributed to the failure of the outcome-based curriculum in South Africa as information was altered and diluted as it was passed down from one level to the other (Dichaba & Mokhele, 2012; Karalis, 2016). As a result, the model did not yield the desired change. Following from the above observations, one could argue that while large sums of money have been spent on professional development since independence, not much has changed in terms of teachers' classroom behaviours (Ngcoza & Southwood, 2015). Part of this failure to change can be attributed in part to the fact that the 'one-size-fits-all' notion underpinning the approaches to models of CPD is inappropriate. It marginalises teachers' contribution to their own professional learning (Ono & Ferreira, 2010).

My experience of that is when we were often called to the district offices for cluster workshops which usually lasted for not more than two days. The workshops were often conducted by the subject advisors with assistance of a few experts. In Vygotskian terms, these subject advisors and their invited experts were the MKOs while we were regarded as the novices. The subject advisors would then present the information and we were expected to take down notes and go to our schools to implement what we had learnt.

In contrast, Bayar (2014) viewed effective professional development as one that matches the teachers' needs as well as actively involving the teachers in the planning and implementation of the transformative continuing professional development (TCPD) activities as reiterated by Ngcoza (2007). In Bayar's view, active participation and engagement coupled with high quality instruction create learning opportunities for teachers. Ngcoza and Southwood (2019) emphasised the importance of participatory and emancipatory approaches to teacher professional development, premised on mutual and collaborative support. In their view, teachers can be agents of their own professional development if they are given the opportunity to take responsibility and ownership of their learning.

In their study conducted in the Eastern Cape province of South Africa, Ngcoza and Southwood (2015, p. 4) found that TCPD shifted teachers' pedagogical content knowledge (PCK) from *transmissive* to being more constructive. The study also revealed that the teachers expanded their subject-content knowledge and PCK as they engaged in collaborative activities in which they co-constructed knowledge with their peers. This resonated with Brodie's (2013) assertion that teachers learn better when given an opportunity to combine their cognitive resources and share their individual practices in a supportive environment. In this regard, Ngcoza and Southwood (2019) proposed that there is a need for creation of professional networks as spaces for learning teachers.

The above arguments underscore the importance of engaging teachers in a CoP in which they collaboratively explore possible solutions to the challenges they face in their work (Lave & Wenger, 1991; Wenger, 1998). Wenger, McDermott, and Snyder (2002, p. 4) defined a CoP as "a group of people who share a common concern, a set of problems, or a passion about a topic, and who deepen their knowledge and expertise in this area by interacting on an ongoing basis". In education, a CoP can be a group of teachers collaboratively engaged in a pedagogical intervention to improve their practice in teaching a problematic topic.

In this study, our CoP was made up of the BEd Natural Sciences in-service teachers, their science lecturer, two expert community members, and me. Our research focus was on exploring how to integrate IK in science lessons. My study explored how to support teachers to develop exemplar science lessons that integrated IK from the making of *oshikundu* and *umqombothi.* Notably, both the two community members were females, which speaks to the gender and science debate. Interestingly, the two community members had different educational backgrounds. While the community member who demonstrated how to make *umqombothi* attained a Grade 12, also called Matric in South Africa, the other community member from Namibia was a master's student and a science teacher from Namibia. Wenger (1998) postulated that a CoP is based on three principles, which are *mutual engagement*, *joint enterprise,* and *shared repertoire*.

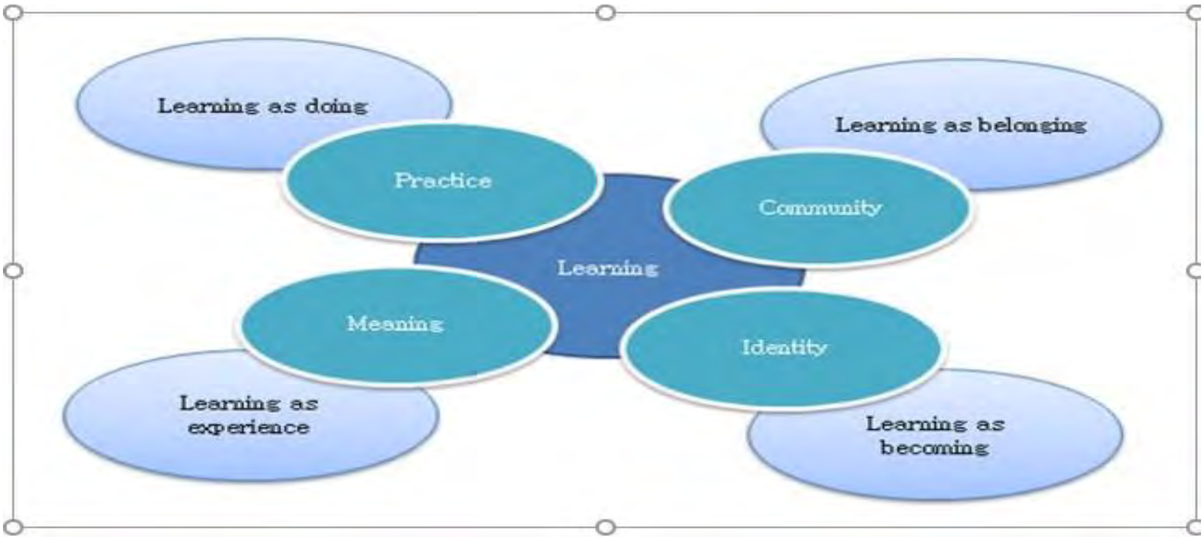

Figure 2.2: The components of social theory (Wenger, 1998, p. 5)

This diagram illustrates how knowledge is co-produced by members of a CoP. The members of a CoP learn from each other by sharing their experiences and collaboratively exploring possible solutions to the challenges that they face in their profession (Vangrieken, Meredith, Packer, & Kyndt, 2016). It follows from the above arguments that unlike the cascade model which is based on the top-down or expert-novice perspective, a CoP seeks to empower teachers by giving them agency and responsibility over their own learning (Engeström, 2015) and this was central in my study.

Vangrieken et al. (2016) drew our attention to the group dynamics that influence the success of a CoP. They argued that the success of a CoP depends on "creating relationships that go deeper than similarities" (p. 49). Accordingly, Hord (1997) argued that the success of a CoP depends on good leadership, a sense of collegiality, and mutual trust and respect. To achieve this, the facilitator needs to create an environment of shared vision, values, and goals in which the CoP members freely share their experiences and challenges without fear of reprimand, and support one another both professionally and emotionally as they co-construct knowledge. In Vangrieken et al.'s (2016) view, such collaboration is only possible if the teachers develop a sense of belonging. This implies that there should be value consensus among the members of a CoP.

However, Thessin (2010) warned that the success of a CoP is often threatened by conflict of interests and contradictions arising from people with different personalities and backgrounds. Research shows that heterogenous CoPs consisting of teachers from diverse cultural and educational backgrounds often face challenges in reconciling the tensions, conflicts, and contradictions inherent in the teachers' orientations (Brodie, 2013; Thessin, 2010; Vangrieken et al., 2016). This often happens when the teachers' level of expertise, tenure, status, qualifications, beliefs about teaching and learning, and experiences are different.

Contrary to Thessin's (2010) view, cultural historical activity theorists such as Engeström and Sannino (2010) saw contradictions as precursors to learning and development. For instance, Engeström and Sannino (2015) contended that contradictions within an activity system often create learning opportunities by stretching the teachers' thinking as they argue. The effect of such arguments as Brodie (2013) noted, is that the participants are forced to move out of their comfort zone, admit their weaknesses, and open up to new knowledge and ideas. Therefore, from a CHAT perspective, the conflicts, tensions, and contradictions within a CoP may lead to learning. The participants reconceptualise their understanding of phenomena as they try to resolve the contradictions within the activity they are involved in (Haapasaari et al., 2016).

In this study, the BEd Natural Sciences in-service teachers had to come up with new ways of teaching science that were not known to all of us prior to the intervention. This implies that knowledge was generated through expansive learning, which Engeström and Sannino (2010) viewed as learning by generating new solutions to problems. In other words, through expansive learning we had to explore ways of integrating IK in science lessons. Shulman (1986; 1987) described such knowledge as pedagogical content knowledge (PCK) which Mavhunga and Rollnick (2013) later modified to the topic specific pedagogical content knowledge (TSPCK), after observing that teachers do not use the same teaching strategies to teach all topics. Both Shulman's and Rollnick and Mavhunga's theories are discussed below.

2.8 Pedagogical Content Knowledge

Pedagogical content knowledge (PCK) is a theory introduced by Shulman (1986) who contended that for teachers to be able to effectively transform subject matter into teachable units that are easily accessible to learners, they need to possess specialised knowledge which he called PCK. In other words, PCK is what teachers use to creatively select the content to be taught, transform it, and present it in a simplified manner that makes it easier for learners to understand. In Shulman's (1987) view, during that transformation a teacher thinks through the subject matter as they try to critically interpret it, simplify, and represent it in metaphors, diagrams, pictures, illustrations and other alternative ways of expressing the ideas in a manner that creates bridges between the learners' understanding and the desired outcomes. Developing this argument further, Ball et al. (2008) added that it is through the repetition of this experience of turning over ideas in one's head that teachers gain their wisdom of practice. In other words, it is the cumulative effect of this experience that enables the expert teacher to easily transform subject matter into a simplified form that can be easily understood by their learners.

However, critiques such as Ball et al. (2008) and Kind (2009) argued that Shulman's theory is not backed by theoretical evidence to support the existence of PCK as a distinct category in a teacher's knowledge base. Additionally, PCK is not explicit knowledge that can be easily identified, classified, and taught to trainee teachers (Kind, 2009). Moreover, Shulman tended to treat PCK as a discrete and static body of factual knowledge about teaching that can be acquired, accessed, and applied independently from the classroom context. Consequentially, it is not easy to distinguish subject matter knowledge from PCK since the two are intertwined and seemingly inseparable (Bednarz & Proulx, 2009).

In light of the above criticism, Petrou and Goulding (2011) preferred to regard PCK as the art of knowing-how to-act that is linked to and situated in the act of teaching and is an integral part of a teacher's general knowledge about teaching. In essence, what Petrou and Goulding were telling us is that PCK is the knowledge the teacher uses to make decisions as they teach. While this body of knowledge may be inseparable from the rest of the knowledge that a teacher possesses it is the knowledge that distinguishes good from bad teachers. Thus the main purpose of this study is to support teachers to develop such knowledge with regard to the integration of IK.

Responding to this elusive nature of PCK, Mavhunga and Rollnick (2013) argued that PCK is topic specific because a teacher cannot use the same teaching methods for different lessons and topics within a subject. In clarifying this, Mavhunga and Rollnick adapted the five content specific components of the TSPCK used in Geddis and Wood (1997, p. 613) shown in the diagram below.

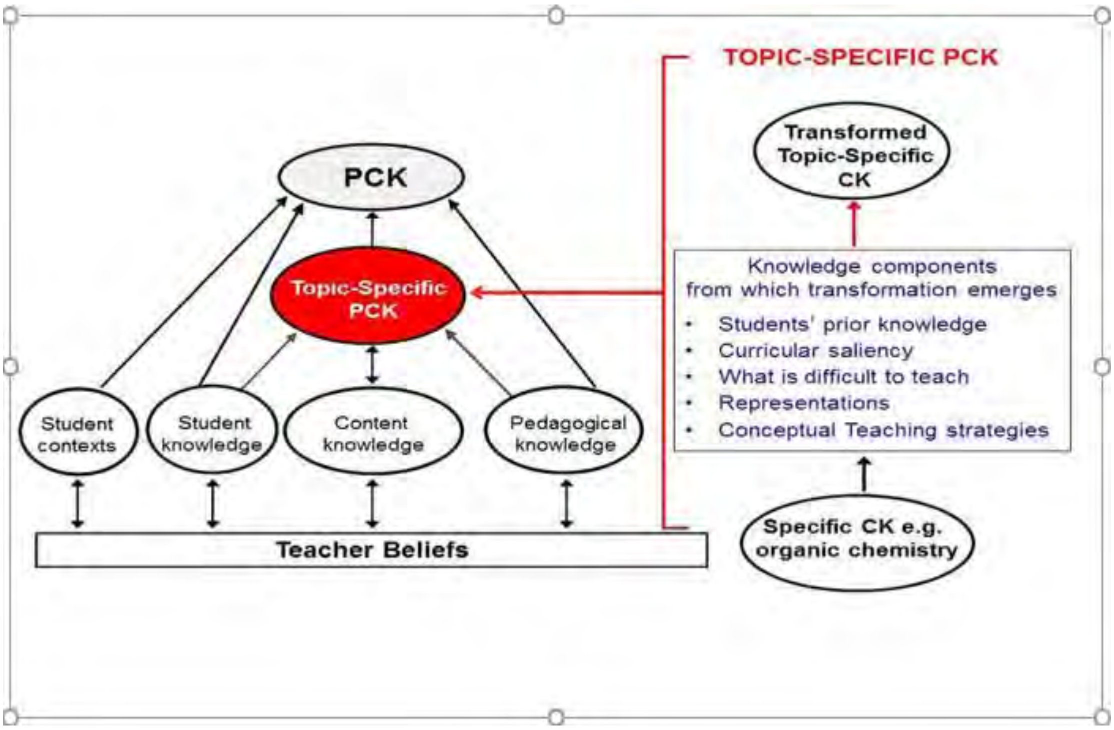

Figure 2.3: The five components of TSPCK (Adapted from Mavhunga & Rollnick 2013, p. 115)

2.8.1 Learners' prior knowledge

Leaners' prior knowledge is understood as the knowledge that the learners already have prior to teaching. According to Mavhunga et al. (2016), such knowledge "include the common learner misconceptions known in a topic" (p. 300). This understanding of prior knowledge tends to emphasise the knowledge that learners bring to a learning situation from their previous formal learning experiences and grades. However, in this study, prior knowledge refers to both the knowledge that learners acquired from their previous grades and their everyday experiences at home.

2.8.2 Curriculum saliency

Mavhunga et al. (2016, p. 300) decribed curiculum saliency as the teacher's ability to "the most important meaning of major concepts of a topic, without which understanding of the topic would be difficult for learners and also includes the knowledge to logically sequence the learning, and the knowledge of pre-concepts needed prior to teaching a topic". In other words the teacher's curriculum saliency can be seen in their ability to identify and emphasise the main ideas around the topic that they are teaching (Shinana, 2019). They should also demonstrate understanding of the sequencing and progression of ideas so that they can enable learners to understand how the different interrelated concepts lead to the big ideas in the topic.

The concept of curriculum saliency was used as an analytical tool to unpack the curriculum and to prepare science lessons that integrated IK. It was used to help teachers understand how the subject matter in Natural Sciences is sequenced and how the concepts taught in one grade lead to the bigger ideas taught in the next grade on the same topic. Commenting on the importance of sequencing, Mavhunga et al. (2016) stated that the sequencing of concepts is very vital if learners are to understand what they are taught. This is because scientific knowledge is hierarchical, such that it is not easy to understand difficult scientific concepts if the learner has not mastered the simpler concepts.

2.8.3 What is difficult to understand?

In TSPCK 'What is difficult to understand' refers to the gatekeeping concepts that make it difficult for learners to understand the topic (Mavhunga & Rollnick, 2013; Mavhunga et al., 2016). As part of a teacher's knowledge base, this concept is of paramount importance because it determines how they break down the subject matter and present it to the learners (Mavhunga & Rollnick, 2013). Such concepts may even be in conflict with learners' prior knowledge of the phenomena in question. Thus, it was necessary to identify the gatekeeping concepts in the different topics of the CAPS curriculum.

2.8.4 Representations

Representations are understood as the different ways in which the teacher repackages the subject matter to make it accessible. In Mavhunga et al.'s (2016, p. 300) view, representation refers to the different techniques and materials that a teacher can use to represent the subject matter at "macro, symbolic and sub-microscopic levels". Thus, a teacher can use different materials and techniques to represent the subject matter. These include linguistic devices such as metaphors, analogies, illustrations, models, and simulations (Shinana, Ngcoza, & Mavhunga, 2021).

In the context of this study, this involved the use of different cultural tools such as *umqombothi* and *oshikundu,* indigenous languages, analogies, chemical symbols, and mind and concept maps, among others.

2.8.5 Conceptual teaching strategies

The last TSPCK component is the conceptual teaching strategies which refer to the specific pedagogical considerations and techniques used by the teacher to make the subject matter accessible to learners (Mavhunga et al., 2016). The selection of the conceptual teaching strategy is done in consideration of the other four factors discussed above. For instance, a teacher must have an idea of learners' prior knowledge and the gatekeeping concepts that may create misconceptions that will make it difficult for learners to understand.

2.9 The Modified/Consensus PCK Model

Although many scholars have agreed that Shulman's theory was a major breakthrough in trying to understand the knowledge base that teachers use to break down and simplify subject matter to make it easily understood by learners, critics have argued that it has no theoretical basis to back it up (Kind, 2009). This has led its proponents to embark on studies to develop it further. For instance, in 2012 in Colorado Springs a group of scholars met to create an agreed model which came to be known as the Teacher Professional Knowledge model (Consensus PCK Model) (Gess-Newsome, 2015, p. 31) which would help them to have a common understanding of PCK. The agreed model is illustrated in Figure 2.4 below.

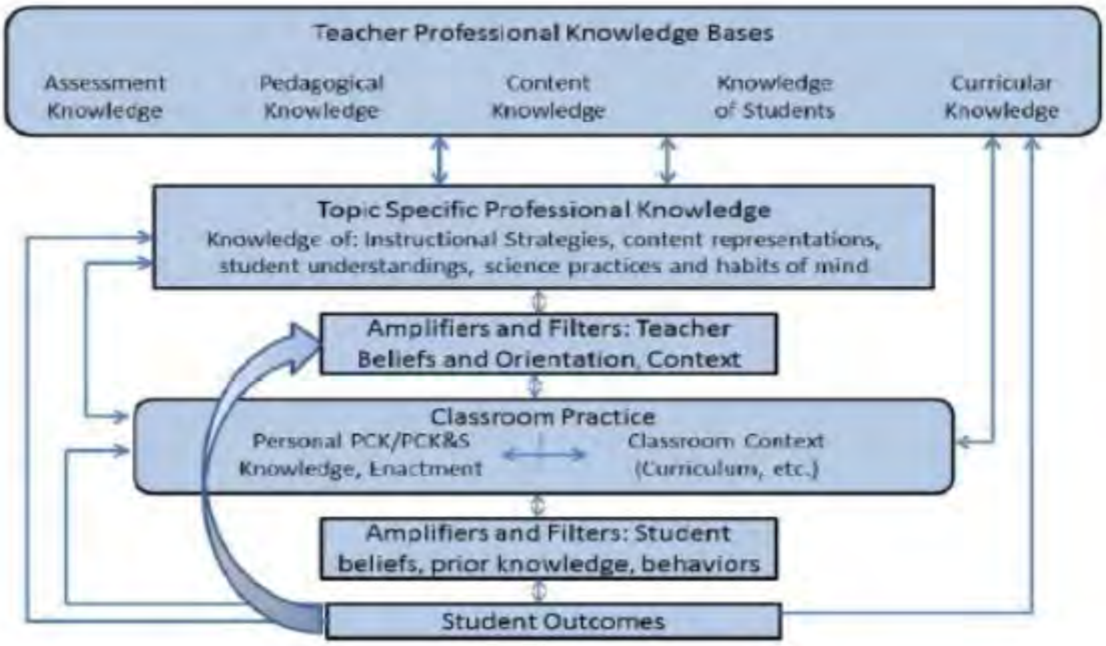

Figure 2.4: Consensus model of PCK from PCK Summit 2012 (Gess-Newsome, 2015, p. 31)

This model shows us that a teacher has a broad professional knowledge base from which to draw insights. Their PCK is multi-layered. It consists of both the knowledge of the subject matter, the learners, and the context within which the teaching-learning process is taking place. Accordingly, Shinana (2019) saw it as the knowledge base for planning a lesson and the actual teaching of the lesson.

On application, this model was found to have limitations since it did not emphasise teaching strategies. To correct these anomalies a refined model was crafted to show the multi-faceted nature of PCK (Carlson & Daehler, 2019). Presented below is the new Refined Consensus Model of PCK which shows the three layers of PCK as the collective PCK, the personal PCK, and the enacted PCK (Carlson & Daehler, 2019).

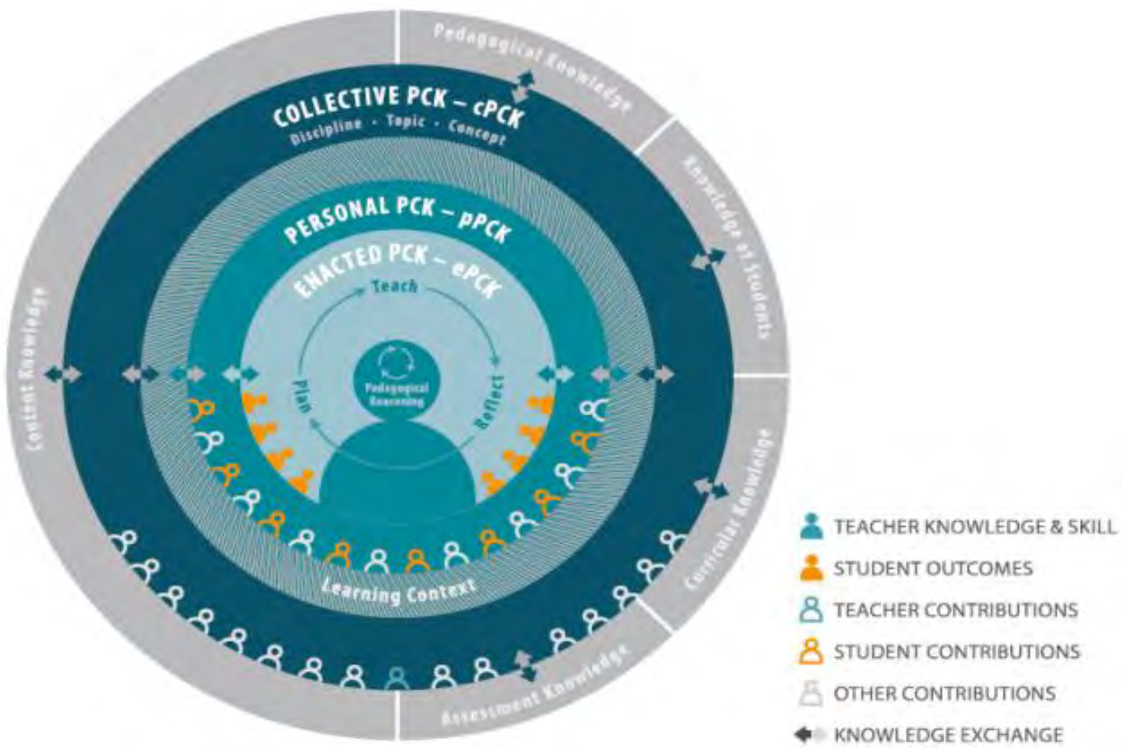

Figure 2.5: Refined Consensus Model of PCK (Carlson & Daehler, 2019, p. 83)

What this model shows us is that PCK has many sub-components embedded in it. These include the collective PCK, which Carlson and Daehler (2019) saw as the knowledge about a particular discipline that is commonly known by teachers in a particular field. What makes it collective is that it is the PCK that is publicly shared among members of a particular discipline. For instance, such knowledge may be what is offered in the teacher training colleges and is therefore common to every graduate teacher (Shinana, 2019). Such knowledge is public because it is not held by one person. It is collective knowledge that is commonly possessed by nearly all trained teachers.

The second layer is the personal PCK which is the knowledge possessed by individual teachers as they think through the collective PCK and try appropriate it and use it in their own classrooms. Personal PCK is unique, because it is built by each teacher as they reflect upon their teaching experiences. It builds over time as the teacher works with different groups of learners, gets feedback from colleagues, reflects and refines their practice from time to time. It is the personal PCK that distinguishes different teachers' uniqueness because each teacher expresses their personal PCK in a unique way (Carlson & Daehler, 2019; Shinana, 2019).

According to the above model, the third layer of PCK is the enactment PCK which is the specific PCK that the teacher uses to teach in the classroom. The enactment PCK is the knowledge that the teacher uses to reason pedagogically while they are planning, teaching, or reflecting upon the lesson. In other words, the enactment PCK is the knowledge that enables the teacher to deliver the real lesson in a manner that enables learners to understand (Carlson & Daehler, 2019; Mazibe et al., 2020; Shinana et al., 2021). From this discussion it can be seen that the enactment knowledge is embedded in one's personal PCK.

All three categories of PCK are important in this study since the teachers were engaged in collaborative and individual activities to enhance both their collective and individual abilities to integrate IK in science teaching, with the ultimate aim of transforming their enactment PCK. Having said this, it is important to briefly look at the gaps in literature that necessitated this study.

2.10 Where and What is the Gap?

What I find missing in the above literature is the focus on tertiary education. Many studies conducted on the integration of IK in science education tended to focus high school science education (Hashondili, 2020; Khupe, 2014; Mutanho, 2016; Shinana, 2019; Shizha, 2007). The common thread in these and many other studies on the integration of IK in science education has been to find out the benefits and constraints of integrating IK in school science education. What this study does differently is to redirect research focus to the integration of IK in science education in tertiary education. Another gap is that the literature on IK has very little acknowledgement of scientific contribution of women in our everyday lives. In my opinion, the claim that women are not interested in science is also patriarchal in that it tends to shift the blame on women and obscures the fact that the science subject itself might be exclusionary. In other words, such a stance tends to blind us from the real fundamental issues that discriminate against women. For instance, the same girls and women who are said to be bad in chemistry do household chores (Oluruntegbe & Ikpe, 2011) and successfully mix different chemical substances at home to prepare food, wash clothes, prepare medicines, and nurse babies among many other traditional roles women continue to perform in many parts of the world.

This marginalisation of women tends to also manifest itself in the literature on IK where the IK-WS debate tends to be framed as a patriarchal, anti-colonial struggle at the exclusion of the gender-science struggle embedded within it. For instance, even though many studies draw on IK from the traditional domain performed by women in many societies such as food preparation, food preservation, and childbirth, very few acknowledge this as women's indigenous knowledge that could be used to motivate girls to like science (Hashondili, 2020; Mukwambo et al., 2018; Mutanho, 2016; Shinana, 2019). In these studies, IK is treated as knowledge that is universally possessed by indigenous people regardless of gender, a stance which I feel obscures the fact that certain IK is possessed by men or women because of the traditional division of labour in many societies.

However, a glance at the above literature on IK shows that despite the fact the DBE (2011, p. 5) clearly states that science teaching should be "sensitive to issues of diversity such as poverty, inequality, race, gender, language, disability and other factors", the main emphasis in studies conducted on IK tend to be on cultural inclusion. There has been a tendency to treat IK as knowledge that is universally owned by the so-called indigenous people regardless of their gender. As a result, no mention is made of how to integrate women's IK in the science curriculum to make science accessible to both men and women. With this, I argue that the fight for the integration of IK in science education has not escaped the patriarchal trap as resistance of African men against dominance by European men.

My study sought to close the gaps identified in the literature above by exploring how to support BEd Natural Sciences in-service teachers to develop model lessons that integrated IK, using the making of *umqombothi* and *oshikundu* as examples. Both *umqombothi* and *oshikundu* are beverages that are traditionally prepared by women in the *Xhosa* and *Oshiwambu* cultures, respectively. Thus, this study sought to provide insights on how to deal with not only cultural but also gender diversity as we integrated IK in the science curriculum. In other words, the study sought to decolonise the curriculum through both cultural and gender inclusivity, an aspect that is missing in many earlier studies that I came across.

In addition, while a lot has been written about the need to decolonise university education, not much has been done to explore the decolonising of the university curriculum. In other words, while calls to transform the curriculum have been made, university education has remained locked in the past mode in terms of the content of its curriculum, pedagogical practices, and knowledge production. As alluded to earlier, the studies cited above and many other studies that I came across also tended to focus on how to integrate IK at high school and junior secondary level and not at tertiary level. My study thus sought to close this yawning gap and explored how to integrate IK in science teaching at university level. In this way, the study goes beyond mere advocacy and validation of IK to exploring how it could be integrated in science curriculum at tertiary level.

2.11 Chapter Summary

This chapter reviewed literature on the pertinent issues to this study. It explored the role of IK in science education, highlighting the benefits, challenges as well as the approaches that teachers use in their attempts to integrate it in their science teaching. Thereafter, the review focused on the cascade model of CPD used in the South African education system and noted that while it is favoured by many developing countries because of its cost-effectiveness, it is inadequate in transferring the envisaged skills because it is imposed from above and is not based on teachers' needs. For any curriculum innovation to be successful there is need to equip teachers with the necessary PCK. For this reason, this literature review later turned to Shulman's (1987) PCK and Mavhunga and Rollnick's (2013) TSPCK. It was noted that the PCK is that knowledge base that distinguishes teachers from other professionals. It enables them to understand their learners and break down the subject matter into forms that learners can easily understand. Because this study was based on the making of *umqombothi* and *oshikundu* which are traditional beverages made by women, there was need to understand the role of women in science education. For this reason, the literature review also looked at gender issues in science education.

CHAPTER THREE: THEORETICAL FRAMEWORKS

> The theoretical framework is the structure that can hold or support a theory of a research study. The theoretical framework introduces and describes the theory that explains why the research problem under study exists. (Abend, 2008, p. 173)

3.1 Introduction

In the above epigraph, Abend (2008) drew our attention to the fact that the theoretical framework is the central component of any study which informs the research process. It is the skeletal structure upon which a research is built. This study is underpinned by Vygotsky's (1978) sociocultural theory in conjunction with the Cultural Historical Activity Theory (CHAT). The sociocultural theory provided the overarching theoretical framework upon which this study was anchored while the CHAT provided the methodological and analytical tools that were used in this study. Additionally, Mavhunga and Rollnick's (2013) topic-specific pedagogical content knowledge (TSPCK) was used to provide extra theoretical lenses to develop and understand the lessons co-designed by the teachers in this study. This study focused on social learning. It used *umqombothi* and *oshikundu* both of which are traditional beverages among the Xhosa and Oshiwambo people, respectively. Vygotsky's sociocultural theory provided the broad theoretical framework to understand how the use of these cultural artefacts as well as language promoted learning. However, the sociocultural lens would only enable me to understand how individual teachers learn through the acquisition of new knowledge. In other words, it would only enable me to conceptualise the learning as a shift in individual teachers' ZPD.

The purpose of this study was to understand how the teachers collectively transformed their knowledge, attitudes, and professional insights through confronting the contradictions embedded in their work as science teachers. This required a theoretical lens that would allow me to conceptualise learning not only as a shift in the teachers' zone of proximal development (ZPD), but as a qualitative transformation that goes beyond the mere acquisition of preconceived knowledge. For this reason, CHAT was chosen to complement the sociocultural theory because it provides what Mukute and Lotz-Sistka (2012) described as "ontological depth" and "empirical possibilities". Thus, from CHAT I drew both methodological and analytical tools to understand this study.

The following sections briefly discuss the three theories. Each section starts with a brief description of the theoretical framework before explaining its relevance to this study.

3.2 Vygotsky's Sociocultural Theory

According to Sannino (2011, p. 1), "The human mind is not located within the brain, not even bounded by the skin of the individual. The mind is in actions and activities in which humans engage with the world, by means of cultural artefacts such as signs and tools". Underpinned in this statement is the assumption that human cognition has a social origin. Thus, a sociocultural lens was used in this study in conjunction with the CHAT to understand how this formative intervention transformed the BEd Natural Sciences in-service teachers' attitudes, knowledge, and pedagogical insights. The sociocultural theory is a learning theory based on the notion that human cognition has a social origin and is mediated through cultural tools. This theory is largely attributed to the work of the Russian psychologist, Lev Semionovich Vygotsky (1896-1934) who is regarded as its founder and main proponent. Vygotsky based his theory on the tenets that learning is a socially mediated process; humans use cultural tools, symbols, and artefacts to mediate their understanding of the world around them; and that learning takes place within the ZPD (Shabani, 2016).

The sociocultural theory views learning as a socially mediated process in which learners construct their own understanding of phenomenon through interaction with their peers and the MKO. Vygotsky (1978, p. 163) reasoned that "any higher mental function first appears between people as inter-psychological category before it is appropriated and internalised by the individual learners as an intra-psychological category". In other words, although at first knowledge is co-constructed through interaction with peers and the MKO, each individual learner builds their understanding as they internalise the learning process. In Hawkins' (2008) view, internalisation refers to the mechanism by which knowledge built during the social, interpersonal interactions is appropriated and incorporated into the individual learner's own understanding.

The role of the MKO (who is usually the teacher) is to give instructional support to the learner so as to stretch their understanding from that which they already know to that which they can potentially know or do with assistance. Vygotsky (1978) referred to this continuum between what the learner already knows and can do without assistance and that which they can potentially learn or do, as the ZPD. Ismail, Ismail, and Aun (2017, p. 155) illustrated the ZPD diagrammatically as shown below.

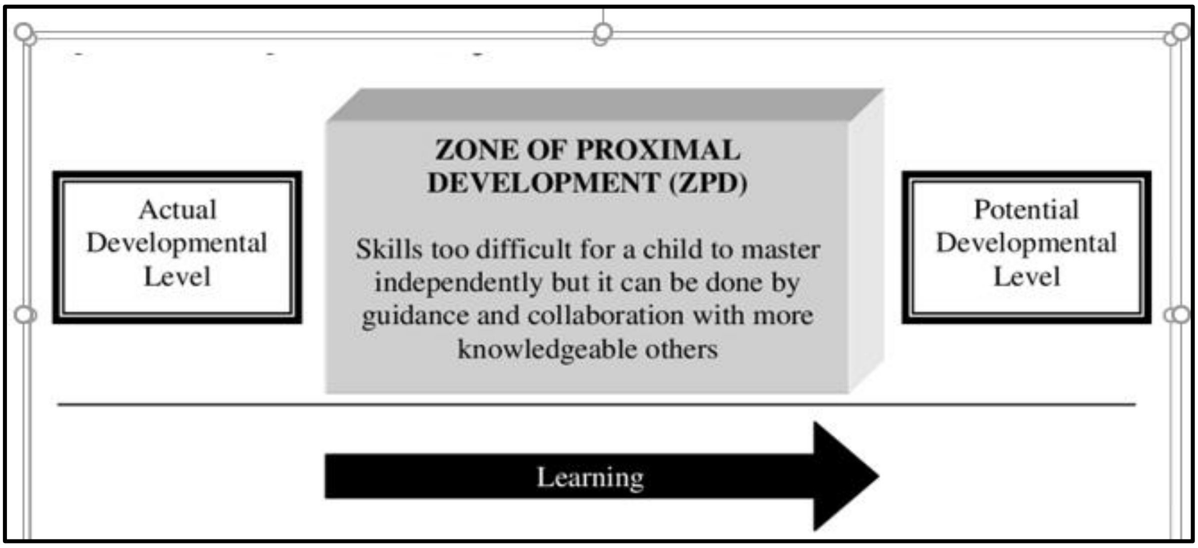

Figure 3.1: Illustration of the ZPD (Adopted from Ismail et al., 2017, p. 155)

This drew Englert et al. (2006) to equate learning to "cognitive apprenticeship" which they view as the use of instructional strategies, devices, actions and instructional tools to support learning (p. 209). These strategies involve actively engaging learners in collaborative activities in which they interact with their peers or the MKO who is usually the teacher. Vygotsky (1978) contends that the role of the teacher in cognitive apprenticeship is to assist learners to reach higher levels of cognitive functioning that would have otherwise been impossible to reach without assistance.

Extending on Vygotsky's seminal work, Wood, Bruner, and Mead (1986) conceptualised this support as scaffolding. Lending support, Rojas-Drummond et al. (2013, p.12) defined scaffolding as the temporary support and gradual withdrawal and "transferring of responsibility to novices so as to promote eventual appropriation of knowledge and abilities as well as self-regulation". This shows that the ultimate intention of scaffolding is to empower learners to take charge of their learning. This should be tactfully done through gradually transferring responsibility to them so that they can complete the task on their own. The MKO's diminishing support and the novice learners' increasing responsibility in the scaffolding process is well captured in the illustration below.

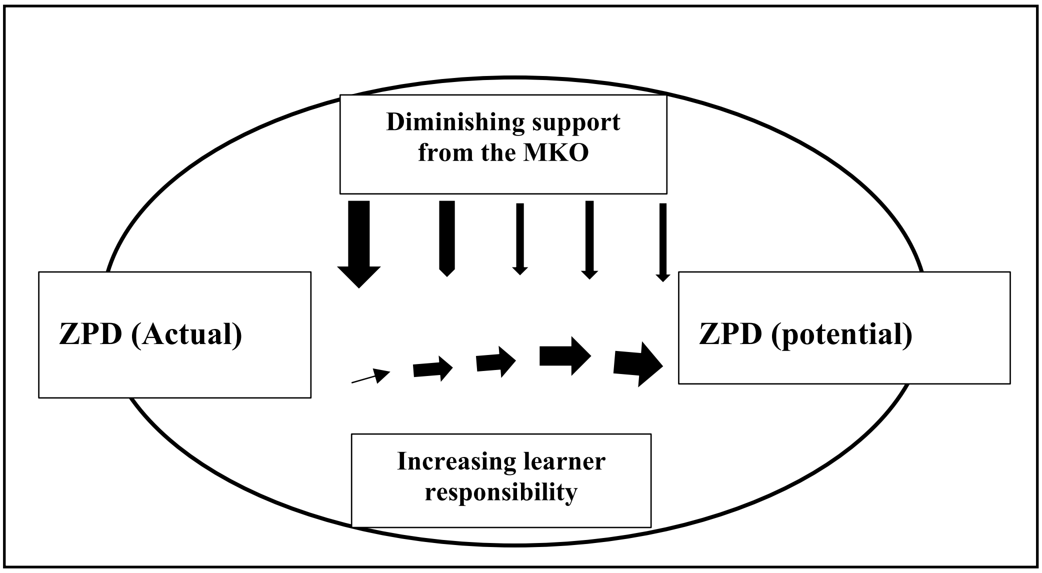

Figure 3.2: The process of scaffolding (Adapted from Drummond et al., 2013, p. 13)

In this diagram Drummond et al. (2013) illustrated how the more knowledgeable other (MKO) gradually hands over the learning process to the learners. As the learners gain more control of what they are learning, the MKO gradually hands over the learning process to them. Accordingly, Van de Pol, Volman, and Beishuzein (2010), identified the three phases of scaffolding as *contingency*, *transfer of responsibility,* and *fading*. In their view, contingency entails the teacher's response aimed at meeting the learners' needs, while transfer and fading refer to the gradual shifting of responsibility from the MKO and handing over to the learner who eventually withdraws as the learners become more competent. This implies that scaffolding is not just any instructional activity by the teacher, but a special type of teaching approach that is sensitive to learners' needs. In other words, teachers do not just scaffold learners. Instead, they offer them assistance in response to the type of challenges that they face. As Van de Pol et al. (2010) noted, teachers scaffold learners in order to structure their thinking, give them feedback, explain, model, probe, and to promote critical and deeper thinking, among others. For instance, in Figure 3.2 the arrows pointing downwards represent the diminishing support from the teacher while the horizontal arrows show the increasing responsibility as the intervention progresses. It could be hypothesised that the increased responsibility is the function of social interactions.

Sociocultural theorists argue that social interactions are mediated through the use of cultural tools, symbols, and artefacts of which language is the most crucial cultural tool. In light of this, Vygotsky (1978) reasoned that just as humans require tools to act upon their physical environment, they equally require cultural tools and artefacts to mediate their understanding of the world. Expanding on Vygotsky's seminal work, Marginson and Dang (2016) averred that cultural tools refer to both the physical and psychological tools such as language and other mental resources that we use to mediate our understanding of phenomenon. For instance, in a science lesson, psychological tools such as the scientific formulae, diagrams, theoretical models, mnemonics, drawings, speech, and written language can be used by both the teacher and the learners to mediate learning while the apparatus and all the material resources are the physical cultural tools (Marginson & Dang, 2016; Vygotsky, 1978). It is through these cultural artefacts and symbols that learners will be able to organise their thoughts, communicate, visualise, and understand the scientific concepts.

Among these cultural tools, language is considered as the most crucial mediational tool since it is the medium through which people express their thoughts and coordinate their actions in inter-mental activities. Through language humans are able to share their experiences, learn from each other, and preserve the wisdom from previous generations (Marginson & Dang, 2016; Vygotsky, 1978). Thus, as a mediational tool, language is the medium through which ideas are transacted between the novice learners and the MKO. Vygotsky (1978) added weight to this by saying that language mediates both inter-mental interaction and intra-mental cognition and self-regulation (Harrison & Muthivhi, 2013).

Drawing from the above arguments, some sociocultural theorists favour teaching methods that promote social interaction among learners and between learners and their teacher. For instance, Chappell (2012) advocated for dialogic teaching methods which she describes as any collective exchange of ideas in which learners talk to each other or to their teacher to share what they think and gain deeper insights of what they are learning. She maintained that dialogic teaching creates an opportunity for learners to co-construct meaning through interrogating their thought processes, criticising each other, and debating and discussing, all of which lead to joint understanding and shared meaning. Her views resonate with Ogunniyi's (2007a) views who postulated that argumentation promotes learning, especially among adult learners. Similarly, Sedlacek and Sedova (2017) also found a correlation between talking and critical thinking in their study on dialogical teaching.

Taking a cue from the above arguments, the lecturer used group work as a strategy to encourage the BEd Natural Sciences teachers to co-construct knowledge [see Chapter Four] as they analysed the curriculum, co-developed lessons that integrated IK, and co-presented their findings. In Vygotsky's view, learners develop higher mental skills through interaction with their peers and the MKO which promotes higher cognition. In support of this, Engeström (2015) also added that engaging participants in collaborative work harnesses their collective transformative agency. In CHAT, transformative agency refers to the willingness to break away from the conventional ways of doing things and seeking new solutions to problems. Their observation was that through engaging workers in collaborative work they collectively envision new possibilities. In other words, their collective change efforts enable them to see things beyond their individual capacities (Haapasaari et al., 2016). The role of the lecturer throughout the intervention was to scaffold the participants where necessary.

However, Rojas-Drummond et al. (2013) took a broader look at scaffolding and argued that scaffolding can also be enacted through the actions of other learners. These findings resonate with the findings of a similar study conducted earlier by Donato (1994) which found that during collaborative dialogue, learners provided each other with mutual support which enabled them to solve problems. Donato concluded that although individually learners may be novices, collectively they are experts. This underscores the value of teaching strategies that promote peer interaction through collaborative learning by engaging learners in activities that enable them to interact, exchange ideas, criticise each other, reflect upon their own thinking, and refine their understanding. Englert et al. (2006) also pointed out that cognitive apprenticeship is not a unidirectional process, but one that involves both the novice learner(s) and the teacher in "combining their mental resources" to solve the given task (p. 209).

Further criticism of Vygotsky's theory comes from those who claim that it is often misunderstood and misapplied in many educational researches that claim to use it as a theoretical framework. For instance, and as alluded to earlier, Palincsar (1998) contended that the ZPD is one of Vygotsky's most misunderstood concepts in educational research. Stott (2016) concurred and added that this is usually caused by the translation and interpretation of Vygotsky's work from Russian to English, the use of the ZPD outside Vygotsky's intended context, and the conflation of the terms learning and development. For instance, Steele (2001, p. 405) simplified this by saying that "the ZPD is that place for learning located somewhere between the child's present understanding and his/her potential understanding".

To Chaiklin (2003), Stott (2016) and others, such a simplistic interpretation of the ZPD is misleading. For instance, Miller (2011) also argued that educational researchers often claim to be working with the ZPD from a Vygotskian perspective yet the meanings and interpretations they impose to the constructs of the theory are not embedded in the original Vygotskian theory. In light of such confusion, Rowlands (2003) suggested that it is better to use the terms *Historical Vygotskian* and *Our Vygotsky* to distinguish between those who are using the theory in its original state and those adapting it to any other context outside Vygotsky's initially intended use. Additionally, some scholars also contest the simplistic interpretation of the ZPD which they see as misleading. For instance, Steele (2001, p. 405), described the ZPD as "that place for learning located somewhere between the child's present understanding and his/her potential understanding".

In light of the above, I argue that conceptualising the ZPD as a place of learning fails to account for the dynamic nature of the ZPD. For that reason, I borrowed Stott's (2016) definition of the ZPD as a continuum between what the child already knows and that which they may potentially know with the assistance of the MKO who may be their teacher or their peers. While Vygotsky's theory was relevant to this study, concepts such as the ZPD and novice-expert assumption underpinning the sociocultural theory were not applicable to this study. The participants in this study were adults with different expertise and experience in their careers and activities, such that it would be inappropriate to consider them as novices. For this reason, the ZPD concept was used to refer to expansive shifts in the teachers' understanding of how to integrate IK as spelt out in the CHAT discussed below.

3.3 The Cultural Historical Activity Theory

> Cultural historical activity theory is a new framework aimed at transcending the dichotomies of micro- and macro-, mental and material, observation and intervention in analysis and redesign of work. The approach distinguishes between short-lived goal-directed actions and durable, object-oriented activity systems. A historically evolving collective activity system, seen in its network relations to other activity systems, is taken as the prime unit of analysis against which scripted strings of goal-directed actions and automatic operations are interpreted. (Engestrom, 2000, pp. 960-974)

The activity theory emerged in the 1920s from the work of Russian psychologists as an alternative explanation of human behaviour to the psychoanalysis and behaviourist theories that dominated psychological research at the time. CHAT, which is a further extension of the activity theory, originates from Vygotsky's idea of mediated learning (Nussbaumer, 2012). It was developed by Vygotsky's students and followers among whom were Leont'ev, Luria, Michael Cole, and Engeström, after the untimely death of Vygotsky in 1934. The term CHAT was coined by Cole (1988) who introduced the theory to the Anglophone Western countries. The theory was then popularised by Engeström who wrote extensively on it and developed it into what came to be known as the second, then third generation, and is now working on the fourth generation CHAT (Engeström, 2015; Nussbaumer, 2012).

As already mentioned above, Vygotsky viewed learning as a mediated social process. To him, the stimulus-response relationship in humans is not a direct relationship as implied by behaviourist learning theories because humans mediate their understanding of the world using cultural tools. By so doing Vygotsky challenged both the cognitivists and behaviourist perspectives on human cognition. According to Miettinen (2001), both the behaviourist and cognitivists' theories are unsatisfactory in that, the behaviourists tend to reduce psychological processes to reflex actions while the cognitivists tend to view human cognition as an independent internal reality. Instead, Vygotsky drew our attention to the fact that human cognition is rooted in our culture and understanding is mediated through cultural tools. Taking up this idea, Engeström (2001) crystallised it into the first-generation CHAT diagram shown on the following page:

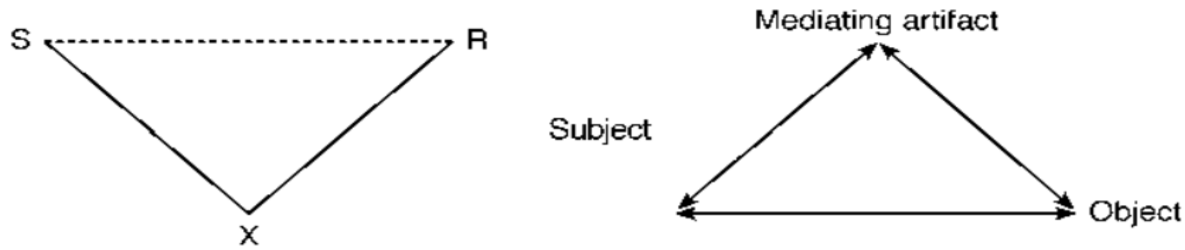

Figure 3.3: Shows the stimulus response as a mediated action (Engeström, 2001, p. 134)

This diagram shows us that human behaviour is complex. Thus, human behaviour cannot be explained using the simple, direct stimulus response relationship because humans mediate their actions through the use of cultural tools, symbols, and artefacts (Engeström, 2001). As such, learning should be understood as a culturally mediated process. In other words, acquiring knowledge through the use of cultural tools.

However, Vygotsky's first-generation CHAT is often criticised for its failure to divorce itself from the traditional Western psychology of that time which focused on the individual as the unit of analysis. In response to this shortcoming, Leont'ev (1981) shifted the unit of analysis from the individual to a collective activity system. He argued that the individual's *being* is a sum of various interacting components which constitute an activity system. Engeström (1987) modelled these ideas into what came to be known as the second-generation CHAT illustrated below.

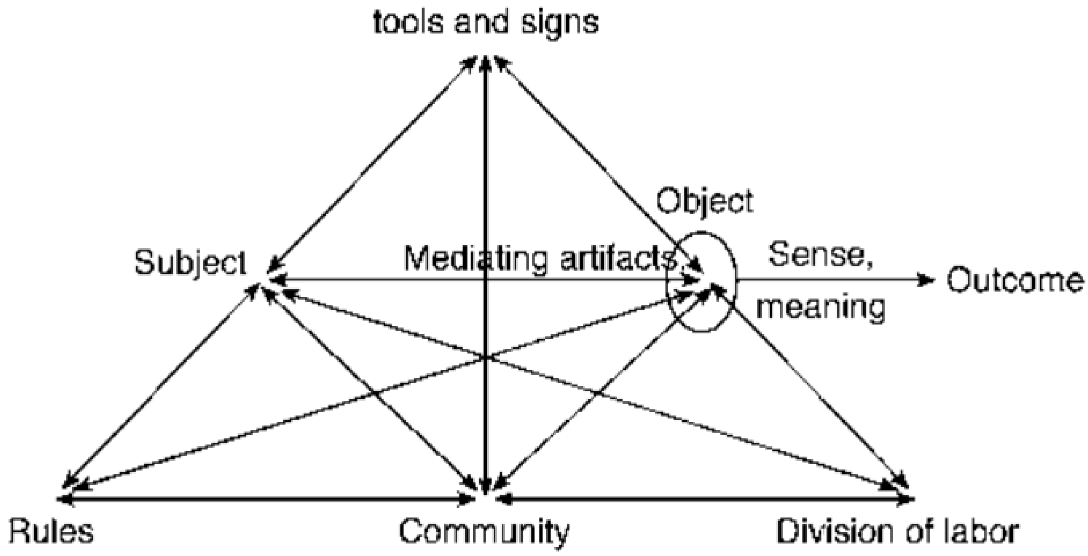

Figure 3.4: The structure of human activity (Engeström, 2001, p. 135)

This diagram shows us the collective activity system which is the central unit of analysis. The activity system is defined by Engeström (2001) as an object-oriented, artefact-mediated, multi-layered and multi-voiced system that is influenced by contextual and historical factors. Hence, to understand human activity we need to consider how it is influenced by many underlying factors. In this vein, Engeström (2001) argued that a human activity system is a system of complex interacting factors which include the subjects, the mediating tools, the rules, the object, the community, and the division of labour. These factors form the basic elements of an activity system. The subjects in this study were the BEd Natural Sciences in-service teachers who explored how to integrate IK in science lessons, using *umqombothi* and *oshikundu* as examples of easily accessible resources that can be used to mediate learning. To understand how the intervention learning created opportunities or not, the behaviour of these teachers could not be analysed in isolation, but in conjunction with other factors such as the division of labour among the different participants. Accordingly, Engeström (2001) posited that human behaviour cannot be understood in isolation without paying attention to the underlying factors that influence it.

However, critiques argued that the second-generation CHAT is insensitive to diversity (Cole, 1988) which means that it does not give the researcher the flexibility to account for the influence of factors outside the ambit of the activity system under investigation. In response to this limitation, Engeström (1987) developed the third generation CHAT which acknowledges that human activity can be influenced by a network of interacting activity systems aimed at achieving a common object as illustrated in the diagram below.

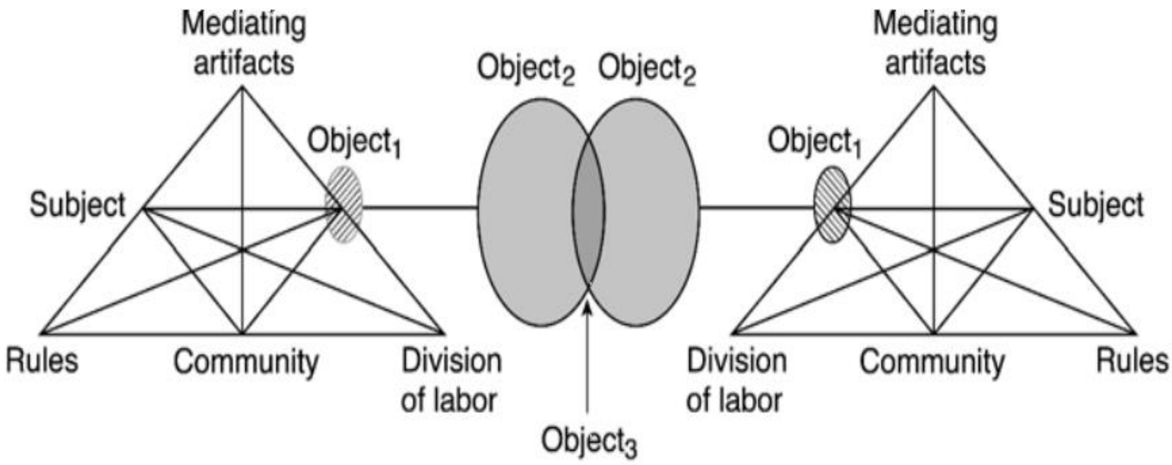

Figure 3.5: Shows human activity as a series of interacting activities (Adopted from Engeström, 2001, p. 136)

This diagram shows that an activity system exists in a network of interconnected activity systems, united by their pursuit of one goal/object. Thus, to understand human activity, the researcher needs to focus beyond the local activity so as to see how it is influenced by other activity systems. It is with this understanding that my gaze in this study focused on how the different stakeholder activity systems in science education accounted for the contradictions identified in this study. The third generation CHAT diagram was adapted and used to analyse the contradictions between the different, overlapping activity systems that can be identified as stakeholders in the policy of integrating IK in science education. These activity systems share the common object which is science education.

3.3.1 Contradictions

Contradictions are understood as structural tensions within any activity system that accumulate over a long period of time and are traceable to the history of the object. CHAT scholars argue that an object is fraught with contradictions that accumulate over time (Chikunda, 2013; Engeström, 2001; Engeström & Sannino, 2011). They usually arise when new tools, new rules, or new ways of doing things are introduced to an already existing activity system. This usually disrupts the system as the elements of the old system resist. In the context of this study, the new tool that was introduced to science education was IK. This created inevitable tension in science education because science is historically known to have been used to eradicate IK in what Le Grange (2016) regarded as epistemological genocide.

According to Engeström and Sannino (2011), contradictions are not observed directly. Instead, they manifest themselves as tensions, dilemmas, and conflicts within an activity system. These tensions, dilemmas, and conflicts are embedded in a participant's actions and words. Thus, contradictions can only be seen through listening to what participants say and observing what they do. To access the contradictions in this study, I used techniques that drew on both the participants' *voices* and observable behaviour to expose the contradictions embedded in their words and actions. While contradictions are usually viewed as negative forces within an activity system, CHAT scholars have argued that contradictions are the driving force behind learning (Engeström & Sannino, 2011; Haapasaari et al., 2016). These scholars argued that people often learn new ways of doing things as they try to resolve the contradictions embedded in their activity. It is with this understanding that I sought to understand how the contradictions at the nexus of the different, overlapping activity systems involved in this study created the agency in teachers to learn how to integrate IK in science lessons. For this reason, Engeström's (2001) second generation and third generation CHAT diagrams were used to understand the intra-systemic and inter-systemic tensions in science education and how these tensions informed the teachers' agency to learn. Learning was viewed as a process that involves both the internalisation of already existing knowledge and the externalisation of knowledge through the generation of new solutions to the challenges that the teachers face in their efforts to integrate IK in their science lessons. In other words, learning in this study refers to both an acquisition and a generative process in which teachers had to come up with new ways of integrating IK in science lessons that were not known to all of us prior to the intervention. The following section discusses expansive learning.

3.3.2 Expansive learning

According to Engeström and Sannino (2010, p. 2), expansive learning is a complex process that can be understood through engaging with the folowing philosophical questions:

- "Is learning primarily a process that transmits and preserves culture or a process that transforms and creates culture?
- Is learning primarily a process of vertical improvement along some uniform scale of competency or horizontal movement, exchange and hybridisation between different cultural contexts and standards of competence?
- Is learning primarily a process of acquiring and creating empirical knowledge and concepts or a process that leads to the formation of theoretical knowledge and concepts?"

They further elaborate that expansive learning should be understood as a transformative process in which members of a CoP collaboratively transform the object of their acitivity. Expansive learning involves the creation of new solutions to the challenges that people encounter in their work. Engeström and Sannino (2010, p. 2) consolidated this by saying, "In expansive learning, learners learn something that is not yet there. In other words learners construct a new object and concept for their collective activity, and implement this new object and concept in practice". This implies that the concept of expansive learning acknowledges the learner's transformative agency.

3.3.3 Transformative agency

Transformative agency is viewed as the learners' willingness to break away from the conventionally accepted ways of doing things and exploring new ways. It entails a collective transition from old to new ways of doing things. Haapasaari et al. (2016) further explained that transformative agency leads to distributed, collective agency whereby members of a CoP undergo collective expansive transition. This expansive transition is not a once off here-and-now event but instead is something that evolves over time as the participants gradually crystallise the object of the activity through debating, discussions, and engagement in activities that transform their understanding of phenomenon. Essentially, transformative agency manifests itself as agentive actions displayed by the participants. Engeström and Sannino (2010) identified five agentive actions as resistance, explicating, envisioning, commitment to concrete actions, and taking consequential actions. Each one of these concepts is explained below.

3.4 Relevance of the Two Theoretical Frameworks in my Study

As already mentioned above, both Vygotsky's sociocultural theory and Engeström's CHAT were used as complementary intellectual resources to gain a deeper understanding of the teaching-learning process that took place in this intervention. While the sociocultural theory provided the overarching theoretical framework, the CHAT provided the methodological and analytical tools that were used in this study. From Vygotsky's theory, for instance, I drew on the following principles: the use of cultural tools; social learning; zone of proximal development; and scaffolding. The nature of this study made these concepts important as a theoretical lens through which I viewed the teaching-learning process in this study.

3.4.1 Use of cultural tools

The study focused on how teachers can be supported to integrate IK in their science lessons using *umqombothi* and *oshikundu*, which are traditional beverages among the Xhosa and the Oshiwambo people, respectively. The sociocultural lens enabled me to scrutinise how different cultural tools were used to mediate learning. These included the IK embedded in the making of the two beverages, English and indigenous languages, as well scientific apparatus, concepts, models, symbols, and diagrams.

3.4.2 Social learning

Drawing on Vygotsky's (1978) concept of social learning, collaborative learning was promoted by engaging teachers in group activities that would create opportunities for them to collectively generate new ideas on how to integrate IK in science lessons. In other words, the principle of social learning informed the decision to use collaborative group work as the major pedagogical approach in this intervention. Hence, the BEd Natural Science in-service teachers were grouped and engaged in collaborative work throughout this intervention. My interest was to see how their participation in group work created (or not) opportunities for social learning. This is consistent with Vygotsky's (1978) observation that although the construction of knowledge is a personal psychological process that occurs within the individual learner, learning is mediated through social interaction with peers and the MKO.

3.4.3 The more knowledgeable other

While in Vygotsky's theory the MKO is usually the teacher, in this study this position was fluidly interchangeable among participants. The reason for this fluidity was because none of us was an overall expert in every aspect of this study. For instance, while the BEd Natural Science in-service teachers and their lecturer were knowledgeable in science, they were the novices when it came to the making of *umqombothi* and *oshikundu.* Instead, it was the community members who were the experts in the making of *umqombothi* and *oshikundu.* At the same time, all of us were novices in the integration of IK in science education since none of us received any formal training on how to integrate IK in science education. as suggested by Shizha (2007) and Mothwa (2011) cited in the literature review, who pointed out that science teachers struggle to integrate IK in their teaching because they received Eurocentric education that denigrated IK.

Thus, the participants took turns to share their expertise as they collaboratively engaged in different activities to co-design exemplar lessons that integrated IK. As already pointed out, these teachers had different science backgrounds. Some specialised in science in their teacher's training while others had not studied science beyond high school. The sociocultural lens helped me to see how the teachers scaffolded each other as they worked in their groups. Thus, taking counsel from Vygotsky (1978), group work was used to harness the social learning potential created by collaborative engagement.

3.4.4 Zone of proximal development

The sociocultural lens was also important in understanding the learning that took place which Vygotsky (1978) conceptualised as a shift in the learners' ZPD. However, Vygotsky developed his theory in an attempt to understand child development, and as the participants in this study were adult and experienced science teachers, the concept of development could not be applied in its Vygotskian sense. This means that the application of Vygotsky's theory had limitations in this study. For instance, while Vygotsky's theory tends to imply learning towards predetermined knowledge, the purpose of this study was to explore, experiment, and generate novel ideas that were unknown to all participants at the beginning of the project. This meant that the sociocultural theory alone would not enable me to get a full picture of the expansive opportunities generated by this study.

To resolve this tension, I relied on the CHAT from which I drew both methodological and analytic tools. Although I had not initially conceptualised my research process as the change laboratory, I realised when I was writing my methodology chapter that my research methodology followed the change laboratory cycle. In essence, CHAT offered me what Foot (2014. p. 329) described as a "a multi-dimensional, systemic approach" in analysing both the research method and the data gathered in this study. It enabled me to understand how different factors interacted to transform the BEd Natural Sciences in-service teachers' attitudes, professional insights, and knowledge of how to integrate IK in science lessons.

This study began with what Engeström (2001) called questioning the need state by exploring the teachers' prior knowledge of how to integrate IK. The data gathered from this became the mirror data against which any shift in the teachers' knowledge would be understood. I applied CHAT to trace the contradictions in science education emanating from the historicity of science education in South Africa. I used Engeström's (2001) second generation CHAT triangles to identify the primary contradictions within the tools, the subjects, and the object. This emerged from the data gathered in phase one through the questionnaire, the individual interviews, and the focus group interview.

The second phase of this study involved two practical demonstrations, after which teachers were asked to draw mind and concept maps using the scientific concepts drawn from the process of making *umqombothi* and *oshikundu*. Thereafter, they co-designed exemplar lessons that integrated IK. In CHAT terms, this phase involved modelling and experimenting with the new ideas. The CHAT lens was used to understand the expansive learning opportunities created by these workshops. In other words, my interest as a participant observer was to see how the interaction of the different participants in this study created learning opportunities. These participants were the science teachers (as the learners), the community members (as the IK experts), and the science lecturer (as a facilitator).

I also scrutinised how participants used different cultural tools, symbols, and artefacts to support their learning. These included their indigenous language, *umqombothi,* and *oshikundu*, as well as chemical equations. This talks to giving back the agency to the learners as propounded by Haapasaari et al. (2016). Speaking about the importance of language in learning, Sedlacek and Sedova (2017) argued that there is a close link between speaking and thinking. Thus, analysing the participants' use of language was important to enable me to understand not only how this intervention shifted or not the participants' dispositions and understanding of how to integrate IK in science lessons, but also the discursive manifestations of contradictions and transformative agency in this study.

3.5 Chapter Summary

This chapter examined the sociocultural theory and the CHAT as the theoretical frameworks that informed this study. It was argued that while the sociocultural theory was the overarching theoretical framework, CHAT provided the analytical and methodological tools. The study's purpose in this was to promote social learning among peers using easily accessible sociocultural resources. It used IK in the making of *umqombothi* and *oshikundu* as a germ cell to promote further learning. Engeström and Sannino (2011) defined a germ cell as that unit that enables the learners to make connections between abstract and concrete manifestations of a phenomenon. Learning is thus a process of ascending from the abstract to concrete (Sannino, 2011). The sociocultural theory provided the lens through which we could understand the social dynamics influencing this study. On the other hand, CHAT enabled us to understand the contradictions embedded in science education and how these influenced learning. It also helped me to account for both the acquisitional and expansive learning experiences in this study. These two theoretical lenses together with Mavhunga et al.'s (2016) TSPCK complemented each other in giving me a clearer picture of the shifts in the teachers' attitudes and professional insights as well as their PCK on the integration of IK in science lessons.

CHAPTER FOUR: RESEARCH METHODOLOGY

> A research methodology refers to a set of systematic techniques used in research. This simply means a guide to research and how it is conducted. Typically, it encompasses concepts such as paradigm, theoretical model, phases and quantitative or qualitative techniques. It describes and analyses methods, throws more light on their limitations and resources, clarify their pre- suppositions and consequences, relating their potentialities to the twilight zone at the frontiers of knowledge. (Igwenagu, 2016, p. 5)

4.1 Introduction

The previous chapter looked at the theoretical frameworks that inform this study. This chapter outlines the research methodology that was followed in conducting this study. Taking counsel from Igwenagu (2016) in the above epigraph, this chapter briefly discusses and justifies the research paradigm underpinning the study, the research design, sampling procedures, the data gathering techniques and the procedure that was used for data presentation and analysis as well as the validity and ethical considerations undertaken in conducting this research. The section on ethics was deliberatively left out in this chapter and presented as Chapter Five of this study so as to illuminate the ethical dilemmas that we encountered in this study. The starts by briefly discussing the research paradigms that underpinned the study before moving the research design and research methods.

4.2 Research Paradigms

All research is guided by a set of philosophical underpinnings. Indigenous methodologies are in line with an indigenous paradigm, while critical and liberatory methodologies fit with the transformative paradigm. Yet indigenous and transformative methodologies share an emancipatory and critical stance and thus are increasingly used in tandem by both Western and indigenous scholars in an attempt to decolonise methodologies, research, and the academy as a whole. However, these multi-paradigmatic spaces only superficially support decolonisation (Held, 2019, p.1).

According to Denzin and Lincoln (2008), a paradigm is an overarching philosophy guiding practice in research. In support, Tracy (2019, p.38) commented that "The type of glasses you were affects the way you see the world". The point that Tracey was making is that the philosophical assumptions that the researcher has at the back of his/her mind influences the way he/she sees reality. In educational research, this refers to what Kivunja and Kuyini call a 'researcher's worldview' or school of thought that informs his or her interpretation of the research data. Enshrined in this world view are *ontological, epistemological* and *axiological* assumptions that inform the research methodology. Scotland (2012) described ontological assumptions as our understanding of what constitutes reality and epistemological assumptions as the means by which knowledge is acquired, while axiological assumptions refer to the values underpinning a research study. Thus, a paradigm determines the type of research questions that the researcher asks and the steps that he/she takes in conducting the research. This study drew insights from the interpretive paradigm, in conjunction of the critical and indigenous research paradigms.

4.2.1 Interpretive paradigm

This study explored how to support BEd Natural Sciences in-service teachers to develop model lessons that integrate IK. An interpretivist paradigm was employed to enable me to see what Denzin and Lincoln (2008) described as multiple realities. In their view, human behavior is so complex that it needs to be studied from many angles. My interest in this study was to understand the shift (or not) in the BEd NS in-service teachers' attitudes, knowledge, and pedagogical insights as they generated new knowledge. To achieve this, I had to understand the teachers' attitudes, knowledge and pedagogical insights that they brought as their prior knowledge so that I could trace if there were any changes. An interpretivist paradigm also enabled me to make a descriptive analysis of the teachers' responses to the questionnaire and the interviews conducted in phase one of this study.

However, the major limitation of the interpretive paradigm is that it tends to focus on descriptions at the expense of explanations (Rehman & Alharthi, 2016; Scotland, 2012). In this study, I wanted a paradigm that would me to go beyond the mere description of phenomena and enable me to embrace the indigenous people's cultures. Commenting on the limitations of using Eurocentric paradigms in conducting research in indigenous communities, Botha (2011) cautioned that indigenous research methodologies should go beyond the conventional practices in research to embrace the indigenous peoples' epistemologies and axiological assumptions "to embrace more appropriate epistemological and axiological assumptions" (p. 313). Additionally, the interpretive paradigm is also silent about axiological issues that underpin a study. These are the values and ethics that are embedded in the study. To counteract these shortcomings, I complemented the interpretive paradigm with the critical and Ubuntu paradigm.

4.2.2 Critical paradigm

This study drew insights from the critical paradigm in conjunction with Ubuntu. The study had an emancipatory mission in that it explored how to decolonise the tertiary science education curriculum through the integration of indigenous knowledge. This ideal aligns it with the critical paradigm which Scotland (2012) described as a tool for emancipation. While both the positivists and the interpretive seek to describe phenomena, the critical paradigm seeks to transform society to make it more egalitarian (Cohen et al., 2018; Rehman & Alharthi, 2016; Scotland, 2012). As such, it can be argued that both the positivist and interpretive paradigms perpetuate inequalities in society by concentrating on mere descriptions without challenging the illegitimate and repressive forces which supress the voices of others (Scotland, 2012; Rehman & Alharthi, 2016). It is this emancipatory nature of the critical paradigm that resonates with the goal of my study.

The underlying assumption in the critical paradigm is that research, like any other human behaviour, silences the voices of 'others' while it protects and legitimatise the interests of those in power as legitimate knowledge (Cohen et al., 2018; Rehman & Alharthi, 2016). Resultantly, scholars who use the critical paradigm pursue a social justice agenda by paying attention to issues such as representation, equal participation, giving voice to participants and inclusivity. These issues were central to this study which is the reason why I chose the critical paradigm.

One of the characteristics of the critical paradigm is that the research questions are usually constructed with the participants. However, in my study I formulated the research questions and later modified them with the participants. This was largely because I had very limited time with participants. My participants were the BEd Natural Sciences in-service teachers who would visit the university for contact sessions that occurred four times as year. As a result, they had a very tight program as every lecturer would be rushing to cover as much work as possible.

Using the critical paradigm enabled me to understand the underlying *historical* factors that influenced the BEd Natural Sciences in-service teachers' behaviour and actions in this study. This is aligns CHAT's central ternant on the surfacing of contradictions within an activity system. For instance, I was able to see how the teachers' experiences, attitudes, and professional insights were influenced by the historicity of science education (Engeström, 2001). My interest in this study was not to merely understand the teachers' experiences, attitudes, and knowledge with regards to the integration of IK. Instead, the ultimate goal of this study was to transform their attitudes, knowledge, and pedagogical insights with regards to the integration of IK. To understand this transformation, I needed a research paradigm that would enable me to look at phenomena from different angles. As alluded by Scotland (2012), human behavior is so complex that it needs to be studied from different angles. In this study, this was achieved through the use of different research instruments from which rich qualitative data was gathered.

The critical paradigm also enabled me to conceptualise and operationalise this intervention as a bottom-up decolonisation process of research, which Le Grange, Du Preez, Ramrathan and Blignaut (2020) viewed as an imperative step towards the transformation of higher education curriculum. In their study, Le Grange et al. (2020) noted a quick-fix instrumentalist approach to transformation as many universities grappled with the aftermaths of 2015/2016 #Rhodes Must Fall campaign which added impetus to the need to transform the existing higher education curriculum. They coined these smokescreen changes 'decolonise washing' which refers to the act of pretending to change while preserving the status quo.

To Le Grange et al. (2020), decolonisation is both a collective and individual endeavour which requires the commitment of many stakeholders. In support, Mbembe (2021, p. 2) avered that the essential philosphical meaning of decolonisation lies in "an active *will to community"* which he equates to the will to power or the will to life. In the context of this study, such will to the community was achieved through a bottom-up decolonisation research approach which acknowledged teacher participants' agency and the invited expert community members who shared their cultural heritage with the BEd Natural Sciences in-service teachers.

The critical paradigm also made me realise that both knowledge and knowledge production are not neutral. because they are influenced by the positional power of their advocates (Cohen et al., 2018; Scotland, 2012). I began to see the micro-aggressive elements embedded in the conventionally accepted Eurocentric research paradigms. It also drew my attention to the power dynamics embedded in my own positionality as a 'foreigner', a PhD scholar and how it could potentially contaminate the data that I gathered.

4.2.3 Indigenous research paradigm

As already pointed out in Section 4.2.1, the interpretive paradigm is often criticised for its silence on relational issues between the researcher and the participants. For this reason, I turned to the indigenous research paradigm. The indigenous paradigm is viewed by many scholars as an emerging approach to research which foregrounds the indigenous people's ontologies, epistemologies and axiologies (Chilisa, 2012; Le Grange, 2017; Mbembe, 2021; Seehawer, 2021; Wilson, 2008). However, it is important to understand that indigenous people are not a homogenous group of people with a universal culture and worldviews. For this reason, I drew on Ubuntu, which is a principle or perspective embedded in the indigenous paradigm, as the relational lens that informed our conduct as we collaboratively engaged in the co-construction of knowledge in this study (Chilsa, 2012; Wilson, 2008).

Ubuntu is an African philosophy that is commonly found among the people of Southern Africa, including the Xhosa who were the main subjects in my study. Ubuntu is viewed by many scholars as a moral quality embedded in the African people's understanding of being (Gade, 2012; Nusbaum, 2003; Seehawer, 2021). It is characterised by putting the interests of others first as summed up by Nussbaum (2003, p. 2) who asserted that Ubuntu is based on the understanding that: "Your pain is My pain, Your wealth is My wealth and Your salvation is My salvation!" – underpinned in this definition is the concept of togetherness where people relate to each other harmoniously through treating each other with dignity. Such people share in times of sorrow and in times of happiness. To Ogunniyi (2020, p. 157), "ubuntu has the potential to tame scientific practice in a way that it promotes human virtues such as humanness, communalism, interdependence, equity, social justice, and moral responsibility not only within the scientific community of practice but the society at large". It is with this understanding that I opted to draw insights from Ubuntu and research *with* my participants as opposed to researching *on* my participants as reiterated by Ngcoza and Southwood (2015). As an element of the indigenous research paradigm, the Ubuntu perspective complemented the critical paradigm by allowing me to also focus on the axiological assumptions of this study. Unlike the Eurocentric paradigms which strive to be as objective and impersonal as possible, the Ubuntu perspective cultivates humane relations between the researcher and the participants (Khupe & Keane, 2017; Seehawer, 2018) which resonates with decolonisation research (Seehawer & Breidlid, 2021).

4.3 Research Design

According to Terr Blanche, Durrheim and Painter (2006, p. 34), a research design can be thought of as "a strategic framework for action that serves as a bridge between research questions and the execution or implementation of the research". Similarly, Bertram and Christensen (2015, p. 40) defined a research design as "a plan of how the researcher will systematically collect and analyse the data that is needed to answer the research question. In other words, the research design determines what data the researcher will collect as evidence and how he/she goes about collecting the data. This drew Nieuwenhuis (2007, p. 70) to conclude that a research design is a "research strategy moving from underlying philosophical assumptions to specifying the selection of respondents, data gathering techniques to be used, and the data analysis to be done".

Within the interpretive, critical and Ubuntu paradigms, a case study research design was employed in this study**.** A case is defined as an enquiry which focuses on a single phenomenon, which is studied its real-life context with the intention of understanding the peculiar dynamics related to the case (Cohen et al., 2018). It can be seen from this definition that the most important feature of a case study is that it involves studying a particular instance to capture a holistic picture through an intensive scrutiny of its features. A case study uses different research instruments to capture data from different angles. It is the convergence of data from different sources that gives validity to the findings of a case study.

A case study research design was chosen in this research because it would enable me to gain an in-depth understanding of how BEd Natural Sciences in-service teachers can be supported to use easily accessible resources and integrate IK in their science teaching. The case in my case study were the BEd Natural Sciences in-service teachers and the bounded phenomenon which was the unity of analysis was the integration of IK in science teaching. This case study was also bound in terms of its geographical confinement in that it was conducted within the teacher education activity system at a particular university in the Eastern Cape Province of South Africa.

Within the case study, a participatory approach was used in which I, as the interventist, and the BEd Natural Sciences in-service teachers, and their science lecturer worked together as co-learners in a learning community (Lave & Wenger, 1991; Ngcoza & Southwood, 2019). To Christian and Bertram (2015) the key element of the participatory approach is that it engages people in a CoP in collaboratively identifying and solving the problems that confront them in their work place. It is this element that justifies my selection of the particpatory approach. As already mentioned in Section 2.7, the cascade model that is usually used in professional development in South Africa does not create enough room for teachers to generate their own solutions to the problems that they face in their profession (Jacobs, 2015). In response to this study used the participatory approach so as to create space for expansive learning (Engeström & Sannino, 2011) as they explored how to teach science integrating IK and using easily accessible resources.

4.4 Research Goal and Research Questions

The main goal of this study was to explore how to support the BEd Natural Sciences in-service teachers to integrate indigenous knowledge and use easily accessible resources in their teaching. This goal was achieved by answering the following research questions:

1. What are the BEd Natural Sciences in-service teachers' attitudes, experiences, and pedagogical insights on the integration of indigenous knowledge in science teaching?
2. What contradictions are embedded in the BEd Natural Sciences in-service teachers' attitudes, experiences, and pedagogical insights in relation to the integration of indigenous knowledge in science teaching?

3. What learning opportunities are created (or not) for the BEd Natural Sciences in-service teachers:

    a) When co-analysing and discussing the curriculum documents?

b) During the practical demonstrations by the expert[8] community members?

4. How can the BEd Natural Sciences in-service teachers be supported in co-designing:

   a) Science lessons that integrate indigenous knowledge using fermentation as an example?
   b) Their own exemplar lessons that integrate indigenous knowledge in other science topics?

5. How do the BEd Natural Sciences in-service teachers enact and envision the integration of indigenous knowledge in science teaching?

4.5 Research Site

This study was conducted at a former 'Whites-only' University in the Eastern Cape Province of South Africa (see Figure 4.1 below). The research was done at a time when the call to decolonization tertiary education was gaining momentum (Le Grange, 2016). Like any other university in South Africa, this university is also faced with the challenge of transforming its curriculum which was modelled along the Oxford-Cambridge style (Le Grange, 2014). Commenting on the state of higher education in the post-apartheid era, Le Grange (2016) and Ngcoza (2019) noted that although South Africa gained independence in 1994, her higher education continued with the colonial agenda of silencing and destroying indigenous knowledge systems. For instance, all the 26 universities in South Africa still use the same old curriculum that they were using prior to independence. A case in point is the university where this study was conducted which is an English medium school despite the fact that the majority of students at the institution are English second or third l language speakers.

Adding weight to this argument, Le Grange (2016) argues that the 'whiteness' of such institutions is also perpetuated by the fact that the shift in the demographic composition of the students in higher education was not accompanied by a similar shift in the demographic

[8]The community members invited to demonstrate how to make *umqombothi* and *oshikundu* were people who had the knowledge and experience of making the traditional beverages. For this reason in this study they shall be referred to as community experts because they are experts in their art.

composition of academics in higher education. As a result, the teaching staff in higher education is still predominantly white.

This brings impertus for studies like this, which explore how to decolonise the curriculum. Thus, one of the major contributions of this study to new knowledge is that it explored how to decolonise the science education curriculum in such institutions through the integration of IK. Presented below are the maps of South Africa locating the Eastern Cape Province as the research site of this study.

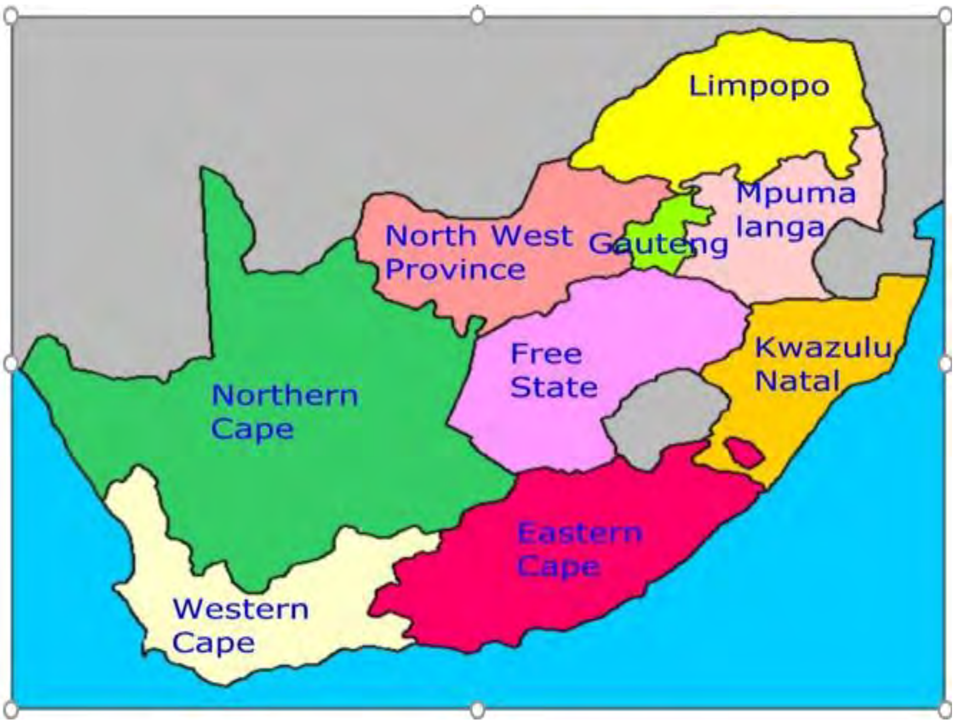

Figure 4.1: South African provinces

(https://www.google.com/search?q=Provinces+of+SA+MAP&tbm)

Figure 4.2: Regions of the Eastern Cape

(https://images.search.yahoo.com/yhs/search?p=Regions+of+the+Eastern+Cape+Map&fr)

4.6 Understanding the Research Participants in this Study

This study was conducted with the assistance of 27 BEd Natural Sciences (NS) in-service teachers who were in their third year. I conducted the study with the assistance of their science lecturer who played the role of the negotiator of consent and the facilitator of learning while I was a participant observer. I also was assisted by two community members (one of whom was a master's student from Namibia and also a member of our CoP) and another colleague who was the interpreter (also a member of our CoP). The BEd NS in-service teachers were the main participants or the subjects in this study. Thus, it was necessary to understand them as human subjects with agency (Engeström & Sannino, 2010; Haapasaari et al., 2016).

In our first visit to the BEd Natural Sciences class to negotiate consent, they asked us a question that broke our hearts. The question was 'Who is next to be excluded from this course?' This left us curious to know why the teachers were so demoralised and thinking of quitting the course. They told us that they were frustrated that 19 of their classmates were excluded from this course because they were said to have failed. They told us that initially they were a class of 46 students but only 27 passed. The rest had been excluded because they were considered to have failed to meet the university's standards in one way or the other. For this reason, the remaining students felt did not see the reason to continue with the course. They explained that as adult students, failure was humiliating. It was their greatest fear because its of its implications to them as teachers, leaders, principals, parents, husbands, and wives. What this showed us was that even though these teachers had managed to pass, they were hurt by what happened to their colleagues. Such Ubuntu was overwhelming. Their joy, hopes and aspirations to study at such a prestigious were shuttered.

In CHAT, it is important to view participants as agents of their own change. Thus, it was important to understand why they enrolled at this institution. Many said that they saw their enrolment at this institution as a golden opportunity because during the apartheid era they were segregated against as Blacks, so they were denied the opportunity to learn in well-equipped and prestigious universities like this. This resonates with their science lecturer's experiences who also said that as a child they used to view this university as 'the Biblical promised land' because even though a walkable distance from their home, it was inaccessible to Black children. They had to send their application to Pretoria, which is 1045 kilometers away for a vacancy to learn at a school at their doorstep. He said despite his good Matric passes, he was turned down several times and he ended up having to leave his hometown to study at Fort Hare which is over 104 kilometres away from home.

Understanding this history was important as it made me aware of the participants' backgrounds, aspirations and fears. It also enabled me to identify their learning needs and design this intervention to respond to these needs. Most of the teachers indicated that they had chosen to study in order to gain more knowledge of how to teach science because they had not specialised in science in their teachers training. Some even pointed out that although they had been teaching science for many years, they were not confident to teach the subject because they were not trained as science teachers and they did not have enough content knowledge. They pointed out that they had enrolled for this degree to equip themselves with the necessary knowledge and skills to teach the subject effectively. Also interesting is that nearly all the teachers mentioned that they wanted to improve their ability to teach science for the benefit of their learners and the nation at large. Others even made a commitment that they would use the information that they obtain from this degree to assist other teachers in their schools and their district. Only a few teachers mentioned personal reasons for wanting to study this degree. The majority of the teachers had teaching qualifications that prepared them to teach as generalists who would teach across subjects. Specialisation was only done by six teachers who trained as high school teachers. Of these six, only three had specialised in science while the other three had been trained to teach other subjects such as English. Another eight teachers had other qualifications such as music, clothing, management, psychology, as well as guidance and counselling, which did not prepare them to teach science, yet they were employed as science teachers.

4.7 Sampling

The selection of who participates in a study is crucial in determining the quality of information that can be obtained and the ultimate result of the study. While researchers in quantitative studies strive to obtain samples that are representative of the entire target population, qualitative studies often use non-probability sampling methods to enable them to gain deeper understanding of phenomena (Cohen et al., 2018). Bertram and Christiansen (2015) pointed out that the aim of qualitative research is to yield rich qualitative data that gives the researcher a detailed understanding of phenomena under study. The data generated may not be generalizable to the larger population. The most commonly used non-probability sampling techniques are convenient sampling, quota sampling, snowball sampling and purposive sampling.

In this study, purposive sampling was to select people with the desired characteristics. My target population were BEd Natural Sciences teachers enrolled in tertiary institution for in-service training. The selection of this target population was done purposively because the ultimate goal of this study was to support this group of teachers to integrate IK in their science lessons. However, I had neither the financial resources nor the time and human capacity to work with all students from all Universities in South Africa. For this reason convenient was used to select only one university and one class of BEd Natural Sciences teachers who were enrolled in the in-service program offered by the institution. To save money and time, I had to do the research at the university where I was studying, where I could conveniently gather data.

On the other hand, the two community members who demonstrated how to make *umqombothi* and *oshikundu*, were selected on the basis of their expertise. As already mentioned above, they were the custodians of these traditional practises. On the other hand, the making of *umqombothi* was chosen since it is a common practice among the Xhosa people. My intention was to use a practice that is known by many participants. This would be a good starting point as an example of how IK can be integrated in science lessons. On the other hand, *oshikundu* which is a Namibian traditional beverage made in an almost similar way as *umqombothi* was chosen to exemplify how teachers can deal with diversity in their classrooms. In other words, the use of two traditional beverages from different cultural groups was done because South Africa is a multiracial society whose classrooms consists of learners from different tribes, racial and ethnic groups as well as other countries. While critiques such as De Beer and Van Wyk (2011) viewed this diversity as a challenge to the integration of IK, this study explored how teachers can take advantage of diversity in their classroom to create opportunities for learners to learn from each other's cultural backgrounds. For this reason, I invited visiting Namibian Students studying at Rhodes to join us during the practical demonstrations. This widened the ethnic diversity in the classroom and created an opportunity for use to see how diversity can be an enabler of learning.

4.8 Participants' *Voices* Matter

One of the major critics of Eurocentric models of research, Tuhiwani Linda Smith (1999), described research as the dirtiest word in the eyes of the researched indigenous people because researchers often treat participants like voiceless guinea pigs from whom data is collected and reported without creating space for them to speak for themselves. Put differently, the researcher usually imposes his/her own interpretation and meaning of the participants' views and actions which often leads to misleading conclusions.

Taking counsel from this, there was need to value the voices and contributions of the participants in this study. Firstly, I had to acknowledge them by using the pronoun we in sections where we collaboratively engaged in making decisions. Although I was the interventionist/researcher in this study, teamwork was the guiding principle that informed our decisions making since this study was informed by Ubuntu paradigm.

Secondly, the participants in this study were asked to keep reflective journals in which they entered their experiences of the intervention (Ngcoza & Southwood, 2015). A reflective journal is defined as a written document compiled by the student as he/she thinks through his/her experiences which enables them to gain insights into their strengths and weaknesses and personal growth (O'Connel & Dyment, 2011). Reflective journals would enable me to see this intervention through the eyes of the participants as Cohen et al. (2018) recommend. This is new knowledge in continuous professional development in education in South Africa because the cascade model being used in South Africa does not create opportunities for teachers to reflect upon their experiences and collaboratively explore alternative ways of resolving the contradictions that confront them in their workplaces.

4.9 The Research Process

The aim of this study was to explore how to support BEd NS in-service teachers to design and enact exemplar lessons that integrate IK. To achieve this, I sought council from Chikamori et al. (2019) who proffered a three phased model of learning as can be seen in the diagram on the following page.

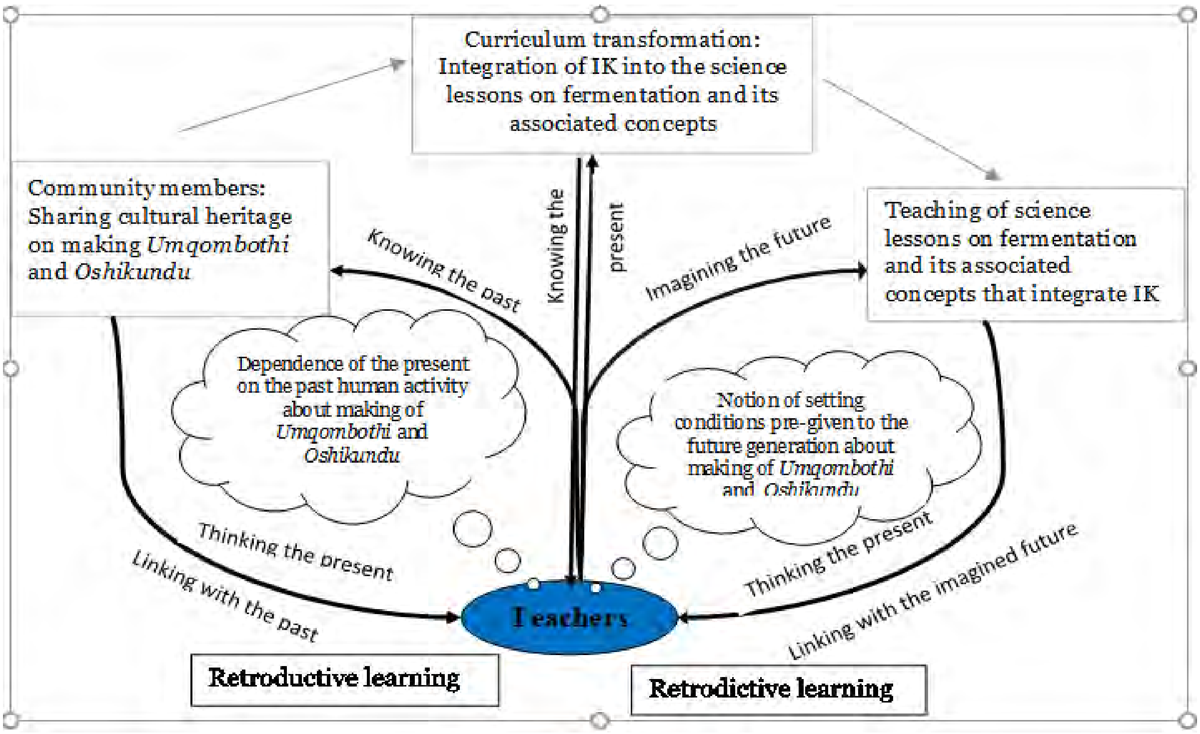

Figure 4.3: Adapted from Chikamori et al. (2019, p. 9)

This diagram illustrates the three learning phases in this study namely knowing the past, knowing the present, and imagining the future. It involved what Chikamori et al. (2019) called the *retroductive* and *retrodictive* learning. They went on to explain that the aim of *retroductive* learning is to understand how current events are influenced by both past and the present. In my case, I wanted to the teachers to understand how the integration of IK in science teaching was influenced by the historicity of science education in South Africa. For this reason, the BEd NS in-service teachers were exposed to some literature on the history of Education in South Africa and the integration of IK by Jensen (1998), Aikenhead and Jegede (1999), Le Grange (2007), Ogunniyi (2007a) and others. The purpose of this was to expose them to the history of science education and contemporary debates around the integration of IK in South Africa. This would enable the teachers to understand how the policy of integrating of indigenous knowledge in science education was shaped by historical-political events and the need to establish an egalitarian society in the post-apartheid South Africa (Le Grange, 2016; Vhurumuku & Molekeche, 2009). Phase one of this study, unearthed the contradictions embedded in science education that manifested themselves in the teachers' responses to the research questions that explored their experiences, attitudes, and professional insights towards the integration of IK. In the second phase of this study, our attention shifted to resolve the challenges that the teachers faced in their efforts to integrate IK in their science lessons, hence the second phase was called the expansive phase. Having explored the different ways of integrating IK in science lessons, the teachers were then expected to demonstrate how they integrated IK in their own teaching. Ideally, this would have been done through class visits, but because of the prohibitive gatekeeping restrictions of the university we opted to ask the teachers to go to their schools and integrate IK and send us their reflections on this experience. These different phases of this study are described in detail in the sections that follow.

4.9.1 Phase one

Many educational scholars agree that effective continuous professional development for teachers should be holistic and aim at achieving a complete paradigm shift to change the teachers' attitudes, knowledge, and skills (Bantwini, 2010; Jacobs, 2015; Ngcoza & Southwood, 2019). As such, any efforts to improve teaching should not be imposed from above. Instead, it should be informed by the teachers' needs and aim to empower the teachers to come up with their own innovative ways of solving the problems that confront them in their workplaces (Ngcoza & Southwood, 2019). To align this study with the teachers' needs, I started by exploring the teachers' prior knowledge and pre-intervention dispositions so that I would be able to identify their learning needs. These needs would manifest themselves as contradictions in their responses to the questionnaire and interviews conducted to provide answers to the following research questions:

1. What are the BEd Natural Sciences in-service teachers' attitudes, experiences, and pedagogical insights on the integration of indigenous in science teaching?
2. What contradictions are embedded in the BEd Natural Sciences in- service teachers' attitudes, experiences, and pedagogical insights in relation to the integration of indigenous knowledge in science teaching?

To understand the need state as propounded by Engeström (2001), exploring the participants' pre-intervention experiences, attitudes, and professional insights. Although there is no precise definition of dispositions, many tend to agree that this term refers to a tendency to display certain behaviours in certain circumstances. Dispositions can be understood as ongoing tendencies that guide one's intentional behaviour (Maciejewski et al., 2021). From this definition, one can deduce that dispositions are mental attributes that are observable over a long period of time. Although dispositions refer to one's state of mind, they manifest themselves through what one says, does and thinks and are expressed through words, actions, emotions, passions, and other expressive behaviours.

It is with this understanding that a questionnaire, individual face-to-face interviews and a focus group interview were conducted to understand the BEd Natural Sciences' teachers' attitudes, experiences, and professional insights with regards to the integration of IK in science teaching. As already pointed out in the literature review section, teachers' attitudes, beliefs, values and experiences are crucial to the success of any curriculum innovation (Bantwini, 2010; Jacobs, 2015; Ogunniyi, 2007a). Thus, understanding the teachers' attitudes and experiences was essential as they can be a barrier to the integration of IK. To achieve this, a questionnaire, face-to-face interviews and focus group interview were conducted, exploring the teachers' experiences, attitudes and professional insights with regards to the integration of IK as discussed below.

4.9.1.1 Questionnaire

A questionnaire is viewed by many as an essential tool to survey people's attitudes, opinions, or knowledge about a particular subject or phenomenon because it enables the respondents to express themselves freely, in the absence of the researcher (Bertram & Christiansen, 2015; Cohen at al., 2018). As a result, questionnaires are often hailed for reducing researcher bias (Bertram & Christiansen, 2020). They also enable the researcher to gather data from a geographically scattered population. In my case, the participants were scattered all over the Eastern Cape province of South Africa. This made a questionnaire a convenient means of gathering data from them because it saved time and financial resources. As already mentioned above, the main participants were full-time teachers who were enrolled for a BEd Natural Sciences in-service degree offered by the institution where I was learning. I had limited contact time with them because they would only come during their school holidays as most of the time they would be in their schools.

For this reason, a questionnaire was emailed to all 27 teachers because they had all agreed to participate in this study. However, online questionnaire are notorious for their low return as many participants simply ignore them. In this study only six responded to the email and the other students asked for hard copies because they had limited access to the internet. Four of them had replied by mobile phone that they had challenges with internet access as they were working in remote rural areas with no electricity. They said that they had to travel to the nearest towns to access the internet. This gave me an idea, that although online questionnaires generally have a reputation of poor return, in this case, the poor return may be attributed to poor access to the internet and the costs involved. I had to give hard copies of the questionnaire to those who wanted them as they were willing to participate. Thus, when they came for their July session of 2018, I had to apologise for my oversight and assumption that they all had access to the internet. Since, I am a foreigner but African, I had limited understanding of the circumstances under which they were working, since our school profiling had covered a limited number of schools due to limited financial resources and time.

I then printed and gave hard copies to those who wanted them. They took it with them and went to answer it in their own spare time. They had to submit the questionnaire back to me on their last day of the session before returning to their schools to avoid incurring further costs. Ten teachers responded and returned the questionnaire while the other teachers did not return the hard copies. In total both the online and hard copies added up to 16.

However, critiques of questionnaires often argue that they are rigid because they do not give the participants room to ask for clarification (Bertram & Christiansen, 2020; Cohen et al., 2018; Creswell & Creswell, 2018). In essence, this means that the respondent simply has to answer the questions as they understand them (McMillan & Schumacher, 2010). Because the questions in a questionnaire cannot be rephrased to enable the respondent to gain a better understanding, there are chances that some questions may be misunderstood by the respondents. For these reasons, the questionnaire was followed by individual face to face semi-structured interviews with three volunteers and a focus group interview for triangulation purposes. In Cohen et al.'s (2018) view, triangulation is one of the most important ways of validating data obtained from qualitative studies.

4.9.1.2 Semi-structured interviews

While questionnaires have the advantage of providing the respondent with the opportunity to answer questions in the absence of the researcher, they usually have very low return rates. In this study, despite the fact that all the teachers had volunteered to participate in this study, some teachers opted not to respond to the questionnaire. This made it necessary to interview the participants to find out their experiences, attitudes, and professional insights with regards to the integration of IK. According to Bertram and Christiansen (2020), an interview is a conversation between the researcher and the interviewee in which the researcher seeks to obtain information that is relevant to their study. Cohen et al. (2011) took it further by arguing that an interview is more than just a data gathering procedure, but a social encounter in which data can be generated through both verbal and non-verbal cues. In other words, through an interview the researcher is able to gather first-hand information from both the verbal and non-verbal cues.

In this study, I needed a research instrument that would enable me to gain access not only to what the teachers said but also to their body language. For this reason, I used semi-structured face to face interviews to gain access to both the teachers' spoken words and non-verbal cues. The interviews were conducted in their lecture room after lessons. This was done to create a non-threatening environment where the participants would respond freely.

4.9.1.3 Focus group interview

While face to face interviews with participants are hailed for yielding rich qualitative data, they can be intimidating for some participants especially if they are children. However, even though in this study I was dealing with adults, I considered face to face interviews as intimidating since there were power dynamics between me and my participants as explained above. For triangulation purposes, I used the questionnaire and the face to face interviews in conjunction with a focus group interview of six volunteers. The focus group provided a less intimidating environment that enabled the participants to generate more responses than in the interview. However, the challenge was that there was one student who dominated the conversations. In the Ubuntu culture it would have been very rude to ask her to give other a turn to speak. My assumption was that she had a lot of experiences to share since she was the only foreign student in the focus group.

4.9.1.4 Participatory observations

Observation can be classified either as non-participant or participant observation depending on the role played by the observer. Maxwell (2012) pointed out that observation provides a direct and powerful way of learning about people's behaviour and the context in which this occurs. In this study participant observation meant that I was observing and recording events while also taking part in the proceedings of the intervention. For instance, I could ask a question to the class to probe them to think critically and look for solutions. Accordingly, Yin (2018) pointed out that the greatest advantage of participant observation is that it enables the researcher to collect data directly from real life lived experiences and manipulate minor events to gain access to the required information. In my case, I would ask questions to promote learning and this enabled me to collect first-hand information from real life situations. For instance, through observation I could observe how different languages and different forms of communication were used as the teachers interacted with one another.

In this study, observations were conducted in all three phases of the intervention which were the pre-intervention, the intervention phase, and the post intervention phase. During the pre-intervention orientation workshop, I observed how the teachers analysed the curriculum. The intention of this observation was to see how their interaction was influenced by the historicity of science education in South Africa. Using CHAT as my lens, I observed how different participants interacted and used different resources to mediate learning. This enabled me to understand how the BEd Natural Sciences in-service teachers' participation in the collaborative curriculum analysis enhanced their understanding of how they could integrate IK.

The second observation was conducted during the intervention when the two community members presented their practical demonstrations of how to prepare *umqombothi* and *oshikundu*. During these demonstrations I observed how teachers collaboratively engaged in co-developing the model lessons and how the facilitator mediated learning. I took a non-participant observer role in which I took notes while my critical friend video-recorded the proceedings. Supporting videorecording, Merriam (2009) argued that it allows the capturing of not only verbal but also non-verbal communication such as movements and facial expressions.

However, video-recording minors raises serious ethical issues around their consent, privacy, and security (Cohen et al., 2011). In this study, I had initially intended to observe teachers teaching in their classes but because the ethical clearance process would take a long time to obtain, I had to work with teachers only because I was on National Research Funding (NRF) so I did not have the luxury to wait for the clearance process to be completed.

4.9.2 The expansive learning phase

The second phase was the expansive learning phase which aimed at answering research questions 3 and 4 of this intervention which are:

3. What learning opportunities are created (or not) for the BEd Natural Sciences in-service teachers:
    (a) When co-analysing and discussing the curriculum documents?
    (b) During the practical demonstrations by the expert community members?

4. How can the BEd Natural Sciences in-service teachers be supported in co-designing:
    (a) Science lessons that integrate indigenous knowledge using fermentation as an example?
    (b) Their own exemplar lessons that integrate indigenous knowledge in other science topics?

To answer these questions, a series of workshops were conducted exploring how to:

- Unpack the CAPS curriculum;
- Elicit and integrate learners' prior knowledge in a multicultural classroom;
- Tap into the community experts' funds of knowledge;
- Use easily accessible resources to teach science;
- Link IK to science using the making of *umqombothi* and *oshikundu* as examples; and
- Develop exemplar lessons that integrated IK.

4.9.2.1 Unpacking the curriculum

Scholars such as Mavhunga and Rollnick (2013) and Mavhunga et al. (2016) view curriculum salience as an important component of a teacher's PCK. Hence, the expansive phase of this intervention started with document analysis to support the BEd Natural Sciences in-service teachers to unpack the CAPS curriculum. In Bowen's (2009, p. 27) words: "Document analysis is a systematic procedure for reviewing or evaluating documents". The purpose of document analysis in this study was to enhance the teachers' understanding of the curriculum content and structure and the role of IK in the teaching of science.

To achieve this, the class was divided into four groups and asked to choose a strand to work on from the four strands of the Natural Sciences curriculum, namely, life and living, matter and materials, energy and change, and planet earth and beyond. The science lecturer who was the facilitator then explained the five components of the TSPCK tool designed by Mavhunga and Rollnick (2013). He then asked them to use the five components to analyse the CAPS curriculum document and the Natural Sciences textbooks that they were using in their schools.

They worked collaboratively in their groups to identify the prior knowledge (including IK as well as misconceptions) that can be used to teach science; the gatekeeping concepts that can make each topic difficult for learners to understand; the different representations that can be used to teach each topic; how the content in the CAPS document is sequenced; and the alignment of the content in the CAPS document and the Natural Sciences textbooks. Each group had a scribe who wrote down what they were saying. They then presented their findings to the class and discussed the findings of each group. Their discussions were characterised by debates, arguments, disagreements, and questioning until they reached consensus (Hewson & Ogunniyi, 2011). Both their group discussions and class discussions where characterised by code switching from English to Xhosa, even though the teachers were in a university setup where they were all able to communicate in English. This workshop was followed by a workshop on how to elicit learners' prior knowledge in a multicultural classroom.

4.9.2.2 Eliciting learners' prior knowledge in a multicultural classroom

One of the contradictions that emerged in phase one of this study is that the teachers were expected to integrate IK, yet they were not properly trained on how to do so in their teaching and learning repertoires. One of the challenges that they mentioned was how to deal with cultural diversity in their efforts to integrate IK. They pointed out that they faced the dilemma of having to choose whose IK to integrate. This resonated with the findings of an earlier study by Mutanho (2016) who found that although teachers were expected to be cultural brokers (Aikenhead & Jegede, 1999), in some cases they have limited understanding of the IK of the communities that they work in.

Moreover, the indigenous people are not a homogenous group as pointed out by Isaacs et al. (2010). As a result, some teachers find themselves teaching in communities with different cultures and IK from the communities that they grew up in. In this regard, the CAPS document recommends that teachers should study the cultures of the communities that they are working in so that they can be able to integrate the IK of the learners that they teach (DBE, 2011). However, this problem is also exacerbated by the fact that the abolition of apartheid in South Africa led to multicultural classrooms. My own experience of this is that for the 12 years that I have taught in South Africa I have never come across a monocultural class. Instead, all the schools that I know of have learners from different cultural groups, including foreign learners, and in some cases learners from other racial groups such as Indians, Coloureds and Whites.

Lightning is a common natural phenomenon that is experienced by people from all over the world (Webb, 2013). Because of its devastating nature, many cultures have different interpretation of this phenomenon which constitutes their local or indigenous knowledge as they try to understand what causes it, why it strikes and often kills people and how to prevent it. The local or indigenous knowledge surrounding lightning often includes 'myths', beliefs and scientific explanations that can enhance or constrain learners' understanding of static electricity (Maselwa & Ngcoza, 2003). For this reason, the facilitator and I thought of it as a good starting point to explore how to elicit learners' prior knowledge (including local or indigenous knowledge) in multicultural classrooms in particular.

4.9.2.3 Modelling how to conduct hands-on practical activities

Science is regarded by many scholars as a practical subject that is supposed to be taught using hands-on practical activities. However, the effectiveness of these hands-on activities is often limited by teachers' failure to harness the potential of such hands-on practical activities to capture learners' interests and promote learning (Asheela et al., 2021). Hodson (1990) attributed this failure of the effective use of practical activities to lack of training. His sentiments tend to resonate with the data obtained in phase one of this study, where it emerged that some of the BEd Natural Sciences in-service teachers were not trained as science teachers. As a result, these teachers indicated that they had enrolled in this course to upgrade both their pedagogical and content knowledge.

In this interventionist study, the teachers were exposed to Hodson's (1990) article as mirror data as an attempt to challenge their orthodox ways of teaching science and make them aware of the limitations of the recipe or cookbook approach to hands-on practical activities. The recipe approach in this study refers to the approach to hands-on practical activities whereby the teacher just simply gives learners worksheets of instructions that they are expected to follow to come up with a predetermined result. Hodson's main criticism to this approach is that it does not promote discovery learning. In other words, the potential to promote learning is often limited by the fact that teachers use it unthinkingly as the panacea to all learning problems in science education without giving learners the opportunity to discover things for themselves.

By exposing the teachers to the literature that challenged these practices, it was hoped that they would be encouraged to relook at what they may have taken for granted so that they would see the need to change. Likewise, Engeström (1999) opines that the purpose of an intervention is to push forward the contradictions of an activity system by challenging participants to redefine their practice. In this case, the teachers were exposed to new conceptual tools to enable them to reconceptualise how to conduct hands-on practical activities as reiterated by Asheela et al. (2021).

As a follow-up to the activity on cultural beliefs on lightning, the science lecturer then introduced a hands-on, words-on, and minds-on approach using the concepts involved in static electricity. The teachers were asked to predict what would happen if two strips of transparent paper were rubbed together with/without a gloved hand. This approach is called the predict-explain-explore-observe and explain (PEEOE) approach (Asheela et al., 2021). The teachers predicted that when the strips were rubbed they would stick together. They rubbed the strips and the strips repelled each other and they were so amazed. They recorded their findings, and explained why the strips of papers repelled each other.

To understand how the intervention impacted on the teachers' attitudes, knowledge, and professional insights about the integration of IK in science education, the teachers were asked to write reflections on this experience and send them to me. The following sections include their reflections.

4.9.2.4 Tapping into community experts' funds of knowledge

In this section, I discuss the practical demonstrations that were made by the two expert community members, [9]MaMngwevu and MaNdlovu.

Practical demonstration by MaMngwevu

A plethora of studies on IK revealed that science teachers struggle to integrate IK in their science lessons (Aikenhead & Jegede, 1999; Le Grange, 2007; Mothwa, 2011; Shizha, 2007). This is partly because they are expected to be 'cultural brokers' yet in some cases they are not familiar with the cultures of the learners that they teach (Aikenhead & Jegede, 1999; Wright & Riley, 2021). For instance, in South Africa there are many science teachers from India, Ghana, Nigeria, Uganda, Zimbabwe and many South African teachers teaching in communities other than their home areas, whose cultures are different from theirs.

This trend also emerged in the mirror data that from the explorative phase of this study which revealed that teachers do not know how to tap into community experts' funds of knowledge which then made it necessary to conduct a workshop on how to tap into community experts' funds of knowledge. Thus, when the teachers returned for their April session (2018), we explored how to tap into community experts' funds of knowledge.

The first practical demonstration was conducted by MamNgwevu who demonstrated how to make *umqombothi*. In the Xhosa culture a married woman cannot be called by her first name as that would be disrespectful. For this reason, throughout this report, I will call the two expert community members by their clan names as MaMngwevu and MaNdlovu.

MaMngwevu is well known in her community for her expertise in the making of *umqombothi*. However, this is in opposition with her Christian religion and her position as a church elder and evangelist. MaMngwevu's son is an ordained pastor in the Methodist church which is the same church that she attends. The paradox in her position lies in that she did not abandon her culture despite the fact that she is an ardent Christian who attends one of the churches that preaches against practices associated with ancestral spirits such as the making of *umqombothi.*

[9] A clan name is a name that is used to identify a particular clan which is usually the name of the first ancestor of that group of people.

Afonso-Nhalivelo (2013) reminded us that both the school and the church were used by the colonial governments to eradicate IK. MaMngwevu stays in the [10]township in Makhanda (formerly known as Grahamstown). Most people in her community still practice cultural rituals such as *umgidi* (a ceremony to conducted celebrate a boy's passage of rites after circumcision) where *umqombothi* is prepared to celebrate and welcome him home as well as to appease the ancestors (Ngcoza, 2017).

The practical demonstration lesson started with the science education lecturer (who was the facilitator) introducing MaMngwevu to the class. He explained that the purpose of the presentation was to explore ways of making the curriculum accessible to all learners and posed the following questions:

- How do we make the curriculum accessible to all learners?
- Is it true or not that our community elders have no knowledge that they can offer to our learners in our classrooms?
- How do we take into consideration other ways of knowing?

These questions were asked as icebreakers to challenge the general perception that tends to treat community members as ignorant people who have nothing to contribute to schools in terms of knowledge. In response, the teachers briefly paused and responded that community members may have knowledge that they can share with schools.

The lecturer went on to introduce MaMngwevu as an expert in the making of *umqombothi*. During the same week, we had visiting master's students from Namibia. When they heard about the practical demonstration lesson, they were so excited to learn about the Xhosa culture and the facilitator invited them to join us during the practical demonstration lesson on the making of *umqombothi*. On the basis of Ubuntu, these students were invited to join us as they could not be denied the opportunity to learn, even though they were not part of the initial target population in this study. The BEd Natural Sciences in-service teachers were so excited to have

[10]A township refers to a residential area located at the periphery of a small town or city where the poor (usually indigenous) people live. Although this name was used during the colonial era to refer to areas that were reserved forthe indigenous people, the name is still used to this day to refer to such places.

visitors from Namibia among them. The Namibians students were also science teachers doing their master's through in-service training.

MaMngwevu explained in isiXhosa how *umqombothi* is made, demonstrating every step of the process while Cirha (clan name), a colleague of mine who was also a master's student and part of our CoP, translated what she was saying from isiXhosa to English to accommodate the visiting Namibian master's students. In Xhosa culture (as well as in many other African cultures) you cannot call an adult by their first name because that would be very disrespectful. For this reason, I called my colleague by his clan name. Even if I were to give him a pseudonym, it would still have been unethical to call him by such a name as it constitutes addressing an adult by a first name. The teachers were free to stop him and ask any questions that arose at any given moment of the demonstration; also, when the teachers asked questions in English, he translated into isiXhosa. MamNgwevu also took this as an opportunity to teach the Xhosa culture.

She started by explaining the cultural significance of her dressing as a married woman and told them that in her culture, it was important for her to show respect to her husband's family, the elders, and the community at large by dressing in a dignified manner when she prepares *umqombothi.* Additionally, she is also expected to be very hygienic by taking a bath, frequently washing her hands and wearing the headgear that covers her hair. She is also not supposed to sleep with her husband as that will make her unclean before the ancestors, which prompted a lot of excitement among the young lady teachers.

She explained that in order to make *umqombothi*, you need *imithombo wombona* (maize malt) and *imithombo yamazimba*, maize meal, and warm water. In the olden days indigenous people used to make *imithombo* (malt) themselves by soaking cereal grains such as maize, sorghum, or millet to make them germinate. They would then dry and pound or grind these germinated seeds to make *imithombo* (malt). Nowadays, however, they just buy them (ready Fmade) from the supermarkets.

MaMngwevu started by mixing equal measures of *imithombo yombona* and *imithombo yamazimba.* She then added warm water while stirring them to a porridge-like consistency. The container with the mixture was then covered and left overnight in a warm place. The following day, it showed signs of fermenting. She then boiled some water in a large container and gently added the fermenting *umqombothi* while she was gently stirring. She allowed it to cook for about an hour before taking it down to cool. When it was warm, she added some more malt (*imithombo yamazimba*) and stirred gently with a traditional wooden spoon *(iphini* or *izamiso*). She then covered the container with a lid and placed it in a warm place. Because it was a bit cold, she covered the container with a blanket.

She explained that at home, *umqombothi* is usually left in the kitchen where cooking is done. If the weather is too cold, she uses a blanket to cover the container to keep it warm. She then filtered the beer with a sieve to separate the solid ingredients and the opaque beverage. Interestingly, throughout the preparation process, the lady teachers were the ones who were actively asking questions and showing excitement while the male teachers were onlookers. As soon as she announced that *umqombothi* was ready for drinking, three male teachers stood up, thanked her for a job well done, and took a sip of the beverage to see if it was well done. The tasting of *umqombothi* after sieving is called *intluzelo* in isiXhosa.

The next demonstration was on the making of *oshikundu* by an expert community member from Namibia, whom, as already mentioned above, I shall call MaNdlovu. Upon hearing that South Africans use their clan names, she asked if she could also be called by the South African version of her clan name as MaNdlovu.

Practical demonstration by MaNdlovu

MaNdlovu was a master's student from Namibia whom I asked to assist me by demonstrating to my participants how to make *oshikundu*. She is *Oshiwambo* and is an expert in the making of the traditional non-alcoholic beverage called *oshikundu.* She explained that although she grew up in town where *oshikundu* was not made, her mother-in-law taught her how to make it because in their culture *oshikundu* is a very important beverage that should always be found in every homestead in case someone arrives home very hungry. She explained that it is part of their *Oshiwambu* culture to offer food and drink to any stranger who visits their homestead because you do not know how thirsty or hungry he/she may be.

MaNdlovu's participation in my study was of mutual benefit to both of us because she used this as an opportunity to pilot her study. Her participation in my study would give her an opportunity to have a feel of how it would be like to demonstrate the making of *oshikundu* to science teachers (which is what she was going to do with her participants in Namibia).

Because this study was informed by Ubuntu, which emphasises transparency, mutual benefits and genuine concern for one another (Ogunniyi, 2007a; Seehawer, 2018; Seehawer, 2021; Tutu, 1999), I had to seek the BEd Natural Sciences in-service teachers' consent for MaNdlovu's participation in our study, clarifying how her participation in our intervention would be of mutual benefit to all of us. They agreed and they were excited to learn how to make a beverage from another country.

MaNdlovu started by explaining the cultural practices and beliefs that one has to abide by when preparing *oshikundu*. She explained that she was wearing *oshitenge* (a cloth that is tied around a woman's waist) to show respect to the elders and the people who would drink the *oshikundu.* Similarly, to the process of making *umqomboth*i, one is expected to exercise a high level of hygiene. *Oshikundu* is prepared by women except in very rare occasions, where a man lives alone or is a widower. In families where there are only boys, the wife has to bring a girl from her family to stay with her to help her with the domestic chores. On the other hand, boys have to sit with elderly men around that fireplace built outside the kitchen so that they can be taught lessons of manhood.

MaNdlovu explained that *oshikundu/ontaku* is a traditional beverage prepared from *mahangu flour* (from millet), fermented sorghum and boiled water. One should not add sugar because it makes the oshikundu to turn sour. It is a common traditional beverage you expect to find in almost every homestead among the *Oshiwambo* tribes of Namibia. Oshikundu is made from the traditional African grains (millet and sorghum).

She had already made [11]*oshiphithitho* which is the starter or catalyst or *umlumiso* or *igwele* in IsiXhosa. She reported that they prepare *oshikundu* with *mahangu* flour and *ungudo* (malt) (*ingoduso* in isiXhosa). The pound the *mahangu* and sieve then soak them in the water and dry for a few days until they turn yellowish. The *mahangu* is then dried and ground. Then you soak millet/sorghum into water for a few days.

An earthworm should never get there because it is believed that the *omaludu* made from that flour will make the people vomit. You have to cover the sack well. Then you have to pound.

[11] *Oshiphithitho* means to speed something up.

After pounding several times, you have to leave some *ushuthu* (first flower that comes from millet) in the containers. When your kids are in the house, they have to eat *ushuthu*.

She started by mixing all the dry ingredients, ensuring that they were thoroughly mixed. Pour 1 litre boiled water and mix until you get rid of all the lumps. If you are preparing *oshikundu* for children, it should be served before it ferments. Allow the mixture to cool down. Add cold water gently and stir. When it is well mixed, she poured the *oshiphithitho*. Finally, she poured the oshikundu in a 20-litre bucket and stirred. She then stored the *oshikundu* in a warm place. She also explained that *oshikundu* is usually placed in the kitchen so that it can ferment fast.

4.9.2.5 Linking IK and the curriculum

According to Haapasaari et al. (2016), expansive learning occurs when a group of workmates collaboratively work together to transform their activity. They further argued that it is through this collective effort that the group can resolve the contradictions within their work situations and reconceptualise their work. In this study, the teachers needed to be assisted to draw the links between IK and science, which are two knowledge systems that were presented to them as conflicting domains in their childhood. To achieve this, they were asked to identify scientific concepts in the making of *umqombothi* and *oshikundu* and draw mind and concept maps showing how these scientific concepts were related to each other. Thereafter, they identified the concepts that link to the Natural Sciences curriculum at the Grade 8 and 9 level that they were teaching. At the end of this session, each group then reported their findings to the rest of the class. At the end of each group presentation, the teachers were given an opportunity to ask questions and make any comments.

4.9.2.6 Conducting practical science lessons using easily accessible resources

In CHAT, learning results from confronting and resolving contradictions. One of the contradictions that emerged from the mirror data in phase one is that although teachers are expected to teach science as a practical subject, they lack proper training on how to conduct hands-on practical activities and many schools do not have the necessary laboratory equipment to enable them to do so. However, while this is a challenge which faces South Africa and many developing countries, there is need to explore alternative ways of making sure that learners from poor socio-cultural and socio-economic backgrounds are not deprived of the opportunity to learn science through inquiry-based learning (IBL) (Nhase, 2019; Ramnarain, 2021; Shinana, Ngcoza, & Mavhunga, 2021). Inquiry-based learning is seen by Shinana (2021 et al.,

p. 5) as “a cluster of learning and teaching approaches in which learners’ inquiry or research drives the learning experience”. However, literature revealed that many teachers often fail to effectively use the inquiry-based learning approach because they are not well trained to do so (Asheela et al., 2021; Hodson, 1990; Shinana et al., 2021).

The above observations made it necessary to explore how to use easily accessible resources to teach science (Asheela et al., 2021). In this regard, the teachers in this study were asked to explore simple hands-on practical activities that they could conduct with their learners using easily accessible resources. They picked plastic bottles from the environment and used them to conduct hands-on practical activities using the *oshikundu* that MaNdlovu had prepared and the following were conducted:

1. Testing the effect of a catalyst *(oshiphithitho)* on fermentation;
2. Testing the effect of temperature on fermentation; and
3. Testing the presence of carbon dioxide (CO_2) using lime water.

After this session, the teachers were asked to go their schools and experiment with the ideas that they had learnt and write reflections that they would email me.

4.9.3 Phase three

I named the last phase of this study as the activity because its purpose was to show how the teachers integrated IK in their planning and teaching and how they envisioned the integration of IK in future. The data gathered in this phase thus answered the last question of this study which is: How do BEd Natural Sciences in-service teachers enact and envision the integration of indigenous knowledge? Ideally, this research question would have been answered by visiting the teachers in their schools to observe how they integrated IK in their teaching and then interview them. However, in this study this was not possible because of the ethical clearance constraints mentioned in Chapter Five (see Section 5.3). To circumvent this challenge, the teachers decided to co-design lessons in their groups from any topic of their choice from their strands, and teach it to the rest of the class during a peer-teaching session. One representative from each group would use the lesson plan that their group co-designed to teach while the rest of the class role-played learners. Our assumption was that this would create an opportunity for the teachers to show their understanding of how to integrate IK and then get feedback from their peers and the facilitator. I would then observe what Mazibe et al. (2020) referred to as their enacted pedagogical content knowledge (ePCK) as they taught their peers who would role-play the learners.

However, the BEd Natural Sciences in-service teachers were not comfortable with the idea of role-playing learners which they thought would not create enough learning opportunities since it would be based on an artificial classroom situation. Additionally, they did not like the idea of being observed while teaching because they felt that it gave the impression that they were being assessed. Since human behaviour is multi-layered as Engeström (2001) noted, there was a need to be sensitive to the teachers' concerns, bearing in mind that some of them had trained and taught during the apartheid era where lesson observation was used by school inspectors as a monitoring tool. As a result, lesson observations were often used for fault finding purposes instead of teachers' professional development during the repressive policing of the Bantu Education system (Bantwini, 2010; Mbembe, 2016). Correspondingly, Heleta (2016) advised that decolonising the curriculum in South Africa requires us to be sensitive to people's social and historical realities. It was with this understanding that I asked the teachers to make suggestions and they proposed that we should have lesson presentation sessions entitled "How I plan, how I teach, and how I envision the integration of IK in my science lessons" instead of the lesson observations that I had initially planned.

4.9.3.1 How I plan

According to Richards (1998, p. 103), "The success with which a teacher conducts a lesson is often thought to depend on the effectiveness with which the lesson was planned". With this, Richards draws our attention to the fact that a lesson plan is like a roadmap that guides the teacher to think through what they are going to teach prior to the actual teaching. Shulman (1987) also posited that a teacher has to turn the subject matter in their head before breaking it down into teachable units. Taking advice from these scholars, the BEd Natural Sciences in-service teachers were asked to co-design lesson plans that integrated IK on any topic of their choice and present it to the class. They used Mavhunga and Rollnick's (2013) TSPCK components to guide them in their planning. Each group wrote its lesson plan on a newsprint and presented it to the entire class. The class then analysed the lesson plans using the TSPCK components translation tool to understand the lesson plans and identify aspects that needed to be improved.

4.9.3.2 How I teach and envision the integration of IK

To understand how they teach, the BEd Natural Sciences in-service teachers were then assigned a task to go back to their schools and design lessons that integrated IK and then teach using those lesson plans. They would then write reflections on this experience and send them to me. While reflections are usually placed at the end of the change laboratory cycle, in this study teachers were asked to reflect after every session or change cycle.

4.9.3.3 How I envision the integration of IK in science lessons

When they came back for their last semester in 2019 they were given an opportunity to share their experiences and choose one lesson plan from their group that they would improve on and present to the rest of the class as to how they envision the integration of IK in their science lessons.

4.10 Data Analysis

Data analysis is the process of making sense of research data. According to Christiansen and Bertram (2015), data analysis consists of three phases which they named data reduction, data displaying, and drawing of conclusions. Similarly, Cohen et al. (2018, p. 537) echoed the same view when they argued that "qualitative data analysis involves organizing and accounting for and explaining the data … noting patterns, themes categories and regularities". In short, the ultimate goal of data analysis is to find out the meaning of the data in relation to the research interests/goal.

4.10.1 Explorative phase data analysis

Informed by the interpretive paradigm, the data gathered in phase one was reduced using inductive categories drawn from the data. The themes were then extracted by reading through the data several times and placing the responses in different categories. I then read through the categorised responses several times to inductively identify the sub themes which were later refined into themes. During this clean-up process, some categories were refined, and some responses had to be shifted from one category to another because I found out that they could not fit in the categories they were placed in. For instance, I started by tabulating the colour coded responses and drawing up sub themes as shown in Table 5.1 above, from which sub themes and themes were then teased out by carefully reading through the data to find out the common ideas underpinning them. The purpose of the interpretive data analysis was to answer the first question of this study. To identify the contradictions embedded in the teachers' experiences, attitudes, and professional insights, Engeström's (2001) first- and second-generation CHAT triangles were used as analytical tools. The first-generation CHAT triangles were used to identify the primary contradictions embedded within and between the different components of the science education activity system. On the other hand, the second-generation CHAT triangles were used as analytical tools to unearth the contradictions between the different stakeholder activity systems in science teaching, in relation to the integration of IK.

4.10.2 Expansive phase data analysis

Data analysis in phase two of this study applied both discourse analysis from the interpretive paradigm and CHAT tools. The main goal of this phase was to understand the expansive learning opportunities created by this intervention. As such, the analysis drew on CHAT concepts of ZPD, expansive learning, transformation, envisioning, contradictions, and resistance to understand the shift in the teachers' attitudes and understanding. It also drew on Mavhunga and Rollnick's (2013) TSPCK rubric which was used in this study as a translation device (Maton & Chen, 2016) to understand the lessons that were co-developed by the teachers (see Appendix G). The reason why I borrowed Maton and Chen's (2016) concept of a translation device is that the intention in this study was not to score or quantify the teachers' PCK as Mavhunga et al. (2016) did in their study. Instead, the intention was to understand and support them on how to co-design and enact lessons that integrated indigenous knowledge. The data analysis done in this phase was guided by research questions 3 and 4 which explored the expansive learning opportunities created by the intervention.

4.10.3 The activity phase data analysis

The last phase focused on understanding the impact of this intervention on the teachers' knowledge of how to integrate IK in their science lessons. It thus covered the last question of this study. To understand the shifts in the teachers understanding, analytical tools from CHAT, PCK, and the sociocultural theory were used to see if there was any shift in the teachers' pedagogical insights from their pre-intervention state.

4.11 Trustworthiness and Validity

Validity is one of the most crucial components of any research. According to Cohen et al. (2018), validity refers to the extent to which a particular research instrument measures that which it is intended to measure. Qualitative researchers employ different techniques to ensure enhance the validity of their studies. In this study I validated the research instruments by discussing them with my CoP colleagues. Thus before the questionnaire was sent to the participants, it was co-analysed by members of my CoP. They made recommendations that I used to improve the questionnaire.

To ensure the data credibility of the data collected in this study, several research instruments were used to collect data (see Section 4.8). The data obtained from these instruments were triangulated. As data were starting to emerge from this thesis, I wrote short conference papers and presented them to other colleagues in my CoP who scrutinised them and made suggestions. The data gathered were triangulated to ensure that it were valid. Yin (2016) viewed triangulation as one of the most commonly used techniques to ensure trustworthiness of data in qualitative research. In this study, data from the questionnaire, the focus group interview, observations, and individual interviews were triangulated.

4.12 Chapter Summary

This chapter gave an overview of the research methodology. It identified the three research paradigms that informed this study as the interpretive paradigm, the critical theory, and the Ubuntu paradigm. These paradigms were used as complementary philosophical lenses that informed this study. A case study approach was chosen because this study was confined to one university in the Eastern Cape province of South Africa. The chapter went on discuss the research method and revealed that the study was divided into three phases, namely the explorative phase, the expansive phase, and the activity in which data were gathered through a questionnaire, face-to-face interviews, focus group interview, participant observations, as well teachers' reflections. The data that emerged from these instruments were reduced and presented in different formats. These included tables, diagrams, direct quotations, photographs, and sample journal entries. The discussion then turned to data analysis where it was pointed out that CHAT and Mavhunga and Rollnick's five components as well as sociocultural tools were used to analyse the data gathered in this study.

CHAPTER FIVE: RETHINKING ETHICS: WITH WHOSE LENSES ARE WE VIEWING THIS TERRAIN?

> In the debate about ethics, the distinctions are drawn between legal requirements and ethical codes of conduct. Indigenous groups argue that legal definitions of ethics are framed in ways which contain the Western sense of the individual and of the individualized property-for example, the right of an individual to give his or her knowledge, or the right to give informed consent. The social 'good' against which ethical standards are determined is based on the same beliefs about the individual and individualized property. Community and indigenous rights or views in this area are generally not recognized and not respected. (Smith, 1999, p. 118)

5.1 Introduction

According to Gatsheni-Ndlovu (2020, p. 7), "African struggles for epistemic freedom often fall prey to the epistemologies and academic practices they set out to critique". This is largely because the knowledge production space is not a free space. In the above epigraph, Smith (1999) draws our attention to the fact that research in indigenous communities is often conducted in a manner that violates indigenous peoples' ways of being. This usually happens because of the 'blind' adherence to Eurocentric research paradigms, with little regard of the indigenous people's cultures, interpretations, and ways of being. This drew Smith to describe research as the dirtiest word in the eyes of indigenous peoples (Seehawer, 2018; Smith, 1999). In support, Ndlovu-Gatsheni (2017) attributed this to the colonial mentality where research was used as a mining tool through which information was extracted from the indigenous people. To this day, some research practices still seem to be insensitive to indigenous people's cultures.

As Smith (1999) pointed out in the above epigraph, one aspect where conflict arises between Western and indigenous values systems is ethics. This tension also emerged in this study. This chapter presents the ethical dilemma that emerged in this study and how Ubuntu was applied to resolve the tension. The chapter begins with a declaration of my positionality after which the ethical dilemmas that emerged in this study are presented. It then focuses on how Ubuntu was applied to resolve these tensions as advised by Emeagwali (2014, p. 2) who argued that "A focus on African cultural resource knowledge is a means of 'epistemological recuperation' and is 'counter-hegemonic'". With these words, Emeagwali invited researchers to interrogate their practices as they engage in research so that they can expose the aggressive elements embedded in the Eurocentric research practices. In this way they prevent the perpetuation of the colonial agenda. In support of this view, Gatsheni-Ndlovu (2019, p. 7) emphasised that the struggle against the epistemic violence of the colonial era should be at the centre of the decolonial agenda. He further warned that the process of decolonising research is not going to be easy because the "dirty history *of research* is so hidden within research methodology that only a careful decolonial mind can unmask and reveal it" [my own emphasis]. Earlier on Emeagwali had also said:

> The decolonization of the African Academy remains one of the biggest challenges not only in terms of the curriculum, teaching strategies, and textbooks, but also in terms of the democratization of knowledge and the regeneration, evaluation, and adaptation of old epistemologies to suit new post-colonial realities. Indigenous Knowledge provides a beacon of light within the tunnel of Eurocentric dogma, misinformation, and untruths. (Emeagwali, 2014, p. 2)

These scholars and many others encourage researchers to explore new ways of confronting the aggressive Eurocentric knowledge systems as they engage in studies on IK systems (Chilisa 2012; Ndlovu-Gatsheni, 2017; Ogunniyi, 2007a; Smith, 1999). Seehawer (2018) questioned the prudence of conducting research on IK using the same Eurocentric paradigms that the researcher seeks to condemn as the colonial tools that were used to silence IK. However, despite this growing interest, I did not come across many studies conducted in Southern Africa to illustrate how the decolonisation of the science curriculum in universities can be achieved. As a result, much of the advocacy for the decolonisation of the curriculum remains as political rhetoric agency. Herein lies the significance of this study which explored how to decolonise the tertiary education curriculum by integrating IK in teacher education.

5.2 The Ethical Dilemmas in my Study

The tension between Western and African value systems often arises when it comes to research ethics. For instance, while the Eurocentric perspective tends to view ethics from an individualistic point of view the indigenous peoples tend to emphasise the mutual benefits that accrue to the rest of the society. In indigenous communities such as the Xhosa, the guiding principle that determines any interpersonal relationship is Ubuntu, which Seehawer (2018) described as an African Philosophy characterised by putting the welfare of others first. Seehawer (2018) In contrast, Eurocentric research paradigms tend to emphasise ethical codes of conduct based on individual rights. This is evident in the emphasis on participants' privacy, confidentiality, right of consent, right to withdraw from the study, and many other self-centred aspects which are at the expense of public good (Cohen et al., 2018; Creswell & Creswell, 2018).

This tension between the Eurocentric and Afrocentric perspectives on ethics presented a dilemma in this study. Notably, although I was the interventionist/researcher in this study, the pronoun 'we' is often used throughout this thesis to acknowledge the valuable contributions of all the above-mentioned colleagues without whose participation this study would not have been possible. Initially, I wanted to conduct class visits to support the BEd Natural Sciences in-service teachers to integrate IK in their science lessons. This would involve conducting lesson observations involving both teachers and learners. However, the university's Higher Degrees Ethics Committee's gatekeeping requirements requires you to go through a rigorous and cumbersome bureaucratic process that is both time consuming and frustrating. Essentially, my study coincided with a period of transition when the university was trying to apply new ethical clearance procedures. Because these were new changes, no one was really sure of what was expected of us. Resultantly, the process was time consuming, tiresome and frustrating. The challenge was that my study was funded by the National Research Fund (NRF) which runs for only three years. This meant that I had to complete the degree within the stipulated time. This compelled me to take the decision to work with teachers only to avoid unnecessary delays. Moreover, I was a foreign student who was unemployed and struggling to make ends meet since I am from a poor family.

Apart from the university, I also needed to obtain clearance letters from various gatekeepers, including the Department of Basic Education, the school principal, the school Governing Board and parents. Given the bureaucratic nature of these institutions, the ultimate clearance to work with minors usually takes a long time to obtain. This compelled me to shift my research focus from lesson observations to working with teachers only, to avoid a long delay.

A further delay was caused by my study coinciding with the university introducing a new online ethics application system which both the students and supervisors were struggling to grasp. None of us understood exactly what was expected. The application process was complicated and full of frustrating technological glitches. For instance, at one time I filled in the form and sent it to the Ethics Manager for review. It was reviewed and I received feedback with only three things to be corrected. I corrected the three things they highlighted and re-sent it, but to my surprise when I got the form back, it had 20 new things to be corrected. I corrected the things that they required me to correct and sent the form and the online system wanted my supervisor's signature because a student cannot send the form directly to the Higher Degrees Ethics Committee. When I tried to retrieve the form to send it to my supervisor, the system had already locked me out. I had to seek the assistance of the Ethics Manager. This was so frustrating, time consuming, and emotionally draining. For me, every day that passed by counted because of the nature of my funding. My problem was compounded by the fact that my main participants were third-year BEd Natural Sciences in-service teachers who were left with less than two years to complete their course. Any delays would have made the data collection process very difficult.

Creswell and Creswell (2018) recommended that the researcher should start by building relationships with their participants. Taking up this advice, I visited the BEd Natural Sciences in-service teachers' schools to build relationships and understand the conditions, challenges, and cultural contexts within which the teachers were working. In my research journey, I worked in close association with the science lecturer, who was also my supervisor. Understanding the hardships, challenges, and cultural contexts within which the teachers were working would enable us to understand the kind of support we would give them. With this in mind, my supervisor and I visited five schools. We had no intention to visit classes because our impression was that the teachers, principals, and parents would not allow us to see the learners since they were the gatekeepers emphasised by the university and the research textbooks (Cohen et al., 2018; Creswell, 2014).

However, when we arrived at the schools, we received a 'cultural shock', because we were received with overwhelming hospitality. In all the five schools we visited, the principals and their teachers invited us to visit their classes, to see the good work that they were doing and motivate their learners. They lamented that they wished that we would visit them more often. The so-called 'gatekeepers' turned out to be 'gateopeners'. This contrast between the university's Higher Degrees Committee's ethical recommendations and attitudes portrayed by the schools towards us brought to surface the tension between the Eurocentric ethics that are universally imposed by universities and Ubuntu. This created an ethical dilemma because the university had not given us permission to visit classes. Accepting the offers and visiting the classes would be unethical in the eyes of the university, while on the other hand, turning them down would ruin the mutual trust that we were trying to build with the teachers and their schools. In Ubuntu-based cultures, turning down an offer may be perceived as impolite. For instance, if you are offered food and you are full, you not supposed to turn the offer down. Instead, you just accept the food and take a little and thank them to show that even if you are full you appreciate the gesture. On the other hand, turning down the offer tends to convey a negative message. It is as if you do not trust the hosts.

In our case, refusing to visit the classes would have jeopardised the relationship that I was trying to build with the participants. Caught up in this dilemma, we fell back on Ubuntu and visited the classes to motivate the learners as requested by the principals. Ubuntu is often defined as an African way of living that is characterised by humanness (Gade, 2012; Keikelame & Swartz, 2019; Seehawer, 2018). People who practice Ubuntu treat each other with love, care, and respect of one another's dignity. For instance, whenwe returned from the school visits, the first thing that I did was to write letters to the school principals thanking them for allowing us to visit their schools and talk to their learners. To my surprise, one of the principals had already written an email thanking us for visiting them. This left me wondering and asking myself the question: "With whose lenses are we viewing ethics?" I began to realise that the blind pursuit of Eurocentric ethics at the expense of people's cultures may be unethical. To validate my ideas, I wrote a short paper on ethics which I presented at the Southern African Association for Research in Mathematics, Science and Technology Education (SAARMSTE) Conference proceedings in Durban in 2019 and in Port Elizabeth in 2020.

I also tested the appropriateness of the statement: "You can withdraw from this study at any given time if you want" which we are required to include as a disclaimer in our research procedures, by running a short questionnaire with other scholars from different southern African countries who attended the research conferences held at the university where I studied. The questionnaire asked them to translate the statement into their home languages (as recommended by Cohen et al., 2018) and read it to themselves and tell me what it made them feel. I repeatedly did this exercise in 2018 and 2019 to five different groups of research scholars to validate my views on ethics. The results of these presentations are summarised in the Table 5.1 below.

Table 5.1: Some contradictions between Eurocentric and Afrocentric ethics

You can withdraw from this study at any given time if you want.		
Country	**Translation**	**How I feel**
Malawi	*Mutha kuchoka mukafukufukuya/Nthawi ina iliyonse yomwe mwafuna.*	It is like you do not want me to be part of your study. I will definitely not participate.
South Africa (IsiXhosa)	*Ungarhoxa kwesisifundo soluphando nangaliphi naixesha ufuna.*	This suggests that I am not very important.
South Africa (Venda)	*A vha pfe vho vhofholowa are vha tshi nga toda u dibvisa kha hei ngudo.*	Even though I understand what you are trying to say but it's inappropriate to say that to someone in our culture.
Zimbabwe (Shona)	*Unogona kuregedza paunenge wadira.*	I will not participate because it shows that you do not care about me.
Namibia (Oshiwambo)	*Ouna uufemba okuliku famo moshinyangadalwa eshi uuna uudite wafa ino hala vali.*	Well, I will not participate because you imply that my contribution is not important. I feel like you are saying life goes on with or without my participation.
Botswana (SeTswana)	*O kane wa hogela dithuto tse na enngwe le enngwe gare go gapelletse.*	It is as if you do not care whether I participate in the study or not.
Lesotho (SiSuthu)	*Onkane watlohela dithuto tsena ning kapa ning.*	I feel like I am not important

In the discussions that followed one of the participants asked the question "*Why would you even invite me to be part of your study if you have got that mentality and that attitude already?*" These sentiments were also shared by many Blacks from Bantu societies who attended the conferences mentioned above. In contrast, most of their White counterparts saw nothing wrong in giving someone the freedom to withdraw if they feel uncomfortable to continue. In fact, it came to them as a cultural shock. For instance, in the SAARMSTE conference held at Rhodes in September 2018, the professor who was chairing the proceedings of the conference, was so shocked that she said: "*Chris, you are hitting me right here! You are hitting me right on my forehead*!" (holding her forehead between the eyes) (Quinn, 2018, pers. com.).

She went on to explain that she never thought that anyone would be offended by such a statement because giving anyone the freedom to leave or withdraw from a study is the 'most polite' thing in her understanding. It is a gesture to show the participants that they are not being coerced to participate in the study.

The lesson drawn from this experience is that many studies on indigenous peoples may actually be unethical because of their blind adherence to Eurocentric ethical standards, at the expense of the indigenous people's cultures. This experience shifted my perception of ethics. It made me realise that there is tension between the Eurocentric and Afrocentric understanding of what is ethically correct. It opened my eyes to see the world through the eyes of the participants as Cohen et al. (2018) recommended. I realised that beyond the non-maleficence concerns underpinned by the university's Ethics Committee, ethical conduct in the African sense is about building genuine mutual relationships based on genuine concern for one another. It is also above being honest, respectful, and loving. As Seehawer (2017) pointed out, I had to follow the local protocols by interpreting and applying ethics as they are understood by the participants.

5.3 Getting to Know my Participants

As a first step into this study, I decided to take an ethnographic approach and immerse myself in the Xhosa culture. Even though I am also a Bantu from Southern Africa, I would not just assume that my interpretation of Ubuntu is the same as my participants'. Thus, I had to start by gaining a better understanding of the local people's interpretation of Ubuntu. Trust is something you earn through mutual engagement with people. Thus, I took a year of visiting my participants in their classrooms so that I could build relationships with them and get to understand their concerns, fears, and challenges. Additionally, I also visited the local communities and attended two traditional Xhosa ceremonies, accompanied by the science lecturer who introduced me to the community and explained the purpose of my visit. He also acted as the interpreter who explained to me in English what was happening so that I could understand how Ubuntu is applied in the Xhosa culture.

On both occasions, as soon as I was introduced, I was treated as if I were a family member. The host families gave me food and made me feel comfortable. As soon as they found out that I was a foreign student, who is also a Bantu who was researching on IK, the elderly people started warming up towards me and shared stories about the area, their culture, its history, and the changing world as if they were telling their grandson. Storytelling from African elders tends to come naturally as they feel compelled to pass on their knowledge, history, and wisdom to the younger generations. According to Tzou et al. (2019), storytelling has been used in Africa and many other indigenous communities as a teaching strategy through which information is passed down from one generation to another. This compulsion to selflessly share knowledge was evident in this study as one of the elders started telling me the history of Rhini (Grahamstown) now Makhanda. He told me an interesting story related to IK about the mountain Ntabayezono which used to be a holy shrine where people would go and worship and conduct rain-making ceremonies whenever there was no rain. I later found out that the name Ntabayezono means the mountain of sinners and that there is a choral song that used to be sung in schools about this mountain which says:

Hambani madoda; Hambani bafazi; Niye kwelo laseRhini; Niyokubona izinto

Kukho intaba yezono; Ejikelezwe yimithi; Yindawo yokuhambela;

Ngemin'ezipholileyo

Bakhona oodali; Zeziponono; Nezicwicwicwi

Yonke indidi zezinto

The song can be interpreted as: "Go ladies and gentlemen to Grahamstown to see things. There is a mountain called Ntabayezono surrounded by trees, which is a place to relax/enjoy yourselves with your lovers. There are beautiful ladies and all sorts of things". The old man explained that Ntabayezono is more than just a name. It is a *concept* that captures not only the history of Grahamstown but also the damage that colonisation/urbanisation has done to IK by turning what was once a holy rain-making shrine into a place of sin.

Sharing their food, experiences, and stories made the community members feel appreciated. It also helped me to gain a deeper understanding of the damage done by colonisation to the indigenous people. Their stories resonated with what I had read in literature, that even after independence, the education systems in Africa continued their traditional of perpetuating colonial ideologies which led to the epistemicide of IK (Ngcoza, 2019). This confirms Afonso-Nhavelilo's (2013) assertion that education was part of the colonial machinery that was used to conquer the body, the mind, and the soul.

5.4 Ubuntu as an Organising Philosophy in this Study

Drawing lessons from the above experiences, I turned to Ubuntu and made it the philosophy that informed my ethical conduct in this study. This meant that I had to follow the Xhosa culture in identifying the potential participants, negotiating consent, and showing appreciation for their contributions. To achieve this, I needed someone who understood the Xhosa culture, so I negotiated with the science lecturer who was teaching the BEd Natural Sciences in-service teachers to assist me as the negotiator and facilitator of learning.

5.5 Identifying Community Experts

The above-mentioned visits also helped me to identify the community IK expert who would demonstrate the making of *umqombothi*. Because I had become an acceptable member of the community, identifying and negotiating with the community expert became easier. The negotiation had to be done through my critical friend who was familiar with the cultural protocols on how to negotiate with a married woman.

Even though my interest was to talk to the community expert who knew how to prepare *umqombothi,* the negotiation process involved the whole family because in Xhosa culture you cannot just talk to a married woman without the permission of her husband or the family to which she is married. Every adult is called by their clan name as a sign of respect. Thus, I called the community expert who prepared *umqombothi* as MaMngwevu (her clan name).

As I was about to approach MaMngwevu to sign the written consent, my critical friend informed me that in the Xhosa culture, verbal consent is more important than written consent. As a result, I had to first negotiate verbally and after she had agreed to participate, then ask her to sign a consent form. When I explained to her that she had to sign that she had agreed to be part of this study and that her name and identity would be anonymous, she was shocked. Her response was: "*Hayibo, kutheni ungathi andinithembi? And why igama lam lingaveli?"* (Why is it that it is as if you do not trust me and why should not my name appear?)

These questions posed a threat to this study. It appeared as if I was hiding something. So, I had to carefully explain to her that these were ethical requirements and procedures that we were required to follow by the university to protect our participants. Her response was that she would not mind having her name and photos revealed in my study because that would make her well known to the world for her knowledge.

This left me in an ethical dilemma. It contradicted the principle of anonymity emphasised in research methodology literature. Insisting on hiding her identity would be suspicious and unethical. It was against Ubuntu ethics and would potentially ruin the mutual trust that I had built with the community expert. To build trust, I had to be transparent and honest about the purpose of my study and explain the implications of her participation in terms of the time she would have to sacrifice away from her family. When everything was clear to everyone, she agreed to participate in my study and signed the consent form.

On her side, she insisted that she wanted to be recognised for her knowledge and I conceded to writing her name and showing her photographs in my thesis as Mama Nolingo (Mrs Nolingo). Thus, in in this thesis, the names uMama Nolingo or MaMngwevu were used interchangeably.

The above experience gave me an idea of how I would approach the BEd Natural Sciences in-service teachers.

5.6 [12]*Unozakuzaku* as the Consent Negotiator

Drawing inspiration from Seehawer's (2018) advice that researchers should observe the local protocols of the indigenous people in conducting research, I asked my Xhosa critical friend (the science lecturer) the Xhosa protocols followed in negotiating consent. I was told that in the Xhosa culture, important negotiations such as *amalobolo* (paying bride price) is done through a mediator called *unozakuzaku* who is usually someone known to both families. Taking a cue from this, I visited the BEd Natural Sciences in-service teachers in their class accompanied by the science lecturer who introduced me to the class and briefly explained my intended study. From then on, I began negotiating consent and building relationships based on mutual trust.

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[12] *Unozakuzaku* is someone who does lobola negotiations in the Xhosa culture.

In the epigraph under the chapter heading, Smith (1999) called research the dirtiest word in the eyes of the indigenous people. Part of the reason why this is so, is because researchers often use the mining approach where they come to an indigenous community with the sole interest of extracting information. Because the researcher does not have the people at heart, they have no time to listen to their stories or their concerns. Instead, they treat them like guinea pigs. It is precisely for this reason that I decided to start my study by building mutual relationships with my participants before asking them to sign letters of consent. Because earning trust from people requires a long period of time of engagement based on genuine concern for each other, I used the whole of 2018 to build relationships with my participants. I had to attend their lectures, listen to their stories, their worries, and fears. They were concerned that they were being failed without being given the necessary support during the course of the year. They told me that they started the course being a class of 46 but 19 of their colleagues had been excluded because they were said to have failed. They asked the question: *"Who is next to go?"* They explained that as adult learners, their greatest fear was failure because it had many implications on their self-esteem as parents, married people, teachers, and leaders. Even though these teachers had passed, they were not happy that their colleagues had failed. I was overwhelmed by such Ubuntu and I decided to work collaboratively with them in their own studies and offered to assist them whenever they needed help. This gave me the opportunity to be accepted as a colleague which made it easier to negotiate consent. I explained the purpose of my study, and the potential constraints and mutual benefits entailed.

Commenting about benefits of participation in a research study, Cohen et al. (2018) advised that researchers should be upfront about how they will reward their participants for taking part in their study. In my case there were no material rewards to be given to the teachers as a token of appreciation. Instead, the benefits we could all potentially draw from this study was professional growth. I assured them that I intended to explore how to teach science integrating IK using easily accessible resource to see how it could potentially make science accessible to all learners, so I wanted to work *with* them and not *on* them as collaborators. In support, the science lecturer reminded them of the African saying which says: *"If you want to fast, walk alone, but if you want to go far, walk with others"*.

They burst into the song:

Ndibambe ngesandla ndingatshi emlilweni x2

Intliziyo kaJesu inene

Sengizo casha kuyona

Ndibambe ngesandla ndingatshi emlilweni

Yatshi iGomorrah, neSodom, Gomorrah emlilweni

The key message in this song is "hold me by hand (help me) so that I do not fall into fire". When one views this through a CHAT lens, a contradiction emerges because a university is supposed to be a place of learning that inspires hope and wets students' appetite to acquire more education, but it seemed to not be the case for this group of students. It can be argued that instead of viewing the university as a place that nurtures talent and gives them hope, they viewed it as a 'Biblical hell' because they had lost 19 of their colleagues due to exclusion because the university rated them as 'poor performers'. Indeed, this to me at least, contradicts the principles of transformation and inclusivity often talked about at the university. The experiences of these teachers tend to give credence to the metaphor of the two mountains in Section 1.2 because they came to the university to learn but it seems they were wounded instead. That necessitated a healing process as advocated by Smith (1999).

In the context of this study, the healing processs was operationalised through the bottom-up decolonisation in which other ways of knowledge (epistemic diversity) are recognised (Seehawer, 2021). To realise such an ideal, I tapped into the cultural heritage and wisdom of community experts or elders who demonstrated the indigenous practices of making *umqombothi* and *oshikundu*.

This song thus became the theme of our PLC as it underscored the need to work together to achieve a common goal. We used it to remind ourselves of the essence of Ubuntu. It ignited what CHAT scholars refer to as transformative agency, which Deci and Ryan (1995, p. 35) described as "those motivated behaviours that emanated from one's integrated self". In support of this Haapasaari et al. (2014) underscored the importance of activating transformative agency that goes beyond the individual. We sang it with passion in nearly all our opening and closing sessions of this intervention. The teachers would sing it as they prepared to return to their schools after a session.

Literature on research methods tend to concentrate on understanding ethics from a beneficence-non maleficence perspective and gives little attention to the importance of following culturally appropriate procedures and treating people with *imbekho* (respect) and humility (Cohen et al., 2018; Creswell, 2014). When everyone was happy and committed to this project, I then asked them to sign consent letters, which they did happily.

5.7 Negotiating with the *Oshikundu* Expert

When my colleague from Namibia who also joined the workshop that was attended by Namibian students saw what we were doing, she offered to demonstrate how to make *oshikundu* so that she could use the demonstration to pilot her study. I discussed this with the science lecturer who in this case would be the facilitator and the BEd Natural Sciences in-service teachers who all agreed to it. In this way, we would all collaborate and draw the mutual benefits underpinned by Ubuntu (Keane et al., 2017; Seehawer, 2018).

While the relationship between the researcher and their participants usually end as soon as the researcher finishes collecting the data that they wanted, the relationship between me and my participants is an ongoing process beyond the research project. Because the study was based on Ubuntu, which emphasises mutual benefits, I traced the mutual benefits that accrued to the participants of this study beyond the scope of this study. These are presented in the sections that follow.

5.8 Calling Participants by their Clan Names

According to Wilson (2008), every indigenous researcher should be a provocateur who challenges the Eurocentric paradigms and thereby seek to provide alternative and viable solutions. In this study, I questioned the approach to anonymity that is recommended by research methodology books such as Cohen et al. (2018), where the emphasis is on hiding the participants' identities through the use of pseudonyms and bluring photographs. However, in some African cultures such as isiXhosa it is considered disrespectful to call an adult by their first name. What this then implies is that, even if I were to give the participants pseudonyms, calling them by those names would still violate the cultural rule which says adults are not supposed to be called by their first names. It would still be disrespectful. Instead, adults are called by their clan names.

Confronted with this, I agreed with the participants that I would call them by their clan names. Instead of imposing my own pseudonyms, I then asked the teachers who participated in the interviews to give me the pseudonyms of their own choice. They gave me names such as Nonto, Babs, and Axe. On the other hand, the respondents to the questionnaire were identified by their question number and gender so that it would be easier to see any patterns in their responses. For instance, the first female respondent to question one would be called Q1F1 and the first male respondent to the questionnaire would be Q1M1 and the numbers go on like that.

5.9 Chapter Summary

This chapter presented the ethical tensions that emerged in this study between the recommended Eurocentric research codes of conduct and Ubuntu. The chapter started with a brief declaration of my positionality as an indigenous researcher. It then discussed the contradictions that surfaced in this study as ethical dilemmas I tried to apply the Eurocentric ethical codes of conduct recommended by the university in dealing with my participants. The chapter went on to demonstrate how Ubuntu was applied in negotiating consent with different participants and ensuring that this study was of mutual benefit to all participants involved. The new knowledge in this chapter is that it challenges the arrogance underpinning by the universal application of Eurocentric ethics as standard behaviour. The chapter demonstrates that the universal application of a monocultural perception of ethics that is insensitive to participants' cultural interpretations of what is ethically acceptable has the potential of being unethical (Gatsheni-Ndlovu, 2019; Smith, 1999). While literature acknowledged that there is need to respect the participants' cultures, there are few studies that demonstrate how the local indigenous ethical protocols can be followed when conducting a study (Cohen et al., 2018; Seehawer, 2018).

CHAPTER SIX: QUESTIONNAIRES AND INTERVIEWS

> A key aspect of contradictions is that their recognition delivers insight into the change and development possibilities of activities. As contradictions arise, or are observed, they expose the dynamics, inefficiencies, and most importantly, opportunities for change and action. (Karanasios et al., 2017, p. 2)

6.1 Introduction

As pointed out in the above epigraph, identifying and surfacing contradictions within an activity has a potential to precipitate development. It is with this understanding that this chapter explores the contradictions embedded in the science teaching activity system. This chapter thus presents the data gathered during the explorative phase which aimed to answer the first two research questions of this study which are:

1. What are the BEd Natural Sciences in-service teachers' attitudes, experiences and pedagogical insights on the integration of indigenous knowledge in science teaching?

2. What contradictions are embedded in the BEd Natural Sciences in-service teachers' attitudes, experiences, and pedagogical insights on the integration of indigenous knowledge in science teaching?

The data presented in this chapter were gathered through a questionnaire, face-to-face interviews, and a focus group interview. For triangulation purposes, the same questions were asked in all the three research instruments so that it would be possible the compare the finidngs. In this chapter I present the findings on each one of these questions.

Presented below is the data gathered from the questionnaire which I first reduced to codes, categorised sub themes, and themes (see Appendix C: Table C1).

Five themes emerged in the data presented above. The data showed that the teachers in this study supported the integration of IK in science education which they viewed as an enabler of learning. Their reasons for supporting the integration of IK ranged from educational reasons to socio-political reasons as explained below.

6.2 Teachers' Experiences

This study revealed that many teachers received an education system that excluded IK. The majority of respondents to the question that asked them about their experiences indicated that IK was not included in their curriculum. For triangulation purposes, the same question was asked in all three research instruments (i.e. the questionnaire, the focus group interview, and the individual face-to-face interviews). Of the 16 respondents to the questionnaire, only three said that IK was integrated in their science lessons when they were still learners at school.

However, when the same question was asked in the face-to-face interviews and the focus group interview, only one respondent (from Zimbabwe) said that IK was integrated in their lessons. It is evident from this finding that the majority of the teachers in this study did not experience the integration of IK in their own learning as school children. A case in point is Babs who participated in the focus group interview who had this to say:

> *When I was at school IK was not incorporated at all because ... the school was a Christian background. IK was taken as barbaric, something which was not there. And it's not working. Though there were people that were there that were claiming that they can cure illnesses like cancer with certain medicines it was not accepted.* (Babs)

In support, Axe who also participated in the focus group interview said:

> *My situation is more or less similar to Babs' experiences. We never had it* [the incorporation of IK] *also in our experiences. We only heard about these stories of medicines that cure and many other examples, but we were never taught about IK. In university we never had any experience with regards to the incorporation of IK.*

He went on to explain that during the time he was in school, only Western textbooks were used to teach science and nothing was mentioned of IK. Bab's and Axe's sentiments resonate with the majority of the responses from the questionnaire and the face-to-face interviews. For instance, Q1M4 responded to question one by saying: "*The teacher barely incorporated IK, and it was not even stipulated on the curriculum*". In support, QIF2 added that "*It's only now that we use indigenous knowledge as part of our curriculum*".

This study also revealed that the teachers do not get support in their efforts to integrate IK from other stakeholders such as the department of basic education, textbook writers, and the community members who are the custodians of IK. This emerged in responses such as Q4F5's when she answered the question "*What were your experiences with regards to the integration of IK?*" by saying:

> *In my experience as a science teacher, I have never attended a workshop where teachers were capacitated on how to integrate indigenous knowledge in their teaching of science. Even in the science assessment it is barely included, I have not come across a single question paper wherein indigenous knowledge has been included and this defeats the purpose of the inclusion of IK as intended in the curriculum document.*

When these responses were triangulated with what emerged from the face-face-interviews, a similar trend was observed. For instance, Litha who participated in the face-face interview responded to the same question by saying: "*When I was taught as a child there was nothing. You were just told that there is something. Just a few examples. It was just pouring information while the listener or the learner is staring at the teacher".* Litha went on to explain that in the high school where she learnt there was a classroom labelled 'Science Laboratory' but for the entire duration of her stay at that school she never saw it being used for any science activities. She added that science was taught through "*chalk and talk, with no direct link"* or relevance to everyday experiences.

The data also revealed that even though IK was not officially part of the curriculum during the apartheid era some teachers would from time to time draw examples from IK to make their learners understand. However, what is interesting is that all three teachers who said that IK was integrated in their lessons were talking of experiences that did not resemble the typical South African classroom of the time. For instance, Nonto (the Zimbabwean teacher) who participated in the focus group interview said IK was used by her biology teacher when he was teaching about reproduction. She also found support from Babs who said:

> *It is only when I went to college that I had a science lecturer that was an Indian guy. He didn't really understand what was going on with the Xhosa culture, but he made an example of ginger beer saying that its part of science. That's when I became interested because I could see that now I can understand things that I didn't understand when I was in High School. Then I asked my father some things. That is when I heard about 'isisele', the hole that they had on the kraal to preserve mealies.*

It was evident that both Nonto and Babs were referring to isolated incidents when individual teachers took the initiative to integrate examples from their learners' everyday experiences in an attempt to make them understand. It was also interesting to note that both cases cannot be used as examples of what was happening in in a typical South African classroom during the colonial era because Nonto was a Zimbabwean and Babs was talking about her Indian lecturer in university. Moreover, when Nonto's account was juxtaposed with research conducted in Zimbabwe, one noticed that her experience tends to contradict with what emerged in literature. For instance, a study by Shizha (2007) found that many teachers in Zimbabwe did not integrate IK in their science lessons because they regarded it as unscientific knowledge that had no place in science education. A similar study also conducted in Zimbabwe, by Dziva, Mpofu, and Kusure (2011) also found that the teachers in their study had negative attitudes towards IK which they regarded as inferior to Western Science. In light of this, it can be argued that although IK was not officially part of the curriculum during the colonial era, there were some teachers who saw it necessary to integrate it in their science lessons to make it easier to understand. These teachers would spontaneously integrate IK when the need arose. Both Nonto and Babs tended to describe the teachers who integrated IK as good teachers who made them not only like science but also understand it. What this tells us is that even though Nonto learnt in another country, her experiences were not very different from that of her South African counterparts.

The thread that ran through all the responses given above is that IK was not part of the curriculum during the colonial era even though some teachers would spontaneously draw examples from IK. This tended to concur with the findings of earlier studies which converged on the notion that many teachers struggle to integrate IK in science lessons because they were schooled and trained using a Western curriculum that denigrated IK (Aikenhead, 1996; Mothwa, 2011; Shizha, 2007). Mothwa (2011) consolidated this by noting that there is a clash between teachers' educational backgrounds and the policy that expects them to integrate IK in their science lessons. She also noted that in many cases, teachers lack either the content knowledge or the pedagogical knowledge to integrate IK.

6.3 The Teachers' Attitudes and Professional Insights Regarding the Integration of IK

The first question of this study also explored the teachers' attitudes and professional insights towards the integration of IK so that it would be possible to trace if there were any shifts in these at the end of the intervention. The teachers' responses to the questionnaire were inductively reduced to categories, sub themes, and themes for easier analysis. The themes that emerged from this analysis are discussed below.

6.3.1 Promoting interest

The data generated from the questionnaire and interviews revealed that the BEd Natural Sciences in-service teachers supported the integration of IK in science education. They argued that it increases learners' interests in science. This was evident in statements such as: "*science is much more interesting. It comprises of practical activities. It is real and used almost in our daily activities. It opens the minds of our learners and increases curiosity*" (Q2F2). In the same vein, Q1M7 also said "*I feel that if it could be included in science lessons, science would be very interesting and more relevant as it would incorporate our experiences*".

Even though these teachers used different words, their responses revolved around the view that the integration of IK in science lessons motivates learners and makes it more meaningful. These teachers tended to view the importance of integrating IK in science lessons from an affective point of view. The assumption is that if science is made more exciting more learners will like it and pass it. This view is supported by a plethora of studies conducted in both southern Africa and abroad (Basu & Barton, 2007; McKinley, 2005; Seehawer, 2018) which also found that learners tend to be more excited to learn science when IK is integrated in their lessons. Lack of interest in science is one of the reasons why learners fail science as Basu and Barton (2007) confirmed when they accentuate that learners fail science because they view it as an abstract and very difficult subject that can only be understood by the exceptionally gifted children. It is this negative attitude that contributes to the high failure rates in science especially among the indigenous learners.

The outcomes of this study revealed that teachers felt that the integration of IK in science lessons makes it more accessible to learners as it raises not only their interest but also their curiosity as can be seen in Q2F1's comments that: "*My students seek more answers to traditional habits and taboos. They also want to practise what they learnt at school*". This shows that the learners began to link what they learnt at school with their daily experiences. In other words, the integration of IK makes learners eager to learn which explains why they were looking for more answers. This teacher's sentiments tended to contradict the claim made by Horsthemke and Schafer (2007, p. 5) that indigenous learners in South Africa reject the integration of IK because they view it as "irrelevant, exotic, backward and culturally alienating".

An analysis of these two views showed that they converge on the claim that integrating IK in science lessons increases learners' interests not only in science but also in IK (Mutanho, 2016; Ngcoza, 2015). From Q2F1's point of view the integration of IK does not only help learners to develop interest in science, but it also helps them to expand their understanding of IK. Learners "*seek more answers to traditional habits and taboos*".

6.3.2 Promoting understanding

The teachers also supported the integration of IK in science lessons because they believed that it promotes learning with understanding. This emerged in responses such as that of Q4F2 who said:

> *I am of the view that local knowledge is very important so it should be respected because it is the previous knowledge our pupils know and understand before they are given new knowledge at school, and as such they first think of things in their natural way. Therefore, teachers should value the indigenous knowledge because it leads to proper understanding of the subject matter. Engaging in indigenous practices that we as learners were very familiar with made us very eager to learn because science was giving new names to what we already know at our homes, for example, sour things like lemon, oranges and some fruit are known as acidic while cleaning detergents are called bases, sodium chloride is salt, hydrogen oxide is water and many others.*

An analysis of the above response showed that Q4F2 raised a number of benefits of integrating IK in science lessons. Firstly, Q4F2 tended to argue that the integration of IK enables the teacher to teach from the known to the unknown which she felt would promote conceptual understanding. This view was also shared by Q1F1 who contended that the integration of IK in science lessons "*lays the foundation (prior knowledge) to what is to be taught at school*" (Q1F1). In other words, the integration of IK enables the learners to make connections between their everyday experiences and science. Q2M2 supported this by saying: "*It makes it easy for learners to understand as they relate to something they know. Thus, the integration of IK makes learners to progress in their learning from the known to the unknown*".

Earlier studies by Aikenhead and Jegede (1999), Ogunniyi (2007a), Le Grange (2007) also found that the integration of IK in science lessons demystifies science which many learners view as very abstract. For instance, Aikenhead and Jegede (1999) viewed the integration of IK as something that enables learners to cross the cultural bridge between home experiences and school science.

6.3.3 Making science accessible to all learners

Closely related to the arguments raised above were those teachers who felt that the integration of IK in science lessons makes it accessible to all learners. In their view, when a teacher makes use of learners' IK in their lessons, they increase the chances for all learners to access science. Underpinned in this assertion is the assumption that all learners are capable of passing science if it is taught in a manner that makes it accessible to all learners. These teachers' responses tended to reflect the inequalities embedded in the current teaching science practices whereupon science is taught in a Eurocentric manner at the exclusion of IK. The findings of this study tend to agree with Gwekwerere's (2016) study which also established that integrating IK in science lessons makes it accessible to learners.

6.3.4 Social justice

Some of the BEd Natural Sciences in-service teachers viewed the integration of IK from a social justice perspective. These teachers saw the integration of IK in science education as a way of redressing the educational imbalances of the colonial era. For instance, Q4M1 said: "*IKS is about re- opening crucial files that were closed in chaos and violence of colonialism in which the cultural, scientific, and economic life of the colonised was subjugated and crushed*". The same sentiments were also expressed by Q4F5 who said: "*The inclusion of IK in science lessons is in my view, a step in the right direction by our government in its quest to decolonise science the curriculum*".

Embedded in these responses are political sentiments which may have emanated from the teachers' childhood experiences since they learnt during the apartheid era. In other words, these responses tended to reveal the *historicity* of science education in South Africa, where both teachers may have learnt during the apartheid era and experienced the unfairness and racial segregation of the Bantu Education system. The words used by Q4M1 showed strong political resentment of the injustices of the colonial era. This response can also be viewed as agentive talk aimed at confronting the inequalities that this respondent might have experienced in his childhood (Haapasaari et al., 2016). Such responses remind us of the assertion made by Vhurumuku and Molekeche (2009) that the integration of IK in South Africa is influenced not only by educational factors but also by the need to redress the educational imbalances of the colonial era. It is therefore important to view this intervention through a CHAT lens as a multi-layered and multi-voiced activity system. Presented below is a CHAT analysis of the science teaching activity system.

Table 6.1: Understanding the integration of IK as a multi-layered activity system

Tools	Indigenous knowledge embedded in the making of *umqombothi* and *oshikundu*; CAPS document; Natural Sciences textbooks; English language; isiXhosa language; chalkboard; newsprints; mind maps, concept maps; scientific models; chemical symbols and equations
Subjects	BEd Natural Science teachers: learnt during the colonial era; some had not trained as science teachers; some were Christians whose churches did not approve of IK; the majority never experienced the integration of IK in their childhood
Rules	CAPS policy which required teachers to integrate IK; culture; the university rules
Community	Experts in the making of *umqombothi* and *oshikundu* who are well respected in their communities but not recognised by universities as experts. Generally presumed to be uneducated and often not consulted on curriculum matters
Division of labour	Community members were the MKOs on the making of the traditional beverages
Objective	The integration of IK in science lessons
Anticipated outcome	Improved access to science education by all learners

An analysis of the data presented in the above table revealed that there were tensions within the elements of the science education activity system with regards to the integration of IK. These tensions can be understood as primary, secondary, and tertiary contradictions. As already pointed out in Chapter Three (see Section 3.3.1), contradictions can be defined as the structural tensions that accumulate over a long time in the history of an activity (Haapasaari et al., 2016). Systemic contradictions occur when the elements of an activity system clash or conflict with each other. This usually occurs when a new element is introduced into an already existing activity system where it clashes with the other elements of the system that were already there (Haapasaari et al., 2016). In the context of this study, IK was being introduced as a new tool in science education. Historically, Western Science was used to eradicate IK because IK was viewed as unscientific knowledge that is based on superstition (Le Grange, 2016; Ngcoza & Southwood, 2019). It is this historical tension between the two knowledge systems that is the source of contradictions in this study.

6.4 Surfacing the Primary and Secondary Contradictions Embedded in the Science Education Activity

The contradictions mentioned above emerged in the data gathered in the explorative phase of this study which sought to understand the contradictions embedded in the teachers' experiences, attitudes, and professional insights with regard to the integration of IK. This data were gathered through a questionnaire, individual face-to-face interviews, and the focus group interview. Contradictions surfaced in the teachers' response to question seven of the questionnaire which asked them to state what they viewed as the benefits and challenges of integrating IK in their science lessons and make suggestions. Engeström's (2001) second generation CHAT diagram was used to analyse these contradictions as shown below.

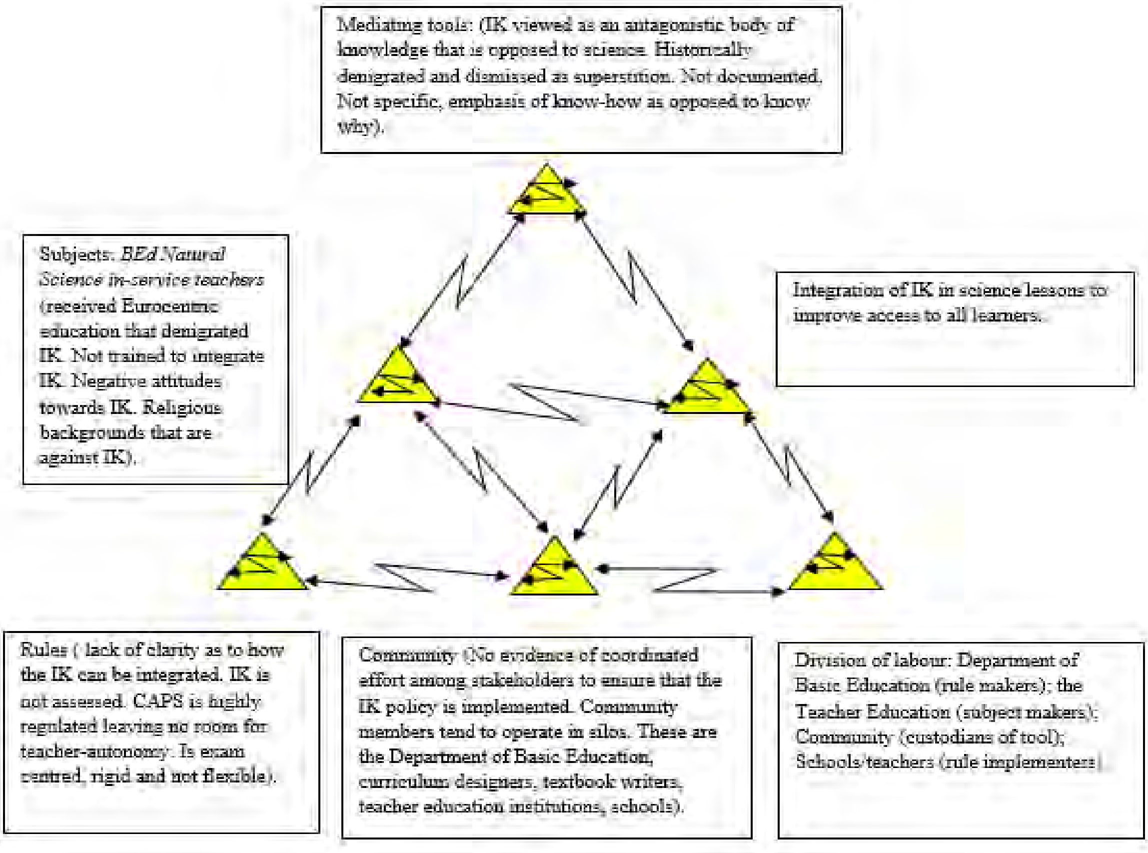

Figure 6.1: Contradictions embedded in the science teaching activity

The above diagram illustrates the primary and secondary contradictions embedded in the science teaching activity system. As Engeström and Sannino (2011) stated, contradictions are not directly observable, but are observable when they manifest themselves as tensions within and between the different elements of an activity system. In this case, they emerged as systemic tensions within and between the different elements of the science activity system that are traceable to the historicity of education in South Africa. Each one of these is discussed in the sections below.

6.4.1 Rules

In this study, the rules refer to the CAPS curriculum. The intra-element contradiction within the IK policy emanates from the fact that that it lacks clarity. Besides stipulating that teachers should integrate IK, the CAPS document does not clarify exactly how the IK can be integrated (DBE, 2011). Literature has revealed that IK as a concept is not easy to define or pin down in precise terms because it refers to a wide spectrum of knowledge which includes both scientific and non-scientific knowledge. In the absence of a clear definition and clarity on how the IK should be integrated, teachers are left to use their discretion to select what IK to integrate, when to integrate it, and how to integrate it. The assumption is that teachers will use their creativity and ingenuity to come up with ways of integrating IK in their science lessons.

However, the outcomes of this study tended to paint a different picture as it revealed that some teachers lacked both the science subject matter knowledge and the PCK to integrate IK in their science lessons. A case in point is Q8F1 who said: "*But it is difficult for teachers to integrate curriculum with IKS, it is not easy to substitute what learners already know with what science is all about*". The reason for this failure to integrate IK in their teaching emerged in Q1aF2's answer when she said: "*Indigenous knowledge was not included in our curriculum, it was taken as a myth*". Hence, there is a contradiction between teachers' educational backgrounds and the rule that expects them to integrate IK. If IK is regarded as myths then teachers have to go through a huge mental shift, from negatively viewing IK to viewing it positively as an enabler of learning.

The study also revealed that in some schools, science is taught by teachers who did not train as science teachers. For instance, Q1M2 responded to question six of the questionnaire by saying: "*I was doing music and not science so I have no experience at all. This is my first experience* *here at Rhodes and it is helping and good*". Similarly Q2F6 also said: "*At college level, I was not a science student. I did science as a didactic subject*".

What was evident in these two responses is that the teachers lacked both the science subject matter and the PCK to enable them to integrate IK in their science lessons as expected of them by the DBE (2011). This surfaces a *rule vs subject* contradiction, in that while the curriculum emphasises that teachers should integrate IK in teaching science, some teachers may be lacking both the science and the methods of teaching it. This implies that the policy of integrating IK in science lessons cannot be realised unless teachers are equipped with the necessary conceptual tools to enable them to implement the rule.

When asked about the challenges they faced in integrating IK some teachers expressed anxiety about completing the syllabus in time. Their main argument was that integrating IK delays them from covering the curriculum within the stipulated time. This is because the implementation of the CAPS curriculum is highly regulated by the department of education. Teachers do not have the latitude to cover the curriculum content at their learners' pace because their learners are given common tasks to monitor if teachers are covering the curriculum content at the same pace with others. From time to time, subject advisors ask teachers to bring their master portfolios and the students' portfolios as evidence that they are covering the curriculum at the expected pace. This leaves teachers hard pressed to cover the curriculum at the expense of learners' understanding. This presents an *object vs rule* contradiction in that, while the rule expects teachers to integrate IK, it does not give them the time and autonomy to cover the curriculum at their own pace.

Additionally, this study was conducted at a university that was a former Whites-only university, where the integration of IK in the mainstream curriculum was unheard of. From what has been said about the role of educational institutions in destroying IK, one can deduce that prior to independence, the making of traditional beverages at the university would have been a serious offence that would have warranted an arrest and possible an expulsion of the lecturer involved. Even though there were no written rules that prohibited the making of traditional beverages at the university, the fact that this was a completely new practice was in itself prohibitive.

6.4.2 Object

In CHAT the object of the intervention is regarded as the motive behind the activity (Edwards, 2011; Engeström, 2001; Engeström & Sannino, 2011). It carries within it the purpose for conducting the activity. In this study, the object was the integration of IK in science education (DBE, 2011). The first noticeable contradiction in this object was that science and IK are two knowledge systems that are ontologically and epistemologically different and are often perceived as contradictory to each other. In South Africa, this contradiction is exacerbated by the fact that science education has a history of being used to suppress IK.

A second contradiction was that while the CAPS document stipulates that IK should be integrated in science education, it does not give any further guidance or supporting information as to how the IK should be integrated in science lessons. The department of basic education does not stipulate which IK should be integrated in the curriculum or how it should be integrated. It is left to the teachers' discretion to choose the IK and use IK as they see fit. It is this *rule vs object* that Ngcoza and Southwood (2015) picked up as the tension between the intended curriculum and the implemented curriculum. Their point was that the curriculum implemented by teachers in their classrooms may not necessarily be in line with what is stipulated in the official curriculum. In other words, if the policy is not clear, then teachers (who are the rule implementors) may find it difficult to translate it into pedagogical strategies that benefit learners (Shulman, 1987).

Added to the above-mentioned challenges, the additional mirror data from the literature reviewed in this study, revealed that there are no textbooks or teacher's guides to support teachers on how to integrate IK in science lessons (Botha, 2012). The BEd Natural Sciences in-service teachers were asked to state the challenges that they faced in their efforts to integrate IK. They pointed out that one of the challenges was that IK is not documented and this study also confirmed that there were no books that teachers could refer to or use in their teaching. The following are some of their responses.

Sekho (in the face-to-face interview) had this to say:

> *There is nothing said in the curriculum except that we have to use that area* [IK]. *So it has to come from you the teacher, which knowledge do you want to incorporate. You have to decide. There are no materials or textbooks on how indigenous people can include IK.*

Similarly, Q6F1, Q6F6, and Q6F3 also complained about shortage of documented materials on IK as they responded to the questionnaire. Their responses are presented in the table below.

Table 6.2: Teachers' views about lack of documentation of IK

Participant	**Responses**
Q6F1	Teachers show reluctance to include IK as it is not documented although it exists and broaden learners' knowledge.
Q6F6	The fact that indigenous knowledge is not written down. It sometimes makes it difficult to relate science lessons to the indigenous knowledge.
Q6F3	Lack of resources like textbooks.

These responses all pointed to the fact that although teachers are expected to integrate IK, there is no literature or textbooks to support their efforts to do so. This represents a contradiction in terms of the department of basic education's policy and the tools that are available to implement the policy. I have called this contradiction *a rule vs tool* contradiction because, while the CAPS curriculum stipulates that teachers should integrate IK in their science lessons, the teachers do not have the books and conceptual tools to do so. This contradiction draws our attention to the tertiary contradiction between the activities of the department of basic education and textbook writers. In other words, while the department of basic of education puts in place the policy to ensure that IK is integrated in science education, the textbook writers did not integrate IK.

6.4.3 The subjects

The mirror data also revealed some primary contradictions within the subjects. When the teachers were asked about their experiences with regard to the integration of IK, it emerged that the subjects had received the Bantu Education which denigrated IK and were not trained to integrate IK, yet they were expected to integrate it in their science lessons. This revelation emerged in the teachers' responses to the question: "What were your past experiences as a learner and a tertiary education student with regards to the integration of IK?"

To expect these teachers, who were the recipients of an education system that denigrated IK, to be the implementers of an IK-based curriculum, without giving them any further training is paradoxical. Teachers like Babs are likely to experience an *internal conflict* within their minds, when asked to integrate IK in their lessons because both the education they received and their Christian background treated IK as barbaric. I argue that unless such teachers are trained and given appropriate support it would be naïve to expect them to see value in IK and integrate it in their science lessons as is envisaged by the department of basic education. In other words, they need to undergo what Jacobs (2015) stated is a paradigm shift before they will be able to implement an IK based curriculum.

The BEd Natural Sciences in-service teachers' responses also showed that they were not given in-service training to integrate IK. This surfaced in their responses to question nine of the questionnaire which asked them to state the reasons why they think some teachers do not integrate IK in their science lessons. Although it would have been more appropriate to directly ask them why they do not always integrate IK in their science lessons, I decided to ask this question indirectly so that the teachers would be more honest in their responses. My assumption was that asking them directly to explain why they do not integrate IK in their teaching, would make them feel uncomfortable and they might become defensive. Instead, I phrased this question in a non-confrontational manner and then followed up with more direct questions during the face-to-face individual and focus group interview. This allowed the respondents to open up and answer questions freely. The following were some of their responses to the above question;

> *Q9M2: They were not trained to integrate IK.*
>
> *Q9F2: They are not aware that the CAPS document allows us to use IK in our classrooms. Some have learners who come from different backgrounds, so it is difficult to cater for all of them.*
>
> *Q9M3: They do not have information about indigenous knowledge.*
>
> *Q9M4: That would promote inferiority of Africans as our knowledge has been deemed irrelevant in science space.*

The thread that runs through all these responses is that the subjects lacked the conceptual tools to utilise the IK tool in their teaching. Q9F2's response suggested that even though the CAPS document may be available in many schools, teachers needed to be trained to unpack it. In other words, the physical presence of the policy document in schools is not enough to make teachers make use of it if they are not supported in unpacking it and made aware of its content.

I argue that making the CAPS curriculum physically present in schools is not enough to make it accessible to teachers. Instead, teachers need to be supported and equipped with the conceptual tools that will enable them to unpack the curriculum. Evidence from this study showed that although the CAPS document stipulates that teachers should integrate IK, some teachers are not aware of the contents of the policy document because they do not often use it as their main resource book. A case in point is Sipho who participated in the face-to-face interview who said:

> *Before I came to university, I didn't mind myself much about this indigenous knowledge, I didn't care about that. I never thought that it is very important because its forming part of their learning. Learners are learning a lot when they learn something and then I decided that I should have a positive attitude towards this IK because really it is helping the community. It helped me a lot because I used to look down upon indigenous knowledge in science. But now being here at university, I realised that IK has a lot of science because people had knowledge that they had. They had knowledge of a lot science, I used to regard that as better but now I have learnt that we have to incorporating indigenous knowledge.*

What was evident in this response is that this teacher did not take the IK-science policy seriously prior to this intervention. This implies that without proper training teachers will not take the policy of integrating IK seriously. When this is juxtaposed with the BEd Natural Sciences in-service teachers' attitudes towards IK alluded to in Section 6.3, it can be seen that even though teachers may positively view the integration of IK, they lack the PCK to integrate it.

The data presented in this section gives the impression that while the South African government seeks to eradicate educational imbalances of the past by integrating IK, not much has been done to confront the contradictions embedded within the teachers who are the implementers of curriculum. A similar observation was also made by Jacobs (2015) and Jensen (1998) who argued that curriculum innovations in South Africa fail because they ignore the role of teachers in bringing about the desired changes. Moreover, some of the teachers in this study had not even been trained as science teachers.

This study also revealed that some teachers had negative attitudes towards IK. A case in point is Q6F3 who responded to the question "What do you think could be the challenges for including local/traditional/indigenous knowledge in sciences lessons?" by saying: "*It can lead to tribalism as knowledge sometimes differ from area to area*". Q6F2 also said that the integration of IK into science lessons could lead to many misconceptions. In both cases, these respondents expressed *a subject vs tool* conflict in which they mistrusted IK as a learning tool. Q6F3 showed that her challenge was how to apply IK as a learning tool in a multicultural classroom. Her response connoted some resistance to implementing a learning tool that promotes tribalism. In other words, this teacher faces the dilemma of handling diversity in a multicultural classroom. When viewed against the historicity of education in South Africa, this concern about tribalism can be viewed as the remnant of Bantu Education which put people in tribal silos (Jensen, 1998).

On the other hand, the mistrust expressed by Q6F2 showed that she lacked the conceptual tools to handle the misconceptions that may arise from the integration of IK. Thus, when confronted with the need to integrate IK, these teachers are likely to face a conflict within themselves because they mistrust IK as a learning tool. Instead of seeing it as something that can be used to make science easier to understand, as anticipated by the policy, they viewed it as a source of misconceptions and tribal tensions. Their responses can be viewed as historically accumulated structural tensions within science education that are traceable to the time of apartheid. As Jensen (1998) pointed out, the Bantu education which these teachers received promoted ethnicity and tribal tensions while at the same time it denigrated African IK.

6.4.4 Mediational tools

The central mediating tool in this study is IK. The intervention made use of the IK embedded in the making of *oshikundu* and *umqombothi* as an example from which teachers would find more ideas on how to integrate IK in science lessons. However, while the integration of IK is supported by both the National Constitution of the Republic of South Africa (Act 108, of 1996) and the DBE (2011), the teachers' responses reported above revealed that there was very little written information to support teachers in their efforts to integrate IK. This emerged as *a tool vs rule* contradiction in that while the curriculum clearly states that teachers should integrate IK, there are no tools to support the policy implementation.

6.4.5 Community

The community in this study consists of the department of basic education (the rule making activity system and employers of the subjects), the teachers' education institution (subject trainers), the schools (rule and tool implementers), textbook publishers/writer (tool makers), and the community (custodians and experts in IK). Indigenous people are the experts and custodians of their own IK (Le Grange, 2016). However, even though they are experts in IK, they are often not acknowledged or formally recognised by universities and the whole education system as experts. As a result, they are most often left out on important curriculum issues such as the integration of IK because they are presumed ignorant.

6.4.6 Division of labour

On division of labour, my point of analysis was how the participants took up different roles during this intervention. For instance, while teachers are traditionally known as the experts mandated to transmit knowledge to society, in this study it was the members of the community who were the experts teaching the teachers. In Vygotskian terms, the community members became the MKOs. During the demonstration there was also division of labour between the science lecturer (facilitator) and the community experts.

6.5 Unearthing the Secondary Contradictions in this Study

Although this study was located in teacher education, it also revealed that apart from the above-mentioned intra-systemic contradictions there are tensions between the stakeholder activities systems involved in science education. This emerged from the teachers' responses to the questionnaire and interview questions. For this reason, the third generation CHAT model was used to help me to identify the contradictions that exist between the department of basic education (rule makers and enforcers), teacher education (the trainers of the subjects), the school system (the tool users), textbook writers (rule interpreters), and the community (custodians of the IK).

To unearth the contradictions embedded in the science teaching activity I asked the teachers the question: "What do you think are the reasons why some teachers do not integrate IK in their science lessons?" in both the questionnaire and interviews. Although this question was intended to find out the teachers' experiences, I decided to make it indirect to avoid being confrontational, in case they would become defensive and most probably not feel free to share the challenges that they faced for fear of exposing their own weaknesses.

The purpose of this question was twofold. Firstly, it was intended to find out the factors that the teachers considered as a hindrance to their integration of IK and secondly it was also meant to unearth the contradictions embedded in the science education activity. As already mentioned above, Haapasaari et al. (2016) view contradictions as historically accumulating structural tensions within an activity system. Taking a cue from this, I was keen to know how the history of science education influenced the teachers' attitudes towards IK. As a result, the above question's answers were analysed together with what emerged from other questions asked in the interviews and questionnaire.

Contradictions emerged in their responses with regard to their experiences and what they considered as barriers or hindrances to the integration of IK in science lessons. Seventy percent of the respondents to the questionnaire indicated that IK was not included as it was not part of their curriculum, while nearly all the respondents to the interview indicated that IK was not part of the curriculum when they were still students. Only 30% of the respondents to the questionnaire said that they had experienced the integration of IK on one or two occasions in their tertiary education.

To gain a historical understanding of how the science education activity has been shaped by events of the past, I posed the question: *"What were your experiences with regards to the integration of IK as a learner at school and as a tertiary level student?"* The responses to this question would give me an insight of the historicity of science education in South Africa. Presented in Table 6.3 are the primary and secondary contradictions that emerged from the data generated as the teachers responded to the above question (see Appendix C: Table C2).

The DBE (2011) IK policy that requires teachers to integrate IK in science lessons created the tensions between different elements of the science education activity system. These tensions are traceable to the *historicity* of science education in South Africa (Engeström, 2001; Engeström & Sannino, 2011; Haapasaari et al., 2016). A sample of such tensions from a few teachers' responses is presented in Appendix C: Table C3.

While it is a policy requirement that teachers should integrate IK in their science lessons, this study revealed that some of the teachers who participated in this study were not trained on how to integrate IK. Moreover, the majority of them indicated that they did not experience the integration of IK in their own learning because IK was not part of their curriculum. This resonates with the findings of Mothwa (2011) and Jacobs (2015) which showed that although many teachers in South Africa support the integration of IK, they lack the PCK to integrate it because they were not trained to do so. Similarly, Ngcoza and Southernwood (2015) also argued that the continuous professional development that teachers receive from the department is inadequate, inconsistent, and not responsive to their needs.

In the case of IK, it means that South African teachers are expected to implement a pedagogical tool that they were not trained to work with. Naturally, you cannot offer what you do not have. Such teachers are likely to face a dilemma as their colonial educational backgrounds (remnants of the old system) clash with the IK-science policy. In essence, this draws us to the tertiary contradictions embedded in such education because it shows us that the activities of the different stakeholder activity systems 'do not speak to each other' or are coordinated towards achieving one goal (Engeström, 2010; Haapasaari et al., 2016). These tensions are summarised in the diagram below.

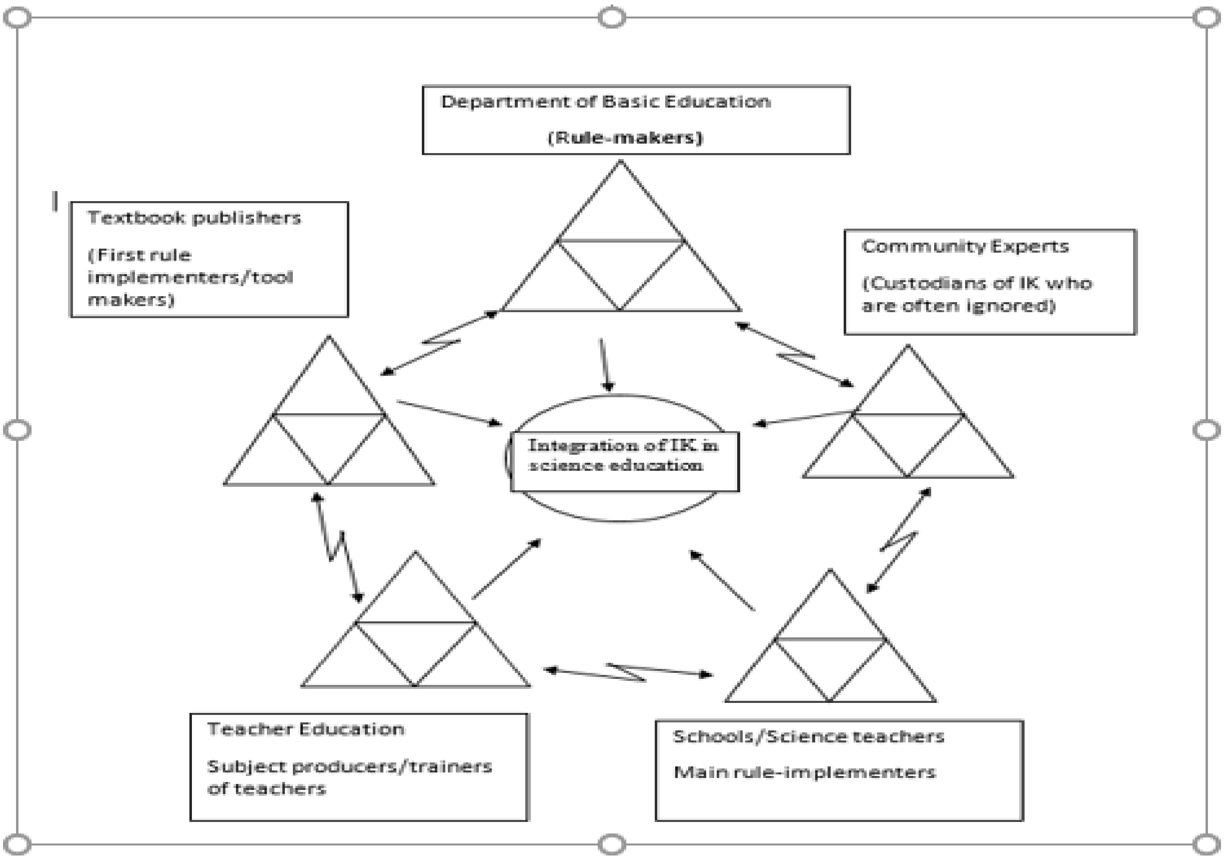

Figure 6.2: The contradictions between the activities of different stakeholder activity systems

This diagram shows that there are tensions between the activity systems of stakeholders with regard to the integration of IK in science education. The department of education does not stipulate what IK to integrate in the curriculum or how the IK should be integrated. This responsibility is left to the textbook writers and teachers who have to use their discretion to select the IK they see fit to include in their textbooks or lessons. On the other hand, textbook writers, teachers' training colleges, and universities as well as schools do not consult or invite community experts who are the custodians of IK to share their IK. As a result, IK is not documented as confirmed by the participants in this study. The teachers in this study cited this lack of literature as one of the major challenges that hinder them from integrating IK. This resonates with the claims made by Van Wyk and Botha (2012) cited in Section 2.3 who also noted that there are no textbooks to support teachers on how to integrate IK.

This scenario presents a dilemma to the teachers who are expected to integrate IK yet they are not given the tools to integrate IK. It also reflects the tension between the activities of the department of education, textbook writers and schools. Teachers who are the curriculum implementers are not consulted to decide what goes into the curriculum. Jacobs (2015) noted that the curriculum is handed down to them like an architect's manuscript to be implemented without questioning. She went on to comment that this reduces teachers to passive implementers of the curriculum. Some of the participants complained that they lacked training. This resonates with the observations made by Mothwa (2011), Jacobs (2015), and Bantwini (2010) who also argued that teachers lack support from the department of education to implement an IK based curriculum. This shows that there is no coordination between the activities of the department of basic education and the teacher training and school systems. Jacobs (2015) identified the top-down imposition of the curriculum as one of the reasons why subsequent curriculum innovations fail in South Africa.

However, as already pointed out, teachers are not consulted as the curriculum implementers to give their own inputs of what they think an IK-based curriculum should look like (Bantwini, 2010; Jacobs, 2015). Instead, the teachers are reduced to mere implementers of the curriculum designer's manuscript. The curriculum is also given to the textbook publishers who are also tool makers to produce CAPS compliant textbooks. The textbooks are approved by the department of education first before they are recommended for use in schools. However, the community members who are the custodians and experts in IK are not consulted by both the textbook designers and the department of education to contribute their knowledge of IK so that it can be included in the curriculum. As a result, the textbook publishers design textbooks that do not integrate IK as reflected by the participants' complaints that IK is not documented and that there are no textbooks or literature to guide them on how to integrate IK.

While this policy is handed down to schools to implement, the teachers are not properly trained to empower them with the PCK needed to do so, as indicated by the participants' responses. While community members who are the custodians of IK and the parents of the children for whom the curriculum is designed, they are not consulted by the department of education, teacher education institutions or schools to contribute their knowledge for the education of their children. On the other hand, the department of education (the rule making activity system) which is responsible for designing the curriculum working in collaboration with textbook writers (tool makers), do not influence the curriculum offered by teacher education institutions such as universities. The teacher education institutions (subject producing system) have the autonomy to choose what to teach and can design lessons as they see it fit. They in turn do not consult the department of education to determine the content of the curriculum they offer to trainee teachers. This disjuncture results in what Ngcoza and Southwood (2015) described as the tension between curriculum formulation and curriculum implementation. It has also been argued that many teachers leave teachers training institutions ill-equipped to implement the curriculum (Ngcoza & Southwood, 2015; Ogunniyi, 2007a). In light of this, I argue that the integration of IK in science education requires a coordinated effort of all the stakeholders right from curriculum designing to curriculum implementation.

As Engeström and Sannino (2011) observed, contradictions are the driving force behind learning. They provide the impetus to change. With this in mind, I sought to understand the contradictions embedded in science education and the transformative agency that emerged in the mirror data so as to see how it evolved during the course of the intervention. The contradictions identified in this phase were treated as the teachers' learning needs. As a result the series of workshops that were conducted in the expansive phase of this study were informed by the contradictions identified in phase one.

6.6 Chapter Summary

The main focus of this chapter was to explore the BEd Natural Sciences in-service teachers' experiences, attitudes, and professional insights with regards to the integration of IK so as to identify the contradictions embedded in science education. The study revealed that many of the teachers support the integration of IK in science lessons. Their reasons for supporting the integration of IK were that it promotes learners' interest in science and makes it easier for them to understand the subject. Additionally, the integration of IK in science teaching was also viewed as a way of redressing the educational imbalances of the colonial era. An analysis of data gathered in this chapter brought to the surface the primary and secondary contradictions embedded in science education. The teachers argued that when IK is integrated in science education learners become more engaged and seek more answers than when science is taught using the conventional approaches.

However, the data gathered in this explorative phase of this study also revealed the contradictions embedded in science education with regard to the integration of IK. For instance, it emerged that the educational backgrounds of many teachers conflicted with the IK policy because they had learnt during the apartheid era when IK was denigrated and regarded as barbaric knowledge that was not worth knowing. This means that the teachers did not experience the integration of IK as learners and were not trained to integrate it during their teacher's training, yet they were expected by the department of basic education to integrate IK in their science lessons. As a result, the teachers lacked the conceptual tools to unpack the curriculum and the PCK to integrate IK in their science lessons. In some instances, they lacked the knowledge of the IK yet they were expected to be cultural brokers as recommended by Aikenhead and Jegede (1999). These intra-systemic contradictions within and between the different elements of the science teaching activity pointed to the tertiary contradictions between the activities of the different stakeholder activity systems in science education. For instance, the teachers complained that they were not trained to integrate IK and they do not receive any support from both the department of basic education and the community experts who are the custodians of IK. Moreover, there is no literature, textbooks, or teachers' guides that specifically dwell on how to integrate IK in science teaching. These challenges show us that there is tension between the activities of the department of basic education, teacher education institutions, textbook writers, schools, and communities as illustrated in Figure 6.2. The contradictions that were identified in this explorative phase were taken as indicators of the teachers' learning needs, which informed the workshops conducted in the expansive phase of this study.

CHAPTER SEVEN: ORIENTATION WORKSHOP

> Transformative agency is about working with the contradictions of an activity system. It includes actions of questioning the status quo and of search for new possibilities. (Haapasaari, et al., 2016, p. 235)

7.1 Introduction

The previous chapter explored the teachers' experiences, perspectives, and professional insights concerning the integration of IK and made visible the contradictions embedded in the current science education activity system in South Africa. Contradictions in this study are understood as structural tensions that accumulate within an activity system over a long period of time (Engeström & Sannino, 2010). They emerged as structural tensions between IK and science that are traceable to the *historicity* of science education in South Africa. Such contradictions manifested themselves as dilemmas, conflicts, and tensions in the teachers' responses to the questionnaire and interviews.

CHAT scholars view contradictions as precursors to learning (Engeström & Sannino, 2011; Haapasaari et al., 2016). Thus, the structural tensions identified in the explorative phase were taken as indicators of the teachers' learning needs. As a result, the purpose of the expansive phase of this study was to confront these tensions by exploring ways of integrating IK in science lessons. This chapter presents the data gathered during the first phase of the expansive phase which focused on answering Question 4a of this study which is: *How can the BEd Natural Sciences in-service teachers be supported in co-designing science lessons that integrate indigenous knowledge using fermentation as an example?*

To address this research question, the teachers were exposed to a series of workshops to support them to develop exemplar lessons that integrated IK. These workshops aimed to resolve the contradictions that emerged from the data gathered in the explorative phase above. As Haapasaari et al. (2016) pointed out, contradictions are precursors to learning. Hence, the contradictions that emerged in phase one were considered as pointers to the teachers' learning needs. As a result, the workshops conducted during the expansive phase aimed to resolve these tensions. The workshops were aimed at how to support teachers to:

- Unpack the curriculum;
- Elicit and integrate learners' prior knowledge in a multicultural classroom;
- Tap into the community experts' funds of knowledge;
- Use easily accessible resources to teach science; and
- Co-design exemplar lessons that integrate IK.

The data gathered from each one of these workshops is presented in the sections that follow.

7.2 Document Analysis

Each group had a scribe who wrote down their ideas on newsprints which they later then presented to the rest of the class at the end of the session. The data gathered in this workshop is summarised and recorded in Appendix D: Table D1.

What is evident in Table D1 is that Mavhunga and Rollnick's (2013) TSPCK tool helped the teachers to unpack the CAPS curriculum and scrutinise it from different angles. Using the five components as their lenses, the teachers began to criticise the content, structure, and the alignment of the textbooks and the curriculum. For instance, although they generally agreed with the sequencing of the content, they criticised the progression of concepts taught from one grade to another. A case in point is group 3 who pointed out that there is a disconnection between the way content is presented in some textbooks and the sequencing in the CAPS curriculum.

It was also interesting to note that group 2 did not come up with any prior knowledge that could be integrated in science lessons. This may mean that they did not see the link between IK and science. They were also the group that managed to raise many concerns about the sequencing and alignment of the textbooks and the CAPS curriculum. However, the other three groups managed to identify the IK that can be integrated in teaching different topics in different strands. This was in response to the contradiction that although the teachers were expected to integrate IK in their lessons, they could not see the links between IK and science. This is well captured in T5's sentiments when she responded to the interview question on what she thought about the integration of IK in science lessons: "*It makes it difficult to relate the science lesson to the indigenous knowledge*".

The group presentations were followed by class discussions in which the teachers commented on the findings of each group and identified further difficulties. This step was necessary as it gave the teachers an opportunity to also contribute to what individual groups had found since each group was confined to working on one strand. Using their collective experiences, the teachers identified the concepts that they find difficult to teach to young learners as shown in Table 7.1 below.

Table 7.1: Scientific concepts identified as difficult to teach to lower grade learners

Strand	**Difficult concepts**
Life and Living	Plants respire (breath in and out), Plants feed and excrete Plants and animal are made up of cells
Matter and Materials	Matter is made up of atoms; chemical equations
Energy and Change	Scientific terminology in this topic is cannot be replaced with local languages. E.g. energy
Planet Earth and Beyond	Concept of life or death of stars can be confusing if we try to apply our everyday life experiences. Earth rotation confuses learners as they think that is the sun and not the Earth that is moving because they see the sun rising and setting every day and they do not feel the movement as they do in bus or car. They also cannot believe that the Earth is oval/round like a ball because they see it as flat. They ask questions like then 'Why is it that we do not fall?'

The teachers complained that these concepts are too abstract for learners in the lower grades. What makes them not easy to teach is that you cannot easily relate them to learners' everyday knowledge or experiences. In some cases, however, learners' experiences can be sources of misconceptions and confusion as reiterated by Mavhunga and Rollnick (2013). For instance, learners fail to understand that it is the Earth that is rotating and not the sun because what they see is the movement of the sun as it rises in the east and sets in the west and in everyday life we say the sun rises and sets which implies that it is the sun that is moving and not the Earth.

At the same time learners do not feel the movement of the Earth as they would do in a car or a bus. Moreover, there are many mythical stories told in many cultures about the movement of the sun. For instance, one teacher said when they were young they were told that every day at sunset the sun falls into the sea and a large crocodile swallows it and swims with it through the back side of the earth and drops it in the east where it rises again. With such myths in their minds, it would be difficult for learners to conceptualise Earth movements such as rotation and revolution because it contradicts what they see every day.

They also explained that it is difficult to explain the concept that the Earth is round like a ball because it contradicts what learners see. The teachers reported that learners often ask questions such as "*If the Earth is round like a ball then why is it that we don't fall off from its surface?* or *"Are we inside the ball or outside the ball?"* Such questions show that most of the content that is taught on the topic "Planet Earth and Beyond" is too abstract for young learners to understand. What makes it more challenging to teach these topics is that you cannot teach much of the content in this topic using laboratory experiments or using their everyday knowledge. In some instances, you cannot use their indigenous languages to explain some scientific concepts (Khupe & Keane, 2017; Msimanga & Lelliot, 2014).

For instance, the word *amandla* in isiXhosa can be confusing because it is has more than one meaning. The word *amandla* can be used to refer to both power and energy (Mapfumo, 2016). These concepts are sometimes used interchangeably in everyday language but in science, power and energy are different concepts. While energy refers to the ability to do work, power refers to the rate at which work is done. In this case, teachers cannot always depend on learners' indigenous knowledge (including language) to teach such concepts.

What is evident in the data presented above is that although these teachers were able to identify learners' prior knowledge (which includes the IK as well as misconceptions), they seemed not to have the conceptual tools to integrate it in their teaching. For instance, even though the teachers were aware that they were supposed to integrate IK, they did not come up with representations and teaching strategies to show how they would integrate IK in their science lessons (see Table D1). Their representations were laboratory equipment, diagrams, and charts among others, which are the equipment that many under resourced schools do not have. No group came up with new and innovative teaching strategies that integrated IK.

Unsurprisingly, this failure to integrate IK despite the fact that the teachers were aware that they were expected to integrate it in their teaching can be viewed as a primary contradiction within the subjects. As already mentioned in the explorative phase of this study, these teachers had received Eurocentric education that denigrated IK (Mothwa, 2011), yet they were expected to integrate it in their teaching. This suggested that they are forced by circumstances to reconcile two contradictory knowledge systems in their minds. For instance, when asked if IK was part of their curriculum, Q1F2 had this to say: "*Indigenous knowledge was not included in our curriculum, it was taken as a myth. Its only now that we use indigenous knowledge as part of our curriculum".* A similar sentiment was also echoed by Q5M1 that: *"The focus was on the 'how' teaching part of the course and knowledge of content (western) and nothing was said about inclusion of IK"*

Thus, without proper training on how to integrate IK, the BEd Natural Sciences in-service teachers could not be expected to effectively integrate it in their teaching. In an earlier study, Mutanho (2016) noted that teachers usually start their lessons by asking learners to tell them what they know about a particular topic, but when the learners have provided their prior knowledge, the teachers usually proceed with their planned lesson without making reference to the prior knowledge that the learners have given them. As a result, learners are left in a state of confusion as they cannot link their prior knowledge with the scientific facts that the teacher presents to them (Kuhlane, 2011; Roschelle, 1995). This draws one to conclude that as teachers, we are good at identifying learners' prior knowledge (which sometimes contains IK from home) but we seem to not be good at integrating it.

In concluding this workshop, the facilitator drew the teachers' attention to the fact that both scientific IK and non-scientific IK can be used to enhance the teaching-learning process in science.

For instance, it would have been relevant to link learners' prior knowledge on clans and clan names to the topic of conservation. Many people in southern Africa derive their clan names and totems from plants and animals. For instance, animals such as *majola* (a certain snake), *imfene* (baboon), *ndlovu* (the elephant), *mpofu* (the antelope), *mthimkhulu* (Grootboom; the baobab tree), lions and many others are associated with different clans. The clan that identifies with a particular animal is not allowed to kill, eat, or harm them and there are 'myths' associated with the prohibition. From a conservationist point of view, that can be used as an example of resource allocation among humans. Each clan had to protect a particular species from ruthless killing and over-exploitation which keeps the ecosystem in a balanced state.

The teachers noted that both scientific and non-scientific IK can be relevant in teaching science. It was argued that while scientific IK can be used to make science knowledge clearer, non-scientific IK can be used to stimulate discussions and arguments that will make science lessons interesting (Nuntsu, 2020). For example, Nuntsu (2020) explored stories about cultural beliefs and practices on traditional foods that promoted argumentation amongst his learners. In my opinion, when learners' traditionally held world views are challenged, they will naturally react, and the teacher can use this as an opportunity to deal with the misconceptions embedded in the IK.

After this document analysis, the next workshop explored how to elicit learners' IK in a multicultural classroom because the teachers had indicated in phase one that cultural diversity was another challenge that made it difficult for them to integrate IK in their science lessons. For instance, Q5M1 said: "*Learners are coming from different backgrounds so some/there will be a lot of arguments in the classroom ended up not finishing my lesson"*.

He was supported by Q5F6 who also said:

> *Local knowledge is local, whose idea about a phenomenon would be documented and examined and whose will be left out? I think the diversity of local knowledge would be a disadvantage, different areas would have to write different examinations.*

In both cases, it seems the teachers viewed cultural diversity as a constraint to the integration of IK. When these views are mirrored against the *historicity* of education in South Africa, one sees that both teachers tended to favour a monocultural classroom which is probably a reflection of the Bantu Education system that they received during the apartheid era. In this regard, Duff (2020) reminded us that the apartheid government used Bantu Education to promote racial and ethnical segregation. As such, the majority of the BEd Natural Sciences in-service teachers in this study were all trained during that era. This means that there was conflict between their past educational backgrounds and the expectation to integrate IK in multicultural classrooms.

To resolve this conflict, a workshop was conducted to explore how to elicit learners' prior knowledge in multicultural classrooms. The purpose of this workshop was to create opportunities for teachers to explore ways of integrating IK in multicultural classrooms.

In sum, what is new knowledge in relation to document analysis in this study is that while Mavhunga and Rollnick's (2013) TSPCK is often used as a tool to understand teachers' PCK, in this study it was used as a tool to analyse the CAPS curriculum document and the Natural Sciences textbooks that the teachers were using in their schools. Additionally, the tool was also used to design lessons that integrate IK.

7.3 Eliciting Learners' Prior Knowledge in a Multicultural Classroom

To help them draw the links between IK and science, the teachers were asked to classify their beliefs into those that were scientific, non-scientific, and those that they were not sure of. This created a lot of debating, arguing, and discussions as they were not sure of which categories to place some beliefs. Their findings are tabulated in Appendix D: Table D2.

The data presented in this table shows the shifts in the teachers' understanding of IK. For instance, in the explorative phase, some teachers showed a dismissive attitude towards IK by treating it as myths and beliefs that have no place in science education. However, after the orientation workshop, the teachers began to see the science embedded in some indigenous practices. They began to see that not all IK is myths and neither is it all scientific. In relation to Taylor and Cameron's (2016) diagram, one can argue that their views shifted from a separatist towards an integrationist perspective where the emphasis is towards exploiting the scientific concepts at the intersection of IK and science.

7.4 Modelling the inquiry-based learning

In this section, I discuss the observed shifts in the teachers' understanding of integration of IK.

7.4.1 Shifts in zone of proximal development

An analysis of the teachers' reflections shows that there was a shift in their ZPD with regard to their understanding of the curriculum content, structure, and the integration of IK. Their understanding of IK also shifted from negative to positive. This shift was evident in that they developed:

- an expanded view of IK;

- a positive view towards IK, thereby shifting from a negative to positive disposition. They began to see that not all IK are myths;

- They began to express a commitment to integrate IK in their future lessons; and

- There was also evidence that some of them went and tried out what they had learnt (see Appendix D: Table D3).

This above is evident in the following extracts:

> *In the January session I gained a lot in analysing CAPS document in groups. It was not very easy at first as some instructions were difficult to follow. I have learnt that it is easy to work through CAPS document if you work as a group. Some topics which are not easy to understand when working as an individual are easily unpacked when you work as a group (T4).*

> *It shows clearly the progression of content from grade to grade. Policy document lays out the forms of assessment for each grade which should be set according to the cognitive levels. It gives you the right to add your information to the one given in the document as long as it is going to help in your teaching and learning (T1).*

> *When I came to Rhodes University, I did not know how important it is to have a portfolio but now I know, and I make sure that my portfolio is up to date. As a science teacher I have learnt a lot about the contemporary methods of teaching science from my lecturers, methods like demonstration, practical investigation, project etc. I was also having a problem on how to plan for the investigation and the project and how to design a rubric for assessment, but now I am using the knowledge and skills from the institution. It was not easy for me to understand how the CAPS document is used, to me it was just like other books but through the influence of the lecturers I have learnt that the document contains all the information a teacher is supposed to know, like how to unpack the specific aims, how the process skills are developed, and how the indigenous knowledge from the real life is linked with the syllabus. Now whenever I am planning a lesson, I always look for the indigenous knowledge that learners know and I build new knowledge from what they already know. In this course I also gained more knowledge on how to utilise the CAPS document especially when incorporating IK in teaching some topics like fermentation using umqombothi, fire to show the lifespan of stars. I now understand the use of science in the community which is stipulated in Aim 3 of the CAPS document (T3).*

From these excerpts, it is evident that the BEd Natural Science in-service teachers developed new insights on the following aspects:

- How to unpack the CAPS curriculum;
- how to plan and conduct investigations; and
- how to draw links between IK and science.

The teachers began to see how the content is sequenced and structured. T4 went on say that prior to attending this workshop, he used to rely on textbooks without referring to the CAPS document. This shows that this workshop opened up opportunities for the teachers to reconceptualise the use of the CAPS document as a teaching-learning cultural tool. Mavhunga and Rollnick's (2013) TSPCK components helped them to unpack the curriculum and view it from different angles. They used the five components as the lenses through which they examined different aspects of the curriculum. They began to question not only the content of the curriculum, but also its structure. For instance, they noted that not all Natural Sciences textbooks that they were using were aligned to the CAPS curriculum, despite the fact that they were approved by the department of basic education.

7.4.2 Shifts in attitudes towards diversity

Another observable change can be seen in the teachers' attitudes towards cultural diversity. Whereas, in phase one, they viewed cultural diversity as a constraint that makes it difficult to integrate IK, in phase two they began to view it as an enabler of learning which creates a rich environment from which learners can learn from each other's culture. This view is well captured in T4's reflections when he said:

> *I have learnt how to work in multicultural classrooms concerning science and IK. Respecting every culture can help in Natural Sciences. Learners will value each and every culture without any judgement. I have learnt that you must know CAPS.*

A comparison of this sentiment and what the teachers expressed in phase one shows that the teachers' attitudes towards the integration of IK in multicultural classrooms shifted from being negative to positive. This shift can also be understood in terms of expansive learning espoused by Sannino, Engeström, and Lamos (2016). In other words, the teachers developed as new understanding of cultural diversity and the multiplicity of cultural views which they viewed as a dilemma in phase one was viewed as an opportunity to learn from other cultures in phase two.

When the above shift is mirrored against the *historicity* of education in South Africa, one realises that these teachers had learnt during the apartheid era which kept them in cultural silos (Bantustans). This could be the reason why they favoured a monocultural classroom (which probably resonated with their childhood experiences) and viewed cultural diversity as a challenge (see phase one).

7.4.3 Shifts in their transformative agency

In terms of their transformative agency (Haapasaari et al., 2016), the teachers' reflections tended to show a shift from a paralysed state of criticism and resistance to envisioning and commitment to taking action. In other words, while the teachers largely viewed the integration of IK in science teaching as something that is difficult and impracticable in phase one, after this workshop they began to see it as something that they could try out in their schools. This shift can be seen when one compares their sentiments at the beginning of this intervention and their reflections after the orientation workshop. Table 7.2 below shows some shifts in the teachers' transformative agency (Oeftering et al., 2020).

Table 7.2: Shifts in the teachers' transformative agency

Phase one	**Resistance**	**Criticism**
	Learning would occur very slowly as we need to observe each natural occasion Some are not welcome in science/done at night (witchcraft) I think in my opinion do not include traditional knowledge. It will be difficult to explain some scientific terms There will be a clash of cultures So not everything can be experimented and displayed	IK is not documented As teachers, we are given very little or no support at all regarding its implementation. Even in the science assessment it is barely included. I have not come across a single question paper wherein indigenous knowledge has been included It is not easy to substitute what learners already know with science Indigenous people do not want to come forward and share their knowledge
Phase two	**Envisioning**	**Commitment to action**
	It is going to make my lessons easy as I will be starting from the known to the unknown. This will make know that learners are not empty slates. So, I must always use their knowledge in every lesson. This will also promote respect for their elders as some information comes from them.	I will first ask the learners about the information that they know or heard from parents about lightning then introduce the topic in matter and material.

This table shows that the teachers' views of the integration of IK shifted from a state of feeling paralysed to seeing it as something that is doable. Their responses to the questionnaire and interviews conducted in phase one showed that they saw the integration of IK as a challenge that is nearly impossible. This view shifted to willingness to try out things in their classrooms. The teachers began to envision the integration of IK in their classes. A case in point is T2 who said:

> *This will help me to always use IK in my Natural Sciences lesson. It is going to make my lessons easy as I will be starting from the known to the unknown. This will make me know that learners are not empty slates. So, I must always use their knowledge in every lesson. This will also promote respect for their elders as some information comes from them.*

This excerpt tells us what the teacher intended to do in the future as espoused in Chikamori et al. (2019) who emphasised that the purpose of learning is to influence the future. The teacher's use of phrases like "*this will help me ... It is going to ... This will make me… I must always ... and this will also promote"* shows that he was envisioning how he would integrate IK in the future. It also shows the teachers' willingness to break away from the conventional methods of teaching science and integrate IK, highlighted by Haapasaari et al. (2016).

Furthermore, the teachers reported that they found the orientation workshop interesting as it enabled them to work collaboratively with their colleagues who supported them on what they did not understand. Usually, the workshops that are offered by the department of basic education do not combine primary and secondary school teachers, which is something that this intervention did differently. Combining the teachers from primary and secondary schools helped the primary school teachers to see how the content that they teach in primary school forms the foundation of what is taught in high school. On the other hand, it helped the secondary school teachers to understand the prior knowledge that high school learners bring from the lower grades.

7.4.4 Expanded view of IK

The data presented in Table 7.5 shows that the teachers' attitudes towards the integration of IK in science lessons shifted from negative to positive. In phase one their responses were mainly negative as can be seen from the following statements:

Integrating indigenous knowledge would be a disadvantage.

IK is not written down or documented.

It is difficult to link IK to Science.

There will be clash of cultures.

Whereas in phase one of this study, the teachers dismissed IK as unscientific knowledge that is based on superstition, in phase two they began to realise that there is science embedded in some indigenous practices. They began to distinguish between scientific and non-scientific IK and used phrases such as:

I realised that there is science embedded in some indigenous practices.

It was also noted that during the discussion that some beliefs were scientific, others non-scientific and others were difficult to classify.

My own view was that elders were doing science unaware, for example, my grandmother used to put a car tyre on top of the house, believing that when lighting strike this tyre, and nothing will be in danger because car tyre is an insulator.

These views show a shift from a dismissive attitude to an appreciation of IK. One can safely argue that their understanding shifted from what Taylor and Cameron (2016) described as the separatist view to an integrationist point of view (see Section 2.2). In other words, the teachers began to see the knowledge link within the intersection between IK and science that they could exploit, that they were previously unaware of.

The negative phrases that characterised phase one were replaced with positive phrases. In CHAT terms, they shifted from a state of being paralysed to a state of viewing IK as an enabler of learning (Hapasaari et al., 2016). This realisation is evidence of an expanding ZPD (Engeström & Sannino, 2011; Haapasaari et al., 2016).

7.5 Chapter Summary

While the previous chapter presented the findings of the explorative phase, Chapter Seven provides the data gathered during the expansive phase. What emerged from this chapter is that although the CAPS document stipulates that teachers should integrate IK in science lessons, some teachers are not aware of this policy. Instead, they rely on textbooks as their main sources of information.

After the document analysis workshop, it was evident that the BEd Natural Sciences in-service teachers had gained new insights on the CAPS curriculum. Their reflections showed that they had learnt how to unpack the curriculum using Mavhunga and Rollnick's (2013) TSPCK components which they used to dissect the curriculum. They were able to identify the IK that could be used in different topics, the content that is difficult for learners to understand, possible misconceptions, and the possible teaching strategies that could be used to teach the topics. They also showed new understanding of the structure and content of the curriculum. For instance, they began to critique the Natural Sciences textbooks that they used to depend on as their main sources of information. They argued that some textbooks were not CAPS compliant and excluded IK and used very few examples or left out some curriculum content stipulated in the policy document. It was this realisation that drew me to conclude that the teachers began to reconceptualise the Natural Sciences textbooks and the CAPS document as teaching-learning cultural tools.

After the workshop on how to elicit learners' IK in a multicultural classroom, it was evident that the teachers' understanding of IK had expanded. They realised that not all IK is unscientific. They classified their own cultural beliefs about lightning as scientific, unscientific, and not sure. This was an eye opener in that it made the teachers understand that there is science embedded in some cultural beliefs and practices. This represented a shift from a dismissive attitude to an appreciation of IK. The teachers began to see that even though there are some myths and beliefs in IK, there are also some practices and beliefs that can be scientifically proven. For the teachers who did not specialise in science, this exercise also broadened their content knowledge. The teachers also gained the autonomy to explore how to work in groups as they co-analysed the curriculum creating opportunities for them to learn from each other.

CHAPTER EIGHT: TAPPING INTO EXPERT COMMUNITY MEMBERS' CULTURAL HERITAGE

> Contradictions need to be creatively and often painfully resolved by working out a qualitatively new "thirdness", something qualitatively different from a mere combination or compromise between two competing forces. ...and generation of novel mediating models, concepts and patterns of activity that go beyond and transcend the available opposing forces or options, pushing the system into a new phase of development. (Engeström & Sannino, 2011, p. 4)

8.1 Introduction

The new 'thirdness' implied in the above epigraph is a qualitative transformation that requires one to break away from the conventional ways of teaching science. In the context of this study, breaking away involved shifting from the traditional view where teachers are seen the fountains of knowledge whose mandate is to educate the community, while community members are viewed as illiterate people who have nothing to offer in education. This study involved the use of local or indigenous knowledge to teach science of which local or indigenous knowledge resides in community members (Breidlid, 2013). Moreover, that schools and universities are learning centres which transmit knowledge. That set up promotes a unidirectional, top-down flow of knowledge from the learning institutions to the society whose member are presumed ignorant. This is exacerbated by the fact that community members do not usually get an opportunity to share their knowledge and expertise with schools and universities since such knowledge is considered as irrelevant (Aikenhead, 1996; Ogunniyi, 2007a). Yet, community members have funds of knowledge and are indeed custodians of such cultural heritage (Smith, 2012).

What was done differently in this study was to invite to the university, community members (as IK experts), to share their knowledge and expertise with the BEd Natural Sciences in-service teachers. This was done in response to what emerged in the mirror data that gathered in phase one, which showed that although teachers were expected to integrate IK in their science lessons, that they are not always familiar with all IK and cultural practices. The community experts conducted demonstration lessons on how to make *umqombothi* and *oshikundu* as already explained in my methodology Chapter Four.

Presented below is the data gathered during the practical demonstration lessons presented by the two community experts on how to make *umqombothi* and *oshikundu,* respectively. The purpose of the practical demonstration lessons was to explore how to tap into the community experts' cultural heritage or funds of knowledge. As a researcher, I wanted to understand the learning opportunities created/not by these practical demonstration lessons, thereby answering the third question of my study which is:

> What learning opportunities are created (or not) for the BEd Natural Sciences in-service teachers during the practical demonstrations by the expert community members?

The data gathered during these practical demonstration lessons are presented in the following sections.

8.2 Tapping into Community Experts' Funds of Knowledge

While science is a school subject that can be accessed through textbooks, IK is not documented. It resides in the heads of community members who are the custodians of such knowledge. As a result teachers cannot access such knowledge unless they find ways of tapping into community funds of knowledge (Hedges et al., 2011). It is for this reason that I invited expert community members to conduct practical demonstration lessons on how to make the traditional beverages of *umqombothi* and *oshikundu*.

As already explained in Chapter four, the first presentation was done by MamNgwevu. Presented below are the expansive learning opportunities presented by each one of these workshops.

8.3 Expansive Learning Opportunities from the Making of *Umqombothi*

In cultural historical activity theory (CHAT), expansive learning is viewed as learning that results in the creation of new ways of doing things (Engeström, 2010; Haapasaari et al., 2016). In this study, it involved the generation of novel solutions to the challenges that faced participants in their workplace. Unlike the conventional perception of learning, CHAT scholars view expansive learning as an innovative learning that creates new solutions to the nagging challenges identified in an activity system. It harnesses the multi-agency of the participants to confront the contradictions within a particular profession and work out novel solutions to the identified challenges (Engeström & Sannino, 2011; Haapasaari et al., 2016). In this study, expansive learning occurred at the nexus of agency of the community members (as IK experts), the science lecturer (as the facilitator) and the BEd Natural Sciences in-service teachers (as the subjects/learners) and me as a participant observer and researcher.

As already pointed out above, one of the contradictions that emerged in this study was that although the teachers were expected to integrate IK in their teaching, they were taught from a curriculum that denigrated IK in their childhood and were not trained on how to integrate it in their teaching repertoires. As a result, they could not see the link between IK and science. To resolve this contradiction, teachers were asked to take a step-by-step analysis of the process of making *umqombothi* to find out the scientific justification behind each step. In the discussions that ensued, those teachers who had studied chemistry automatically took the leading role in explaining concepts. This talks to the importance of teacher agency (Engeström, 2010) and the MKO (Vygotsky, 1978). They explained the science concepts and helped their colleagues to see the links between IK and science.

Through these discussions scientific concepts emerged. The teachers compiled a table in which they categorised their ideas into everyday explanations, misconceptions, and scientific explanations (see Appendix E: Table E1).

The data presented in this table shows a shift in the teachers' understanding of the process of making *umqombothi* from everyday explanations to scientific explanations and back again. On reflection, one of the criticisms of the outcome-based education (OBE) was that although it recommended the use of learners' everyday experiences (including IK), it did not emphasise the need to link such knowledge with scientific explanations (Jensen, 1998; Le Grange, 2014). It literally stopped at everyday explanations. The ideas presented in the last column of this table were generated during the discussions and constituted new knowledge generated through the discussions and arguments. Notwithstanding, even after the presentations some teachers still needed clarification on aspects that they had not understood. So, they asked their colleagues to clarify some aspects that they felt were not adequately explained. Giving back agency to the teachers, the science lecturer made sure the questions were directed to the class.

While Vygotskians would call the three teachers who asked for clarification novice teachers, in this study I borrowed Vokwana, Rollnick and Mavhunga's (2020) terminology and call them the 'out of field teachers' because the term novice tends to be belittling. Presented below are the different aspects that the teachers needed clarification on. The teachers doing the explaining are identified by MKO 1 etc., and the novice teachers as NT1 etc.

MKO1: Use of plastic containers/clay pots

> ***NT1:*** *Can someone clarify on the use metals. Kanindicacisele. Andivanga kakuhle. (Can you please clarify I did not hear it properly).*
>
> ***MKO1:*** *In the olden days, people in Africa used to make large clay pots (inqgayi) but now due to modernisation people are using metals and plastics as utensils. Umqombothi is acidic due to the dissolving of carbon dioxide in water to make carbonic acid. Generally acids react with metals to give metal salts and hydrogen gas. This can be shown as follows:*
>
> $$\textit{\textbf{metal + acid}} \longrightarrow \textit{\textbf{metal salt + hydrogen gas}}$$
>
> *So, if umqombothi is stored in metal containers there will be a chemical reaction between the metals and the acid. Acids corrode metals. Secondly, metals are good conductors of heat while clay and plastics are poor conductors of heat. Heat speeds up the fermentation process and produce more alcohol and more acids, thereby causing the umqombothi to lose its taste. Storing the umqombothi in inqgayi (clay pot) or plastic containers will slow down the process of fermentation and make the umqombothi to last longer. It increases the shelf life of the beverage*
>
> ***NT2:*** *What about the use of cow dung?*

MKO2: Use of cow dung

> *The placing of dry cow dung underneath the container with umqombothi is done to prevent the loss of heat from the container to the floor due to conduction. Yeast which causes fermentation thrives in warm, wet conditions. In places where there is ground frost, dry cow dung acts as an insulator preventing the loss of heat between the container and the ground. It prevents the rapid conduction of heat from the flow to the container which will affect the rate of fermentation.*
>
> ***NT 3:*** *And what makes umqombothi sour?*

MKO3: The sour taste

The sour is an indicator that acids have been formed due to the reaction of Carbon dioxide and Water to form carbonic acid… Fermentation forms lactic acid which give beer its characteristic sour taste.

MKO1: Alcohol content of *umqombothi*

Umqombothi mostly contains alcohol content of 1-8%. Traditionally brewed umqombothi contains maltose which is the last sugar formed by yeast under anaerobic conditions during fermentation.

Because some of the teachers (such as Sisekho) indicated that they did not study science beyond junior secondary school, it was necessary to ask them to work collaboratively with others in their groups to draw mind and concept maps from the scientific concepts that could be drawn from the making of *umqombothi.* My assumption was that through these discussions, the teachers would support each other as proposed by Vygotsky (1978) and Stott (2016). In this regard, Stott (2016) added that learners may be novices as individuals but when they collaboratively work together, they become experts as they support each other and enhance their understanding. Earlier on, Engeström and Sannino (2014) argued that engaging learners in activities where they collaboratively work towards a solution brings about collective transformative agency.

8.4 Drawing Mind Maps and Concept Maps

Although they were asked to draw the mind maps as groups, the teachers first worked individually asking each other questions and explaining concepts to each other in their mother tongue isiXhosa. Each teacher first drew their own mind map in their own her notebook which they later combined into group mind maps for presentation to the rest of the class. The following are some examples of mind maps drawn in groups. To save space I shall present only one mind map that I found interesting.

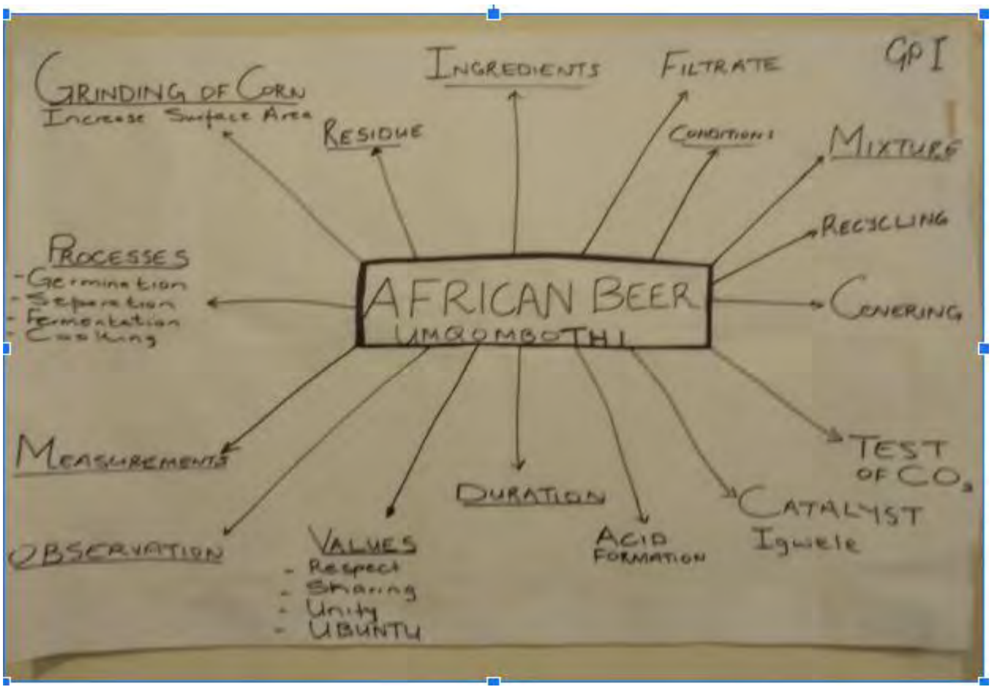

Figure 8.1: Mind map drawn by one of the group

After drawing the mind maps there was need to help the teachers see the links between the different concepts and the Natural Sciences curriculum (see Section 6.2). To achieve this, the teachers were asked to draw concept maps from their mind maps by drawing arrows to show the concepts that were related. Through this exercise, the teachers came up with concept maps such as this one:

Figure 8.2: Concept maps drawn from the concepts derived from the process of making *umqombothi*

After presenting the maps the BEd Natural Sciences in-service teachers were asked to identify concepts from their mind and concept maps that they could teach to their learners. These concepts were then tabulated as follows:

Table 8.1: Specific scientific concepts/lessons that can be taught from the process of making *umqombothi*

GRADE 8	**GRADE 9**
Atoms • Building blocks of matter • Pure Substances • Elements • Compounds • Mixtures of elements and compounds • Particle model of matter • Change of state • Density, mass and volume • Density and states of matter • Density of different materials • Expansion and contraction of materials • Pressure Chemical Reactions • Reactants and Products	Compounds • Periodic Table • Names of Compounds Chemical Reactions • Chemical equations to represent reactions • Balanced equations Reactions of metals with oxygen • General reactions of metals and oxygen • Iron with oxygen • Magnesium with oxygen • Ways of preventing rust Reaction of non-metals with oxygen • General reaction of non-metals with oxygen • Carbon with oxygen • Sulphur with Oxygen Acids & Bases and PH value • Concept of PH value Reactions of Acids with Bases • Neutralisation and PH • Acid & Metal oxide • Applications • Acid & Metal Hydroxide • Acid & metal Carbonates • Acids with Metals

To Engeström (2001), contradictions are the structural tensions that are the driving force behind change. In his view, such contradictions accumulate over time *between* and *within* activity systems and components of an activity system. Moreover, contradictions often arise when new tools are introduced, and old elements of the activity system inhibit their use.

In this study, IK was the new tool to be integrated in science education, against a historical background where science was used as a tool to destroy the IK systems (Smith, 2012). As such, the teachers had to reconcile the two knowledge systems that are often pitted as dialectically opposite knowledge systems that are antagonisitic to each other. Herein lies new knowledge in this study which required the BEd Natural Science in-service teachers to deviate from the conventional ways of teaching science and explore new and unconventional ways of doing things.

The mirror data from phase one revealed that some of the teachers had not studied science in their tertiary education. For instance, Sisekho explained that when she was deployed at a school where there was an acute shortage of science teachers, she was asked to teach science, even though she had specialised in English. Among the other teachers whom she was deployed to the school with, she was the one who had the best pass mark in science in her Grade 12 certificate. She argued that her reason to study for the BEd Natural Sciences degree was to empower herself with the necessary skills that would enable her to teach the subject effectively and with confidence.

It is such responses that draws our attention to the need to support teachers to develop science lessons that integrate IK using easily accessible resources (Asheela et al., 2021). As an extension and to achieve this, a workshop to explore how to conduct experiments using easily available resources was conducted at the university's Chemistry Laboratory with the assistance of the Bachelor of Science (BSc) students and their lecturer. The purpose of this workshop was threefold.

1. To model to the teachers how to make use of the easily accessible resources in developing lessons that integrate IK;
2. To enhance the teachers' understanding of basic chemistry; and
3. To introduce them to the inquiry-based approach to teaching and learning.

8.5 Expansive Learning from MaNdlovu's Practical Demonstration of Making *oshikundu*

After MaNdlovu's demonstration, the teachers were asked to find scientific concepts that could be taught from the making of *oshikundu*. They came up with the following hands-on practical activities which they could do with their learners.

Table 8.2: Hands-on practical activities that can be taught from the making of *oshikundu*

Hands-on	Scientific concepts that can be taught from oshikundu
Rates of reactions	• effects of temperature and rate of reaction • the role of catalysts
Acids and bases	• properties of acids and bases • testing acidity and the pH scale
Diffusion	• movement of gases through the air • properties of gases and liquids
Living and non-living things	• living things respire • living things grow • living things die • seeds are living things • yeast is a living thing
Respiration	• Carbohydrates are broken down during the process of respiration. • CO_2 is given off during respiration
Properties of carbon dioxide	• CO_2 smells • It forms a weak bond with water • CO_2 does not support combustion • CO_2 dissolves in water to form carbonic acid.

The hands-on practical activities shown in the table above came out of intense discussions, debates, and constructive argumentation (Ogunniyi, 2007a). Throughout the discussions, the teachers who specialised in science at tertiary level exercised agency and took the lead in assisting others to understand the link between IK and science. This enabled the teachers to undergo what Haapasaari et al. (2016) described as collective expansive transition. In other words, the learning process that occurred was a result of their collective efforts. Each one of these hands-on practical activities is explained below.

8.5.1 Effect of o*shiphithitho*

During the demonstration, MaNdlovu had explained that *oshiphithitho*[13] is a catalyst that is used to speed up the process of fermentation during the making of *oshikundu*. What is interesting is that the name carries the meaning of this term. She showed the participants how to prepare it, using mahangu flour, sorghum, or millet flour. She then added it to *oshikundu* to make it ferment faster.

The teachers then designed a hands-on practical activity that they would do with their learners where they tested the effect of *oshiphithitho*, by putting the same amount of *oshikundu* in plastic bottles and adding different amounts of *oshiphithitho* in each bottle. The bottles were then placed on windowsills where they were exposed to the same amount of sunshine for two days (because the climatic conditions were cool at that time). The teachers recorded their observations during the course of the hands-on practical activity.

8.5.2 Effects of temperature on rates of reaction

They also tested how temperature affects the rates of reactions by placing the different containers of *oshikundu* in different places where they would be exposed to different temperatures.

8.5.3 Test for carbon dioxide

When the teachers had the balloons filled with air, they were asked to think of possible investigations that they could do with their learners to find out what gas is produced during fermentation. They suggested that they could test it with limewater and a burning splinter. MKO3 then explained that the reason why they would use a burning splinter is because carbon dioxide does not support combustion or burning. She used the following chemical reaction to show what happens during respiration:

$$\mathbf{C_6H_{12}O_6 \longrightarrow CO_2 + 2C_2H_5OH}$$

She went on to elaborate that during the process of glycolysis the glucose molecule is first broken down into two pyruvate molecules (C3). These are further broken down first to ethanal

[13] *Oshiphitho* is a catalyst that is added to *oshikundu* to speed up the process of fermentation. Worth noting is that the meaning of such a catalytic process is embedded in this term.

and then to ethanol, through the process of decarboxylation (removal of carbon dioxide). The carbon dioxide is what forms the bubbles that we see in *oshikundu* or *umqombothi* as it escapes from the beverages. Having listened to MKO3's explanation, I seized the opportunity to link what she said with the traditional practice of placing a burning firewood over the *umqombothi* to see if it is ready for drinking. This excited the teachers as they began to realise that some indigenous practices were scientific. Even though the indigenous people might not know the scientific explanations, they knew that the air released during fermentation extinguishes fire.

8.6 Chapter Summary

This chapter explored the learning opportunities created by the two practical demonstrations and the accompanying workshops. This chapter presented the data generated from the workshops that followed each practical demonstration lesson, and analysed the expansive learning opportunity in each workshop. The data gathered in this chapter revealed that this phase created expansive learning opportunities because teachers were able to generate new ideas on how to tap into community members' IK, how to draw links between IK and science, and how to conduct practical science lessons using easily accessible resources. Evidence of transformation could be seen in the teachers' ability to draw links between IK and science, which they once regarded as two incompatible bodies of knowledge. This also showed a shift in their attitudes from classifying all IK as superstitions to realising that some IK is actually scientific.

The teachers were able to understand the scientific reasoning and concepts and explain the science embedded in different indigenous practices and technologies involved in the process of making *umqombothi* and *oshikundu.* They were also able to expand their understanding of both IK and science by drawing mind maps and concept maps. Evidence of expansive learning could also be seen in their ability to identify scientific concepts embedded in the making of the traditional beverages and the links between the Natural Sciences curriculum and the scientific concepts identified and when they conducted some experiments that they could conduct with their learners.

CHAPTER NINE: HOW DO I PLAN, TEACH AND ENVISION THE INTEGRATION OF IK

> Teacher professional learning is considered crucial for improving the quality of education. Teacher collaboration in professional learning communities can contribute to the effectiveness of professional development efforts. (Prenger, Poortman, & Handelzalts, 2019, p. 441)

9.1 Introduction

Accordingly, Shulman (1987) posited that a teacher has to turn the subject matter in their head before breaking it down into teachable units. Taking counsel from the above epigraph, the BEd Natural Science in-service teachers collaboratively co-designed exemplar lessons that integrated IK with the intension of answering the question:

> How do BEd Natural Sciences in-service teachers enact and envision the integration of indigenous knowledge?

9.2 How I plan

To answer this, the teachers were asked to collaboratively co-design Natural Sciences lesson plans in which they integrated IK and use easily accessible resources. Commenting on the importance of engaging teachers in collaborative work, Lee and Tan (2020, p. 2) said: "The collaborative planning and debriefing of research lessons provide teachers with learning opportunities through shared classroom experiences in which certain aspects of teaching and student learning may be highlighted and reflected upon as a group".

It is with this understanding that the BEd Natural Sciences in-service teachers were engaged in the co-development of lesson planning workshop in which they co-designed lessons that integrated IK and/or easily accessible resources, in their groups. Each group wrote their lesson plans on newsprint and presented it to the class for debriefing. Presented below are examples of the lesson plans that were collaboratively co-designed in their groups.

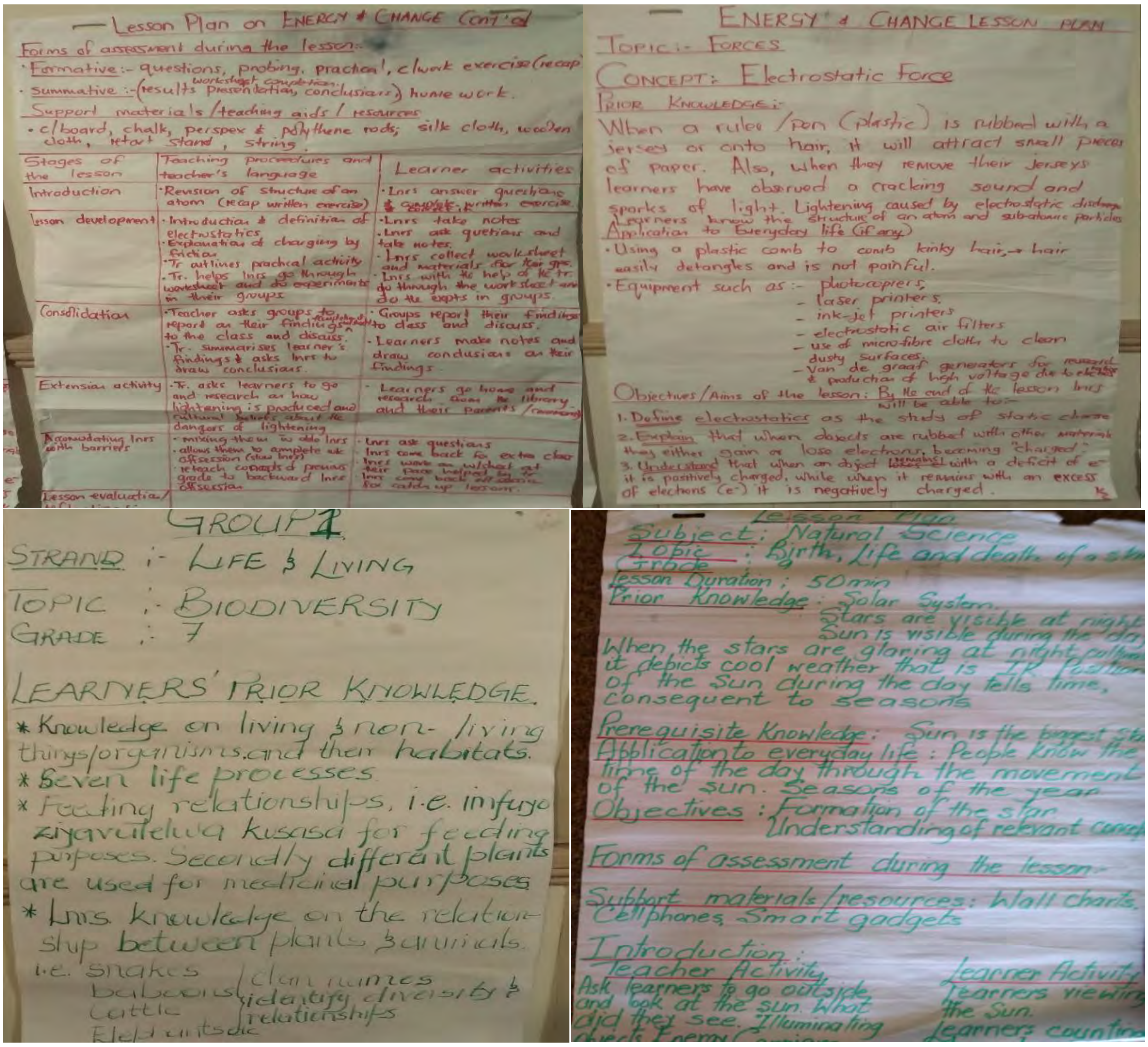

Figure 9.1: Examples of the lesson plans co-designed by the teachers in their groups

9.2.1 Analysis of the co-designed lesson plans

An analysis of the lesson plans showed that although all the four groups were able to identify and state the prior knowledge that learners are expected to have, they did not clearly show how they would use such knowledge to enhance learning. After stating the prior knowledge, no reference was made as to how IK would be used during the lesson. Moreover, there was no link between the rest of the lessons and the identified learners' prior knowledge.

This tended to suggest that although teachers may be aware of the CAPS requirement to integrate IK in their science teaching, they lack the PCK to do so. From a CHAT perspective, one realised that the *subject vs tool* mentioned in Section 6.4.1 was still persistent. The lessons designed in this workshop showed that the teachers did not have the conceptual tools to integrate IK in their science lessons.

The lessons presented by different groups also showed that the teachers were at different zones of proximal development in terms of their understanding of the Natural Sciences subject matter. For instance, some presentations had some misconceptions which were identified and corrected by those who had strong science educational backgrounds. It can be argued that this workshop created opportunities for those who did not train as science teachers to learn from their peers.

Another finding is that although all the four groups were able to write down the main concepts in their strands into smaller concepts, their teaching strategies and content representation did not deviate from the conventional science teaching methods. It can also be argued that the lessons presented showed high curriculum saliency, but there was no evidence of strong TSPCK. Instead, one got the impressions that the teachers lacked the pedagogy to integrate IK.

9.2.2 Group discussions

The debriefing sessions comprised of group discussion. What I observed from these discussions was that the teachers were willing to break away from the traditional ways of teaching science. They were aware that their efforts were crippled by their lack of conceptual tools to do so and realised that it was themselves who had to come up with innovative ways of integrating IK. In this session, they discussed, argued, and debated and were able to point out the shortcomings in each other's lessons. Additionally, they also generated ideas which they offered to each group as suggestions on how to improve the lessons. An expanded view of IK also emerged when the teachers argued that there is need to help learners understand that not every IK is non-scientific knowledge and based on myths and beliefs.

9.3 How I teach

To understand how the teachers integrated IK in their classes, they were assigned a task to go and try out what they learnt from this intervention in their classes and write reflections which they would email to me. They had the freedom to explore new ways of integrating IK in any topic of their choice. Presented below are reflections from two teachers that I found outstanding. These two were selected because they showed a radical shift in their understanding of how to develop model lessons that integrated IK. The two teachers showed an impressive effort to implement what they learnt during this intervention. I will call them T1 and T2.

9.3.1 Teachers' reflections on how they used easily accessible resources (including IK) in their science classes

T2: After our January session on beliefs about lightning I learnt a lot from my colleagues. When I got to my school, I decided to try it with my learners. These are the photos of my class.

Figure 9.2: Learners working in groups of five to create opportunities for social learning

Figure 9.3: Learning about the beliefs about lightning

This is a grade eight class which consists of 42 learners. There are 15 boys and 27 girls. Their ages range from 13 to 18 years. The average age is 15 years. All these learners are from the rural area of Maqhingeni. The level of literacy is very low in this area. The area is very rich in dagga and as a result most boys are exposed to dagga smoking, which is a great challenge for educators. Each group was given a chance to make their *presentation in front of the class. Since all the learners are from the same area, their cultural beliefs and experiences are almost the same. I then asked the learners to group the concepts using the following headings as we did in our session in January, and this is what they presented.*

Table 9.1: Shows learners' classification of cultural beliefs about lightning

Scientific	Not scientific	Not sure
Stay away from trees. Switch off electrical appliances. Making fire (to dry the air). Stay away from livestock. Open windows.	Humans can make it. Put a car tyre on top of the roof. Lightning can be created by humans. Cover all shiny surfaces.	Open windows. Extinguish fire with milk. There are plants that attract and repel lightning. Do not stand or sleep. Do not eat anything milk or sour milk. Cover the eggs. Performing.

In sum, I explained that from the scientific point of view that lightning is a large static discharge. It is a transfer of charges between two objects because of a build-up of static electricity. As air masses move and swirl in the cloud, areas of positive and negative charges build up. Enough charges build up to cause a static discharge between the cloud and the ground. Electric charges collide with atoms and molecules resulting in the emission of light.9.3.2 Analysis of T2's reflections

A glance at the above reflections shows a shift in the teacher's understanding of how to integrate IK. Unlike, in the lesson plans presented in Figure 9.1 above, where teachers teachers did not make use of the learners' prior knowledge that they elicited, this teacher elicited learners' indigenous knowledge and used it to enable learners to understand the concept of lightning. Following the same teaching strategy that the science lecturer used during the January session, the teacher gave learners an opportunity to scrutinise their beliefs and distinguish between those that were scientific and those that were not. Applying Vygotsky's (1978) social learning principles, the teacher used groups and discussions to create opportunities for social learning to take place (Vygotsky, 1978) as can be seen in the photos in Figures 9.2 and 9.3.

Another interesting deviation is that learners were allowed to interact in their mother tongue and present their findings in English. They discussed in their mother tongue and then translated their responses into English for reporting purposes (Probyn, 2009). This finding supports proponents of translanguaging such as (Creese & Blackledge, 2010) who argued that a multilingual approach to teaching science promotes genuine engagement with the science subject matter. In their study, Karlsson et al. (2019) also found that translanguaging promotes deeper understanding of scientific concepts.

The lesson presented by T2 shows an inclination towards a learner centred approach with the teacher playing a peripheral role in facilitating learning (see Figure 9.3). Vygotsky (1978) described the role of the teacher as that of scaffolding learners. In his lesson, T2 did this by drawing learners' attention to the scientific explanation of lightning to consolidate their understanding of the scientific explanation of what causes lightning. It seems that the learners were not made to regurgitate scientific facts but to build their own understanding by consolidating what they already knew about lightning with scientific knowledge. Most likely by the end of this lesson, the learners' ZPD had shifted, and they had a better understanding of both IK and science.

Another noticeable trend is that this lesson also shows a shift in the teacher's agency from the state of resistance and rejection that characterised the explorative phase to a 'yes we can try it' state (Mukute & Lotz-Sistika, 2012). The negativity that was evident in the teachers' responses to the questionnaire and interviews, seems to have given way to innovative thinking as T2 attempted to integrate IK. So, instead of complaining about the challenges encountered during the integration of IK, T2 experimented with the same teaching that their science lecturer used in his own class which points towards T2's growing agency (Haapasaari et al., 2016).

The BEd Natural Sciences teachers also raised the concern that IK is not scientific. It is based on myths and unfounded beliefs. But what we see in this extract is that the teacher allowed his learners to learn science in a language that they understood. As a result, learners were able to generate a lot of ideas which were then later translated to English (Probyn, 2009). Instead of classifying all IK as superstitious, the teacher gave his learners the opportunity to critically look at their beliefs and classify them as scientific and non-scientific. Most probably the learners were able to gain a deeper understanding of both science and IK.

However, although the January session was supposed to be a germ cell (Vygotsky, 1978) to enable teachers to generate their own ideas, this teacher followed exactly the same steps used by the facilitator in January. There is no evidence from this lesson that the teacher will be able to explore other ways of integrating IK in future. This intervention was not meant to be a prescription, but instead its purpose was to support the teachers to explore different ways of integrating IK in their teaching. This means that the methods of teaching that were used in this intervention were only some of the ways of integrating local or indigenous knowledge.

> **T3:** *As a teacher I am going to reflect on the science project that was done by Grade 5 learners. The investigative question was, "What happens to a plant when you put it in a closed glass jar and place it in the sunlight?"*
>
> <u>*Method*</u>
> *Learners were divided into groups.*
> *The teacher asked each group to bring a glass jar with a lid the following day.*
> *On the next day, the teacher went to the garden with the learners and asked them to pick out the plants from the garden and put them in the*

Figure 9.4: Learners collecting plants

Figure 9.5: Photos of learners conducting the mini ecosystem experiment

She told them to water the plants and close the glass jars tightly so that air should not enter and place them in the windowsills where there is sunlight. Each group labelled its bottle with a group name of its choice. The teacher told learners that the investigation would take a month and she also told them that they must observe what happens to the plants every week and not to open the jars. The teacher told them to start by writing their own predictions.

Learners subsequently came up with different predictions: some said the plants would die after three days, others said the plants would change their colour, and others said the plants would grow for a long time without dying. The teacher told learners that the aim of the investigation was to test whether a plant could survive in a closed container without carbon dioxide. The teacher explained to them that the plant needed water, sunlight, and carbon dioxide to make its own food (photosynthesis). She told them that if any of the requirements of photosynthesis are absent, the plants would not survive.

Figure 9.6: Shows T3 scaffolding learners on how to conduct a mini-ecosystem

In her reflection she said:

In the first two weeks nothing happened to the plants, they showed signs of health such as green leaves, thick stems and growth in size. There was mist in the bottles and there were also tinny droplets of water. On the third week, the plant that was in one of the small jars started showing signs of deficiency. The leaves started to change colour, from green to brown and the stem started to shrink as shown in the picture below As the days went by the leaves withered, and the plant eventually died. The plant in the other small jar and the one in the big jar grew healthily but at the end of the third week, the plant in the small jar started to show signs that something is deficient. Leaves dried due to limited air.

T3: consolidating the learning process from this activity by drawing learners' attention to the fact that, *there are processes that took place in the plants that were in different jars, like photosynthesis, evaporation, condensation and respiration. The three plants did not die immediately after being put in airtight jars because there was carbon dioxide inside the jars, so photosynthesis took place. When the rays of the sun heat the water in the jars, the water changed from liquid to gas state (vapour), this is called evaporation. The mist that was in the bottles was the vapour. During the night when there is no sunlight the vapour condensed and changed from the gas state to liquid state and went back in the soil. That is called condensation.*

She further hypothesised that;

The plants in the small containers withered due to lack of air and nutrients compared to the plant in the big jar, whereas they did not wither at the same time. The reason might be that the plant that was the second to wither is because of the unauthorised access by learners who are curious by nature. When children are told not to do something, they always want to know what will happen when they do it. It might happen that they opened the jar whereas they were told not to open it. The plant in the big container did not wither because there were lots of nutrients, air and oxygen inside the jar. The big container has more access to sunlight because of its size and evaporation takes place freely. The plants in the small jars died because of the environmental conditions that were not right, like warmer temperatures. Maybe the sunlight shining through the jar made the temperature so high that the plant could not survive, or they died because of the higher moisture level inside the jars because many plants need air in the soil and will die if there is no oxygen.

The class reached the conclusion that:

A closed container does not necessarily mean that the plant will die immediately. The bigger the container the better there are chances of survival. The theory proved that the size of the container determines the rate of depletion of the available resources such as water and sunlight an air. This is what determines the lifespan of the plant.

9.3.2 Analysis of T3's lesson

T3 experimented with the use of easily accessible resources. Instead of complaining about the shortage of laboratory equipment, she involved the learners in collecting the materials that would be used in the experiment. She went on to conduct the experiment with her class using plants, soil, water, and bottles; all of which are easily accessible resources. In CHAT terms, this shows a break away from the traditional ways of teaching science, which can be taken as evidence of her growing agency (Haapasaari et al., 2016).

The exemplar lesson plans that the teachers co-designed in the previous session showed an inclination towards the lecture method, where the teacher's concern is to complete to syllabus by dishing out as many scientific facts as possible. However, the above lesson showed a teacher whose focus was on discovery learning. Learners were involved in finding out things for themselves to develop such skills as observation, recording, hypothesising, and experimenting. They were made to work in small groups to promote social learning (Vygotsky, 1978). It was also evident that the learners in this class enjoyed the lesson because when they were asked to choose names for their groups, they called themselves such names as '*Thoughtful guys and girls'*, '*Angels*', and '*Young scientists'*, which shows a positive disposition towards science. This shift in learners' dispositions in science is a welcome development because a plethora of literature showed that one of the reasons why science is one of the most failed subjects, is because learners viewed it as an abstract and very difficult subject (Asheela, 2017; Basu & Barton, 2007; Hodson, 2009; Nhase, 2019).

Contrary to the view held by Hodson (1990), that learners enjoy practical activities because they view them as a way to escape from the boring classroom environment, a look at this class' level of involvement tended to suggest that the practical activities promoted learning. The photos give the impression that the learners were actively involved in finding out information for themselves with the assistance of their teacher.

These two extracts were examples of the shifts that occurred in the teachers' TSPCK (Mavhunga et al., 2016) and willingness to break away from the traditional methods of teaching science (Engeström & Sannino, 2015; Haapasaari et al., 2016). When this data is juxtaposed with the mirror data from phase one which painted the picture of teachers who lacked the confidence and expertise to integrate IK, one sees a shift in their mindset, from a state of paralysis (Haapasaari et al., 2016) to an innovative mindset that is willing to try things out.

Even though both teachers followed exactly the same methods that the science lecturer used in teaching them, at least they took the initiative to try out what they had learnt.

Arguably, allowing these teachers to reflect upon their experiences and share how they tried out what they learnt from the in-service training can be regarded as this study's contribution to new knowledge in that quite often, CPD workshops offered by the department of basic education do not offer teachers the opportunity to try out the new ideas and share their experiences. Worse still, in many cases there is no follow-up to monitor implementation, which prompted Jacobs (2015) to describe such workshops as disjointed.

9.3.3 Missed opportunities

An analysis of T2's conclusion also showed that there was a misconception of what causes lightning when she said: "*Electric charges collide with atoms and molecules resulting in the emission of light".* The teacher seemed to be unsure of the difference between saying air particles and saying atoms and molecules. To her the two concepts could be used interchangeably. It was also noted from these extracts that these teachers did not explore new ways of integrating IK. They followed exactly the same teaching methods that their lecturer used in January. When this is mirrored against the historicity of education in South Africa, one can argue that this could be because they were coming from an education system that had limited teacher autonomy. To be able to explore new ways of teaching, one needs to be flexible and creative. Both traits were restricted in Bantu Education which was highly monitored. The above examples also suggests that teachers tend to teach in the same way that they were taught. This means that if one expects teachers to change, their lecturers should use the same teaching methods that they expect the teachers to go and use in their own classes. This is not what happens in teacher education, where in many cases teachers are taught using the lecture method but are expected to go and use the learner-centred approach to teaching.

9.4 How I envision the integration of IK in my Science lessons

When they came for the last semester in Septemper 2019, the BEd Natural Sciences in-service teachers were asked to share their experiences of integrating IK in their science teaching and share their ideas of how they would teach Natural Sciences in future. Each group prepared a presentation which it shared with the rest of the class. Presented below are the presentations made by different groups.

9.4.1 Group 4: Strand 4: Planet earth and beyond

Topic: The birth, life and death of a star

After introducing the topic, group 4 (the presenter for group 4) went on to explain that the aim of the lesson was to let her learners understand the birth, life, and death of stars. She explained that they had chosen this topic because it was difficult for learners to understand. It is also difficult for them as teachers to teach because it is about extra-terrestrial things that cannot be brought to the classroom. Moreover, learners' prior knowledge of birth, life, and death in living things cannot be applied to explain this topic as it creates misconceptions. When learners try to relate the concepts taught on this topic to what they know they often ask questions like: "Who gives birth to stars?" and "Where are they buried?"

The group reported that in future they would draw on learners' IK of making fire from firewood. They would ask learners to bring the materials that are needed to make a fire such as twigs, firewood, matches and so on. All these things are easily accessible resources (Asheela, Ngcoza & Sewry, 2021), especially in rural areas where learners use them as part of their everyday experiences. They would then light the fire and ask learners to observe and record the changes that take place during the different stages of the fire.

T4 explained this process saying:

> *I will then explain to the learners that the beginning of the fire is like the birth of a star. Lamlilo ndithe it is like the birth if a star, because nje nge star ngokwaso xasithi give ibirth siqhalla sisincinci and icolour yaso iyellowish. But ngokuya ke ngoku kukula emililo, bajongile ke khuti kwenzeka ntoni emlilweni. Bayaubona umlilo ke ngoku. (Just like a firewood fire, it begins burning slowly, producing a yellowish colour but as the fire grows, more fuel is burnt and more energy is produced and the fire grows bigger and brighter. They would be seeing what is happening as the fire burns)". I will explain that we are in the second stage of the life of a star ke ngoku. I will also ask them to write down their observations. Umlilo wakula. When the fire finally goes out, I will ask them to explain why the fire stopped burning. They will come up with explanations such as that the fuel in the firewood got used up and fire stopped burning. I will then use this explanation to explain that when all the fuel in a star is used up it dies off just like a fire. What made us think of the fire was because for many years we have been struggling to teach this topic. Children struggle to grasp the concept of the birth, life, and death of stars because of their prior everyday knowledge of these processes.*

Analysis of group 4's presentation

To see if there was any shift in their understanding of how to integrate IK in science lessons, Table 9.1 was drawn up to compare the lesson presented in Figure 9.1, in Section 9.1 and the lesson presented above. The focus of this comparison was to trace the shift (if any) in the teachers' TSPCK and agency towards the integration of IK. With regards to PCK, Mazibe et al. (2020) drew our attention to the fact that what people say is not always what they do. They went on to make a distinction between the reported TSPCK and the enacted TSPCK. In this study, I had to rely on the teachers' reported TSPCK because I had no access to their classrooms because of the ethical restrictions explained in the methodology chapter.

A look at Table 9.1 shows that the teachers' understanding of how to integrate IK tended to shift from a restricted to an expanded form (see Appendix F: Table F1). The expansion is evident in their teaching representations and teaching strategies. For instance, in the first lesson, the teachers drew on the prior knowledge from previous grades about the solar system. Their attempt to include learners' cultural knowledge shows a restricted understading of how to integrate IK. For instance while they said learners were aware that stars are visible at night and that they are culturally used to predict the weather, they did not draw links between the cultural beliefs that they identified as learners' prior knowledge with the lesson concepts. This was picked up by other classmates who argued that their identified IK was irrelevant or not related to the lesson.

However, in the second presentation (see Appendix F: Table F1) there was a noticeable shift in their understanding. Notably, they began to be more creative and draw examples from learners' everyday lives. For instance, they used the analogy of the burning firewood to illustrate to the learners the birth, life and death of a star. Such innovations are in line with the CAPS document which stipulates that teachers should use their creativity to integrate IK in their science lessons.

Instead of complaining about the lack of science equipment to teach science, the teachers used the easily accessible resources or cultural tools to teach science as reiterated by Nhase (2019) and subsequently Asheela et al. (2021). Their presentation shows a shift in mindset from a teacher centred to learner centred approach whereby learners would be actively involved in collecting the teaching-learning materials and conducting the experiment. The teachers started to envision a teaching method that involves learners in active learning throughout the lesson.

One of the key points raised in the discussion that followed the first presentation was that the teachers had not shown how they would use the IK that they had identified. As a result, the identified IK was of no relevance if it was not integrated in the science lesson to make scientific concepts more accessible to learners as required by the department of basic education (2011). What the teachers did differently in the second presentation, is that they drew on learners' IK and integrated it into their learning. Instead of just stating it as learners' prior knowledge, the teachers drew an analogy from learners' everyday experiences and used it to explain the birth, life and death of stars. This can be taken as evidence of an expanding understanding of how to integrate IK in science lessons.

What emerged as new knowledge is that while many studies on IK tend to focus on the benefits of integrating IK, (Asheela et al., 2021; Mutanho, 2016; Shinana et al., 2021) these teachers highlighted that in some cases IK can be a source of misconceptions and confusion. Unlike the opponents of the integration of IK such as Hodson (2009) and Horsthemke and Schaffer (2007) who bluntly argue that IK is incompatible with science, the data from these teachers pointed to the fact that in some cases learners' everyday experiences can lead to misconceptions that teachers need to confront in their teaching. For instance, the biological meaning of birth, life, and death is not the same as the birth, life, and death of stars. In other words, these concepts are used figuratively when applied to stars. These teachers had to carefully select the IK that would be relevant to the teaching and learning of science.

In the discussion that followed after this lesson, the class noted that the same analogy can be used to demonstrate what a chemical reaction is. Understanding what happens during a chemical reaction is fundamental to understanding chemistry. A chemical reaction can be described as a process in which two or more substances react to form new substances. The substances that react are called the reactants, while the substances produced as a result of the chemical reactions are called the products. For a chemical reaction to start, it needs energy to kick-start it. This energy is called the activation energy. Unlike in a physical change, a chemical reaction is not reversible by physical means. In other words, the products formed during a chemical reaction cannot be returned back to their original state by physical means. During a chemical reaction, heat energy is often produced or absorbed. Chemical reactions that produce heat energy are called exothermic reactions while those that absorb heat energy are said to be endothermic. A chemical reaction between two substances can be explained as follows: A + B

C, in which case A and B are the reactants while C is the product. C is a different substance from both A and B, and can be a compound of the two reactants.

Using the above knowledge, the teachers then explained that the matches that we light to start a fire provide the activation energy to kick start the chemical reaction between oxygen and firewood (i.e. burning). The chemical reaction produces heat energy which means that it is an exothermic reaction. The fire continues to burn as long as oxygen is present until all the carbon in the firewood is used up. The reaction between carbon and oxygen produces carbon monoxide (an invisible and odourless gas), which reacts with more oxygen in the air to form carbon dioxide. The heat and the carbon dioxide are released into the atmosphere while the unburnt carbon remains as the charcoal, ash, and soot. The carbon dioxide, heat and light energy, ash, charcoal, and soot (products) cannot be converted back to firewood and oxygen (the reactants).

9.4.2 Group 2: Strand 2: Matter and materials

Topic: Acids and bases Group 3 explained that their topic was on acid and bases and the target population were learners in Grade 9. They had chosen this topic because for many years they struggled to teach this topic due to shortage of teaching-learning materials. All the teachers in her group came from schools where there were no science laboratories or equipment to teach science. She explained that she would ask the learners to bring easily accessible resources from their homes which included lemon juice, oranges, nartjies, milk, *amasi* (sour milk), household cleaning agents, aloe leaves, beat root, red cabbage, and black tea (as indicator). She would bring the things that learner may not be able to afford such as turmeric and toothpaste. She would explain to the learners that it is the fluoride in the toothpaste that kills the germs. Learners would be asked taste the lemon, oranges, nartjies, and *amasi* and discuss the taste of acids and bases.

The class would then prepare the indicator by boiling the beetroot and taking the water from it which would be used as an indicator. She would then divide the class into different groups and ask them to pour small amounts of beetroot into their test tubes and observe the colour and record their observations. She would draw the attention of the learners to the pH scale and mention that if the beetroot turns pinkish that shows a weak acid and if it turns bluish then it is a weak base. They would then test the various substances and record their findings and classify different substances as acids and bases. They would realise that some substances do not cause any changes. Through this experiment, learners would realise that they could still do more experiments even in their own homes. They could test whether something is an acid or a base using substances that they can easily obtain within their homes so that they may not forget.

After the presentation, the audience was given an opportunity to ask questions, make comments, and reflect upon this experience. It was pointed out that in such lessons it is not advisable to make learners eat/taste the substances that they are going to use for any experiment for health reasons. Instead, learners should be discouraged from consuming anything during science lessons and especially in the science laboratory to avoid poisoning. Some members asked the question, "*Where is the IK in your lesson*?" to which she replied that in their understanding, IK is not only knowledge from the past, but also knowledge that is currently in use by indigenous people.

Analysis of group 2's presentation

What is noticeable in the above presentation is a shift towards the use of easily accessible resources to teach science. While the shortage of laboratory equipment and chemicals to teach science was mentioned as one of the challenges that affect the teaching of science, the lesson presented by group 2 shows how they would use the easily accessible teaching learning materials to teach science. It can be argued that the teachers' understanding of how to teach science shifted from narrowly viewing science as a laboratory-based subject to seeing the possibility of teaching it using the easily accessible resources. The teachers showed an understanding that in the absence of the commercially bought laboratory chemicals such as acids and bases, they can still teach science using the easily accessible resources. This may be taken as evidence of an expanded understanding of how to teach science. It also means that their understanding of acids and bases might have expanded from seeing them as laboratory chemicals to seeing them as chemical substances found in our everyday lives.

When this lesson was compared with the lesson that they presented in Section 9.1 on electrostatics, it can be seen that there was a shift in their conceptual teaching strategies and representations.

9.4.3 Group 3: Strand 3: Energy and Change

Topic: Heat transfer

Although the lesson on electrostatics also involved a practical, the teachers followed a recipe approach where learners would be given a worksheet to guide them to do the experiment. They would use laboratory equipment such as Perspex and polythene rods, silk cloth, woollen cloth, retort stand, and string. Although some of these materials can be easily accessible, some can only be found in schools with well-equipped laboratories. The teachers use of these materials in their first presentation is understandable. It reflected the teachers' understanding of how to conduct practical activities prior to the intervention. However, in this second presentation the teachers showed a new understanding of how to teach science using the easily accessible resources. Instead of focusing on using laboratory equipment, they turned to the easily accessible resources that learners use in their everyday lives. They would also actively involve learners in collecting the teaching-learning materials, conducting experiments, and drawing conclusions. They showed a shift from a teacher centred approach to a learner centred approach in their teaching strategies.

Group 3 presenter, MaMoyo explained that they chose the topic on conduction because they used to find it difficult to explain to learners what really happens during heat transfer. They identified learners' prior knowledge as experiences of lighting fire such as *imbawula* and the whole house becomes warm. *Imbawula* is a perforated container that is filled with burning coal or charcoal that is often used during cold weather as a traditional heating system in areas where people have no electricity or electric appliances such as heaters. Learners are also familiar with cooking. They know that when you want to boil water you put a pot on the fire and the pot gets hot and the water also gets hot.

She confessed that she used to struggle with how to approach this topic. She used to show her learners a picture of a three-legged pot on the fire and explain the process of conduction based on learners' responses. She said that she now asks learners to tell her about their own experiences on cooking and heat transfer, taking from what they do at home. She starts her lesson with a brainstorming session on those experiences and picks on the points that are relevant for conduction. MaMoyo explained that when you hold hands, heat will be transferred from the warmer hand to the cooler hand until a point of equilibrium is reached. Transfer from a hotter body/object to a cooler body/object. When we talk about conductivity, we are talking about heat transfer from one part of a body or object to another. We talk about temperature and temperature is a measure of kinetic measure.

On application of IKS, we will teach learners that in situations where they have no refrigerators, they can take an empty rice plastic and fill it with water and wrap it with a piece of cloth and hang it outside to let the water evaporate. The water in the plastic will become cold because heat is conducted away by the evaporating water particles. The water can even freeze if left overnight. This will enable learners to see the link between science and local or indigenous science.

Analysis of group 3's presentation

Evidence of innovative thinking were noticed in the group's use of examples from learners' everyday lives. The teachers used the heating of a house using firewood or *mbaula* as examples of how heat is transferred. MaMoyo also took this opportunity to clarify some misconceptions about heat transfer that are commonly found among learners. This sparked a discussion that lasted for more than 25 minutes in which different teachers asked questions and she explained the scientific concepts found in this topic. MaMoyo's knowledge of science was helpful to many who struggled to understand the scientific concepts. She used her presentation to enhance their content knowledge while at the same time presenting their findings.

9.4.4 Group 1: Strand 1 : Life and living: Topic microorganisms

Group 1 presented a lesson

Learners are familiar with baking. Yeast is a non-living thing, but when activated it becomes a living thing. The misconception is that learners do not know that there are **some bacteria** that are good for life while others are not good for life. In our teaching we will prepare dough with yeast and dough without yeast. We will use the same amount of yeast, same amount of dough, and place them in the same conditions. The main point of this activity is for learners to understand that there are good and **bad bacteria**. Learners will learn science concepts such as temperature, measuring, fermenting, favourable conditions, experimenting and many others. They will also learn the use of control experiments which in this case is used to show the effect of yeast. We will use a stopwatch and learners will observe that bread without yeast will not rise.

Coming to the science concepts '*sesizidibene nazo endleleni apha'*, we meant concepts such as temperature, measuring, mixing and processes like fermentation. Learners will observe that yeast has an effect. Learners will realise that yeast is having a good impact although yeast is a bacteria, it is a fungus of some sort. As a teacher, how can we accommodate learners with learning barriers? You must have some *nontshebuza* there, that is the written scientific concepts. As the lesson progresses we gradually introduce concepts and may end up with a concept map. Yeast is a catalyst. They will reflect on other things that act as yeast or need yeast in order to ferment.

9.4.5 Analysis of group 1's presentation

When the above presentation was juxtaposed with the group's previous presentation, one also saw a shift towards using learners' everyday knowledge. In the previous presentation, one of the major comments made about this group's presentation was that they did not explicitly show how they would use the IK that they stated as learners' prior knowledge to make science accessible to learners. In other words, they had not shown how they would integrate the IK that they identified in their lesson.

In the second presentation, the teachers showed how they would use learners' everyday knowledge on baking to teach about microorganisms. They identified the things that learners find difficult to understand. Their lesson was also based on how to use easily accessible resources to teach science. This represented a shift from the initial paralysed state where the teachers complained about the shortage of teaching-learning materials which they saw as the government's responsibility. The teachers expected everything to be provided by the government and did not see themselves as agents of change who could take up the responsibility to provide teaching-learning materials. They realised that although the responsibility of providing teaching-learning materials is for the government, they could still teach science by making use of the easily accessible resources. The teachers began to come up with innovative ways of teaching science and broke away from the conventional teaching methods that they used in the first lesson. In other words, their understanding of teaching science shifted from a deep concern for syllabus coverage to a teaching for understanding.

Using the constructivist approach, learners were given the opportunity to construct their own knowledge. They were actively involved in the gathering of teaching-learning materials, setting up experiments, and drawing conclusions. Drawing on what they learnt, the teachers asked the learners to draw mind and concept maps from the practical demonstrations. This showed that the teacher had found ways of tapping into the science embedded in IK. Both English and IsiXhosa or indigenous languages were used to teach science. This resolved the language barriers brought about by having to learn science in a second language.

However, the group had the misconception that all micro-organisms were bacteria, hence, the treatment of yeast as a bacteria. The group could not distinguish between a fungi and a bacteria. During the class discussion this misconception was corrected during the feedback from the rest of the class.

9.5 Discussion of the Findings

The four presentations showed a major shift in the teachers' understanding of how to integrate IK in science lessons. When compared with previous presentations, one sees that the teachers gained the confidence to explore different ways of integrating IK. The resistance that emerged in phase one gave way to innovation and envisioning. The teachers began to see science as a subject that can be taught using easily accessible resources from learners' everyday lives (Asheela et al., 2021; Gwekwerere, 2016; Shinana et al., 2021). There is also evidence of an expanded view of IK from viewing it as ancient knowledge to viewing it as knowledge that is applicable in modern day life. One can safely argue that the teachers' knowledge, attitudes, and professional insights with regard to the integration of IK shifted from being negative to positive. Another noticeable shift was in their agency, which shifted from resistance to envisioning and taking concrete action. Having said this, it is important to turn to the benefits that accrued to the participants that they attributed to this intervention.

9.6 The Emancipatory Effect of this Intervention on the Research Participants

While research ethics are largely formulated along the non-maleficance or do no harm principle, this study also explored the benefits that accrued to the articipants that they attributed to their participation in this study. Ruch (2014) noted with concern that the concept of beneficence tends to receive less attention in educational research than maleficence. In instances where the researcher pays attention to the benefits that accrue to participants, there has been a tendency to focus on an instrumentalist material benefits approach. In my view, emphasising material gains is against Ubuntu which focuses on the mutual benefits that accumulate to people who mutually co-exist (Ruch, 2014; Seehawer, 2018).

In the context of this study, Ubuntu was the relational philosophy underpinning this study. Therefore, there was need to find out if this intervention benefited the participants beyond its intended outcomes or not. Below are some of the benefits that the participants who wrote back to us mentioned. What emerged was that this study had an emancipatory effect on the participants as can be illustrated by the following examples from their reflections. Emancipation in this study is viewed as freedom from any factors that may have been constraining the teachers from realising their full potential.

9.6.1 Winning 'the best teacher' award

A month after the last session of this intervention one of the teachers sent an email thanking us for teaching them how to integrate IK because she had won the Eastern Cape Provincial Best Natural Sciences Teacher Award. Additionally, she was nominated to represent the Eastern Cape Province in the National Natural Sciences teaching competition. In addition to the Best Natural Sciences Teacher Trophy, she also won monetary awards from the department of basic education and Sanlam, gift vouchers from Old Mutual, a cell phone, a two night's voucher from Osner hotel which was valid for six months and R125 voucher for data bundles from Macmillan. In her email she attributed her success to the teaching methods she learnt from us. Her photos are attached below.

Figure 9.7: The Gala Dinner 2018: Provincial Award

After winning the provincial award, she was nominated for the National Best Natural Sciences Teacher competition which she won, beating candidates from nine provinces. She wrote an email to thank me and their science lecturer for exposing them to the intervention. Presented below are her national trophy and Certificate of Excellence.

Figure 9.8: Best Natural Sciences Teacher National Award

In her reflections she wrote the following:

> *When I came to Rhodes University, I did not know how important it is to have a portfolio but now I know and I make sure that my portfolio is up to date. As a science teacher I have learnt a lot about the contemporary methods of teaching science from my lecturers, methods like demonstration, practical investigation, project etc. I was also having a problem on how to plan for the investigation and the project and how to design a rubric for assessment, but now I am using the knowledge and skills from the institution. It was not easy for me to understand how the CAPS document is used, to me it was just like other books but through the influence of the lecturers I have learnt that the document contains all the information a teacher is supposed to know, like how to unpack the specific aims, how the process skills are developed, and how the indigenous knowledge from the real life is linked with the syllabus. Now whenever I am planning a lesson, I always look for the indigenous knowledge that learners know and I build new knowledge from what they already know. In this course I also gained more knowledge on how to utilise the CAPS document especially when incorporating IK in teaching some topics like fermentation using umqombothi, fire to show the lifespan of stars. I now understand the use of science in the community which is stipulated in Aim 3 of the CAPS document.*

It is evident that this teacher gained new knowledge on how to unpack the curriculum and how to integrate IK. She gained confidence in herself and improved her teaching by integrating not only IK but also conducting experiments. This enabled her to be nominated as the best teacher in the province. This emerged in the following reflections:

> *Through the experience I gained from the institution, I have been nominated by the National Teaching Awards Coordinator to participate in the National Awards Competition in 2018. I competed and won at sub-District level, District level, Cluster level and also competed at Provincial level. It was not difficult for me to prepare my presentation on PowerPoint and also the information that I used in my presentation is the information that I gained from the institution. My NTA coordinator was so impressed such that she even invited my EDO, the DG, CES and other officials to come and observe my presentation. I was nominated in the category, Excellence in Primary Teaching, and my presentations had a lot of evidence from the information I gained from the institution.*
>
> *This year I was also nominated in the category, Excellence in Teaching Natural sciences. I competed at subdistrict level, district level, cluster level and provincial level. I am now a provincial finalist to compete at National level. Even this year a lot of information that I used in my presentation is the one I gained from the course. I feel very much happy and confident that I will also make it at National level. The information I gained on how IK is incorporated in teaching science helped me in planning for my presentation and really it is that IK incorporation that made my presentation unique.*

9.6.2 Awarded a distinction for her master's degree

Another mutual benefit that accrued from this study is that MaNdlovu (who demonstrated how to make *oshikundu*) got a distinction in her master's thesis. She described herself as a generally shy person who would have found it difficult to demonstrate how to make *oshikundu* to the teachers in her study. Arguably, her participation in my study helped her to gain confidence because it gave her an opportunity to gain insights on how she would conduct the practical demonstrations in her own study. She also said that she was inspired to carry on with her studies up to doctorate level. Her participation in my study made her develop the 'I can also do it attitude' and she has since enrolled for her PhD. I am willing to assist her in any way should the need arise. She attributed her success to her participation in this study which she described as an eye opener. MaNdlovu wrote thanking me for inviting her to participate in my study which she says enabled her to clearly conceptualise her own study. Presented below is her WhatsApp message:

> *Before anything else, I would like to thank you Mr Chris Mutanho for having asked me to present our Namibian indigenous technology to South African in-service teachers. As I went on to my demonstration, at first I had questions like' Will these teachers be*

interested in this demonstration? Will they even understand what is going on here? However, as the presentation started to unfold some of these doubts were cleared. To begin with, the teachers were asking culturally related questions and they were also keen to know the reasons behind different behind the different procedures. To me this was very surprising as I least expected the teachers to have any form of interest in an indigenous knowledge from another country. However, these teachers did not see the differences in nationality and ethnicity but rather so saw us as one, Africans. Indeed, we are Africans with many commonalities in our indigenous technologies which we used in our communities regardless which part of Africa we live. With this experience, I gained confidence to conduct my own study and demonstrate to teachers in my own country.

While explaining the process of making oshikundu, the teachers were able to relate to their own indigenous technologies practised in their own communities. Comments such as 'This is like amarhewu and umqombothi could be heard from the teachers', possibly referring to the indigenous technologies in terms of the brews which are also made in their communities.

Moving on to this demonstration also contributed positively towards my own study which I passed with a distinction. For instance, I had the opportunity to identify aspects from the demonstration that were not clear. Similarly, there were instances when the teachers asked those culturally related questions. Many times, I could not answer these questions, however, I managed to record them and asked the community elder during her own demonstration in my study. In conclusion this was a good learning experience where I had the opportunity to meet the BEd NS in-service teachers from South Africa and having to interact with them and learn their culture.

9.6.3 Becoming more grounded in my culture

Another interesting reflection came from MaMpondo, who said that for the first time she was able to prepare *umqombothi* for her family. In the Xhosa culture, *umqombothi* is an important beverage that is prepared for both social and religious reasons which range from family get-togethers, weddings, traditional ceremonies such as *umgidi* (passage of rites), and appeasing ancestors. As such, it is essential that every married woman should know how to prepare it. Preparing *umqombothi* for one's family is something that is very important and can earn the *umakhoti* (daughter in-law) respect. MaMpondo is a married woman who has been living with her husband for years but has never prepared *umqombothi* for her family because she did not know how to do it. Cultural practices such as the preparation of *umqombothi* are gradually disappearing in many indigenous cultures as many young women get educated and embrace modernity.

MaMpondo was very thankful to MaMngwevu for teaching them how to make *umqombothi*. She was so happy that she was able to prepare *umqombothi* for her husband's family for Christmas, using the notes that she jotted down as MaMngwevu was presenting and sent me the following photographs.

Figure 9.9: Making *umqombothi* for the family for the first time using notes from the practical demonstration

From this evidence of cultural revitalisation (Cocks et al., 2012; Smith, 2012), it could be surmised that this study was not only about epistemological acess at the university but also about ontological and axiological access (Afonso-Nhelevilo, 2013; Seehawer, 2018). For instance, MaMpondo reflected that:

> *Mama Nolingo was the person from the Grahamstown community who showed us how to prepare umqombothi. I was never involved in the preparation of umqombothi at home and my mother used to do it alone with my aunts. I have also been married for 20 years and yet I have never prepared umqombothi on my own; instead I used to hire people to come and assist me. But since I studied at Rhodes I do umqombothi without any assistance from my family members. I would like to appreciate the work done by Chris to develop us totally. We are now better teachers, better wives and better mothers. My husband is so proud of me.*

This excerpt reinforces the importance of indigenisation of science curricula at universities through tapping into the cultural heritage of elders or community members who are the custodians of such cultural heritage.

9.6.4 Recognition beyond the borders

The Namibian students wrote reflections and emailed me reflecting on this experience, thanking my supervisor, MaMngwevu and me for affording them the opportunity to participate in this study. They were so thankful to MaMngwevu for demonstrating to us how to make *umqombothi*. While community members are often perceived from a deficit perspective as people with no knowledge they can contribute to schools, in this study MaMngwevu got international recognition for her expertise to integrate IK. Both the teachers from Namibia and South Africa recommended that the university award her a certificate of recognition for her contribution to science education and the education of the poor child. This was a great achievement for someone who, as a community member is generally regarded as someone who cannot contribute any knowledge to schools, even less at university level. During her practical demonstration lesson, one of the science teachers (MKO1) explained to her the scientific reasons why metals are not recommended for the storage of *umqombothi*. Even though she is not a science teacher she also learnt the scientific reasons behind certain practices because some of them were done in isiXhosa in her presence.

9.6.5 Recognition by the university

Another success story is that four of us in our CoP got recognition from the university for our research efforts and appeared in the Rhodes University Top Thirty 2018 Research Report. The science lecturer, who is our supervisor, was number 30 in 2018 and in 2020 was number 22. What makes this a great achievement is that unlike most of our White counterparts, we were not funded. Cirha (the translator during MaMngwevu's presentation) also got recognition from the university for two consecutive years after outperforming many well-resourced schools in the district to attain number three. The school's results were only superseded by two former Whites-only high schools despite being a township school. In South Africa, township schools are usually among the poorest schools and usually produce the poorest results, but through Cirha's leadership as the principal his school has become a force to be reckoned with in the district.

One of the greatest achievements in my study was the shift in the teachers' confidence in themselves. In my first encounter with them the teachers asked us the question: "Who is next to go?" because they had started the course as a class of 46 students and had lost 14 members of their class due to exclusion for failing. This had demoralised them. They did not see any reason to continue with the course for fear of failure because nearly half of the class had already failed. This prompted me to start this intervention by motivating them and reassuring them that they had the potential to pass. We sang the song '*Ndibambe ngesandla'* (see Section 5.7).

9.6.6 Furthering studies

Lastly, it is important to mention that at the end of this intervention, six of the BEd Natural Sciences in-service teachers applied to continue with their studies to BEd Honours. Of the six, three were accepted and proceeded with their BEd Natural Sciences honours degree. The level of their self-confidence both as individuals and as a class had positively changed. Unfortunately, one of them (referred to in this thesis as MaMoyo) passed on due to COVID-19. May her soul rest in peace! (MaMoyo was a very active participant who volunteered to be interviewed and presented on the co-developed lessons on behalf of group three: heat transfer).

When I reflect back on the experiences of working with these teachers I feel grateful to have met Prof Ngcoza (Mthembu) who infused Ubuntu in my study. Now the benefits of Ubuntu can be seen manifesting in these teachers' lives. These teachers were some of the teachers who doubted their ability and were not hopeful to complete this course because of the attrition rate that their class had experienced. It brings a warm feeling to think that their lives will never be the same again.

9.7 Chapter Summary

This chapter presented the last phase of this study which I described as the activity. The main purpose of this post-intervention phase of this study was to understand how the teachers would enact the integration of IK. The data presented in this chapter shows a shift in their understanding of how to integrate IK in science lessons and the teachers were able to come up with novel ideas on how to do this. They began to see new possibilities that they were not able to see at the beginning of this study. There is evidence that their understanding of both science and IK expanded. For instance, the teachers began to see traditional cultural practices such as the lighting of firewood as a resource that could be used as an analogy in teaching such topics as chemical reactions and the birth, life, and death of stars. The teachers began to see materials such as firewood, kitchen ingredients, detergents and many others as resources that could be used to teach science. Thus, instead of complaining about lack of resources, the teachers began to see new possibilities where they could use the easily accessible resources in their environment to teach science. It can be argued that their understanding shifted from viewing science as a laboratory subject to seeing it as a subject that could be taught using easily accessible resources found in learners' everyday lives. Lastly, the chapter challenged the negative perceptions embedded in the conventional presentation of ethics by presenting the mutual benefits that accrued to the participants that are attributed to their participation in this study.

CHAPTER TEN: SYNTHESIS, IMPLICATIONS AND RECOMMENDATIONS

> The decolonization of the African Academy remains one of the biggest challenges not only in terms of the curriculum, teaching strategies, and textbooks, but also in terms of the democratization of knowledge and the regeneration, evaluation, and adaptation of old epistemologies to suit new post-colonial realities. Indigenous Knowledge provides a beacon of light within the tunnel of Eurocentric dogma, misinformation, and untruths. (Emeagwali, 2014, p. 2)

10.1 Introduction

In the above epigraph, Emeagwali (2014) reminds us that there are no short cuts to the process of decolonising education. Thus, what this study has done is an attempt to decolonise the university curriculum through the integration of IK as recommended by Emeagwali. This chapter presents a brief synthesis of this study, based on my reflections of the research journey. It starts with a brief overview of the research process. This is followed by a presentation of the brief summary of the conceptual framework, key findings, the new knowledge, recommendations, and suggestions on areas for further research. Lastly the chapter discusses the limitations of this study before turning to my reflections of the research journey and conclusions drawn from this study.

10.2 An Overview of the Study

This study was conducted in South Africa at a time when the call to decolonise the curriculum was louder than ever before. Thus, it sought to contribute to social justice by decolonising the university science curriculum and making science accessible and relevant to all students. The study was conducted as part of a wider project on the integration of IK in science education by a CoP which included a supervisor, two PhD students, and seven master's students. Each one of these students was investigating a different aspect of how to integrate IK in science teaching at different levels of the school system. While the other studies focussed on how to decolonise the science curriculum by integrating IK in science teaching at primary and secondary school level, this study's unique contribution is that it focussed on how to integrate IK in science education at university level.

As already pointed out in Section 1.5, the main aim of this study was to explore how to support BEd Natural Sciences in-service teachers to develop exemplar lessons that integrated IK using easily accessible resources. This ideal would be achieved through answering the following questions:

1. What are the BEd Natural Sciences in-service teachers' attitudes, experiences, and pedagogical insights on the integration of indigenous knowledge in science teaching?

2. What contradictions are embedded in the BEd Natural Sciences in- service teachers' attitudes, experiences, and pedagogical insights in relation to the integration of indigenous knowledge in science teaching?

3. What learning opportunities are created (or not) for the BEd Natural Sciences in-service teachers:

    (a) When co-analysing and discussing the curriculum documents?
    (b) During the practical demonstrations by the expert community members?

4. How can the BEd Natural Sciences in-service teachers be supported in co-designing:

    (a) Science lessons that integrate indigenous knowledge using fermentation as an example?
    (b) Their own exemplar lessons that integrate indigenous knowledge in other topics?

5. How do the BEd Natural Sciences in-service teachers enact and reflect on the model lessons integrating indigenous knowledge they developed?

The research journey comprised of three phases, namely, the explorative phase, the expansive phase, and the activity phase. The first phase explored the contradictions embedded in science education that would manifest themselves in the teachers' attitudes, experiences, and professional insights with regards to the integration of IK. In other words, the explorative phase of this study aimed at answering research question one of this study. This was done through a questionnaire, individual face-to-face interviews, and a focus group interview as explained in Chapter Four.

The identified contradictions were taken as the teachers' learning needs that informed the expansive phase of this study. Thus, the purpose of the expansive phase was to create opportunities for the teachers to expand their understanding of how to integrate IK in science lessons. It comprised of a series of workshops aimed at resolving the contradictions identified in phase one.

10.3 The expansive lenses of this study

Different researchers view expansive learning differently depending on the purpose and scope of their studies. According to Engeström and Sannino (2010), expansive learning can be interpreted as transformation of the object, movement within the zone of proximal development, a cycle of expansive actions within a change laboratory, or boundary crossing, among others. The expansive learning that was evident in this study was the movement in terms of teachers' knowledge, skills, and attitudes towards the integration of IK. As a researcher, my interest was to understand the learning opportunities created through this intervention especially the practical demonstration lessons on the making of *umqombothi* and *oshikundu*. Evidence of expansive learning was interpreted as the qualitative shifts in the BEd Natural Science in-service teachers' attitudes, professional insights, and understanding of how to integrate IK in science lessons. The data gathered in this phase answered my research questions 2 and 3.

The last phase of this study was the activity phase which sought to answer research questions 4 and 5 by trying to understand how the teachers enacted the integration of IK in their science lessons. This was done in three stages namely, "How I plan"; "How I teach" and "How I envision the integration of IK in my science lessons". Ideally, the above questions would have been answered by visiting teachers in their schools and observing how they integrated IK in their teaching. However, in this study class visits were made impossible by the university's ethics requirements as explained in Section 5.2. This was resolved by letting teachers go back to their schools and develop lessons that integrated IK and teaching using the lesson plans. The teachers then sent their reflections on how they integrated IK.

10.4 Key Findings of the Study

It has been noted in Section 1.5 that the aim of this study was to answer the research question, "How can the BEd Natural Sciences in-service teachers be supported to integrate indigenous knowledge in science lessons using easily accessible resources?" In this section I present the key findings that emerged from different phases of this study.

10.4.1 Findings from the explorative phase

The main aim of the explorative phase was to unearth the contradictions embedded in science education that would manifest themselves in teachers' responses to the questionnaire, face-to-face interviews, and focus group interviews which explored teachers' experiences, attitudes, and professional insights with regards to the integration of IK in science teaching. The data gathered in this phase sought to answer my research questions 1 and 2. Presented below are findings in trying to answer these research questions.

10.4.1.1 Teachers' attitudes, experiences, and pedagogical insights with regards to the integration of indigenous knowledge

These questions were answered through a questionnaire, complemented by focus group and individual face-to-face interviews. The results show that the majority of the BEd Natural Sciences in-service teachers supported the integration of IK in science teaching. Their reasons for supporting its integration ranged from educational to socio-political justifications. Educational reasons for supporting the integration of IK in science teaching revolved around making science accessible and relevant to all learners. For instance, Q4(h)F4 said, "*It will make science meaningful even to rural child and more interesting as it would include home community and society perspectives".* What is evident in this response is that the teacher views the integration as a means to making science accessible to learners from disadvantaged socio-cultural backgrounds (Mavuru & Ramnarain, 2020). In her view, if science is made more relevant it becomes accessible to all learners. Her sentiments are shared by many who also feel that the integration of IK makes science more interesting and easier to understand.

However, the results also reveal that although the BEd Natural Sciences in-service teachers support the integration of IK in science teaching, they seemed to lack the conceptual tools to do so. These tools include both the pedagogical and conceptual strategies to integrate IK in science lessons. This can be seen in statements such as:

Q2(h)F2: In my own classroom I do include indigenous knowledge by making examples of what they know, But I didn't know/relate to indigenous knowledge until I came to Rhodes.

Q2(h)M4: I only was able to incorporate some of the indigenous knowledge during my lesson presentation through studies that we discuss in our BEd in-service training. And this has been an eye-opening experience and development on my teaching.

From these extracts, one can see that both teachers did not know how to integrate IK in science lessons. Although Q2F2 spontaneously used IK in her lessons, she was unaware that she was implementing the policy that requires them to integrate IK in their lessons. Her use of it was not deliberately preconceived but determined by the learners' learning needs. As a result, her use of IK was superficial in that she blindly drew a few examples from their daily experiences without knowing that she was using IK. Prior to this intervention, both teachers were not aware that the integration of IK was a requirement expected of them by the department of basic education. This was confirmed in their reflections where some revealed that they rely on textbooks as their main sources of information. The findings of this study demonstrate that even though the CAPS document may be found in many schools, teachers do not use it because they do not have epistemological access to it since they are not equipped with the skills to unpack it. This implies that the availability of the CAPS document in schools is not enough of a guarantee to ensure that the policy is implemented. Teachers cannot implement the intended curriculum if they are not equipped with the necessary conceptual tools to unpack it.

10.4.1.2 Teachers' experiences with regards to the integration of indigenous knowledge in science education

The study also found that many teachers did not experience the integration of IK in their own education both prior and during teachers' training. For instance, in the focus group interview, Babs reported that IK was not part of the curriculum in the school where she did her secondary school because it was regarded as barbaric. She went on to describe the school as a Christian mission institution where IK was treated as evil. However, in tertiary education she was taught science by an Indian lecturer who drew examples from their IK. Her experience was similar to Nonto who also reported that one of her teachers used examples from their IK to teach science. Nonto studied in Zimbabwe which means that although she might have learnt at the same time as Babs they received different curricula since they were in different countries. Babs' example is one of the many examples of how IK was viewed during the apartheid era. As a result, these teachers did not know that IK could be included in science lessons since these two knowledge systems were often presented to them as antagonistic bodies of knowledge. Although in some exceptional cases, some of their teachers would draw on learners' IK to help them understand their use of IK, it was spontaneous and often erratic because IK was not officially prescribed in the curriculum.

The teachers also indicated that the department of basic education did not give them support by way of training to help them understand how to integrate IK. This tends to contradict the government's expectations that teachers should integrate IK in their science lessons with the intention to make it accessible to all learners (DBE, 2011). The teachers' attitudes, experiences, and pedagogical insights towards the integration of IK in science lessons brought to the surface some of the primary and secondary contradictions embedded in science education in South Africa. The primary contractions manifested themselves as tensions within the different elements of the science education activity system (see Section 6.4.1), while the secondary contradictions were located at the nexus of the activities of the department of basic education, teachers' training colleges/institutions, textbook publishers, the schools, and the community as shown in Figure 6.1.

The secondary contradictions emerged as tensions between the activities of different stakeholder activity systems. A case in point is that although the DBE (2011) expects teachers to integrate IK in their lessons, the teachers were not trained to do so. What this shows is that there is tension between the activities of the department of basic education – the rule making body – and the teachers' training colleges (the subject shaping institution). It also shows the tensions between the department of basic education and the school system since the teachers ultimately do not implement the policy as expected of them by policy.

10.4.2 Findings from the expansive phase

The expansive phase explored the learning opportunities created (or not) for the BEd Natural Sciences in-service teachers when engaging in co-analysing the curriculum and exposure to practical demonstration lessons by community experts on how to make the traditional beverages of *umqombothi* and *oshikundu*.

The study also shows that the teachers gained new insights on how to unpack the curriculum. During the orientation workshop, they co-analysed both the CAPS document and the Natural Sciences textbooks that they were using in their schools, using Mavhunga and Rollnick's

(2013) TSPCK components. They were able to identify the concepts that are difficult for learners to understand in each topic, the teaching strategies that can be used to teach them, the prior knowledge (including IK) on each topic, that learners bring to school. However, the study also reveals that although teachers can identify and elicit learners' prior everyday knowledge (including IK) they often do not use it in their teaching. When asked to co-design lessons that integrate IK, three groups out of four identified the prior knowledge that they thought learners would bring to school on each topic, but they did not explain how they would use such knowledge to enhance learning (see Table 7.1). In some cases, the identified IK was not relevant to the concepts to be taught. From this observation one can argue that the identification of learners' prior knowledge is more like a ritual procedure that teachers are expected to follow in their lesson planning but that has no meaning to their teaching.

As evidence of their expanded view of the curriculum, the teachers in this study began to critique the sequencing and progression of content in the CAPS document and the Natural Sciences textbooks. They also realised that the Natural Sciences textbooks that they used to depend on as their main sources of information were not always aligned to the curriculum. One can also argue that Mavhunga et al.'s (2016) TSPCK components enabled them to view the curriculum from different angles. It gave them the conceptual lenses with which they were able to unpack the curriculum and made it easier for them to understand both its content and structure. In essence, the teachers started to reconceptualise both the CAPS document and Natural Sciences textbooks as cultural teaching-learning tools (Engeström & Sannino, 2010; Haapasaari et al., 2016). Their collective analysis of the curriculum created opportunities for them to support one another and learn from each other's expertise and experience. As a result, some of the BEd Natural Sciences teachers described the workshop as a fruitful eye opener from which they gained a lot from their peers (T1, T2, T4).

The findings of this study also show that the intervention created an opportunity for the teachers to shift their attitudes towards cultural diversity. In the explorative phase, the teachers identified cultural diversity as one of the constraints that makes it difficult for them to integrate IK in their science lessons. They argued that they face the dilemma of choosing whose culture to use in a class where learners come from different cultural backgrounds. However, this attitude shifted after the orientation workshop after which they began to describe cultural diversity as an enabler of learning. They began to realise that cultural diversity creates a rich learning environment from which learners can learn from each other's cultures. The teachers even described their own experience of learning in a multicultural classroom as exciting and argued that it had made them appreciate other people's cultures and they began to envision how they would take advantage of diversity in their classes. This was an important realisation in a multicultural country grappling with xenophobia and how to recover from the divisive politics of the apartheid era (Nyamnjoh, 2016). In educational terms, this finding is also an important contribution to new knowledge in that it equips teachers with the conceptual skills of how to deal with diversity in their classrooms whereas there is a tendency in literature to treat indigenous learners as a homogenous group with a universal culture (Aikenhead, 1996; Mothwa, 2011; Mutanho, 2016).

There is also evidence that this intervention created opportunities for the teachers to expand their understanding of the nature of IK. The findings from both the orientation workshop and the demonstration lessons show that the BEd Natural Science in-service teachers developed a wider understanding of IK. Initially, some of them dismissively regarded IK as unscientific knowledge that cannot be proven. They did not see its value in education. This attitude may have been a reflection of the education that they received that treated IK as barbaric. Their arguments were characterised by the uncritical classification of all IK as myths and beliefs with no empirical evidence, while science was portrayed as objective knowledge that is free of beliefs. When this view is juxtaposed against the need to integrate IK in their science teaching, a contradiction within the teachers emerged.

However, data from the expansive phase showed some qualitative shifts in the teachers' attitudes from being predominantly dismissive to a critical appreciation of IK. For instance, the teachers began to realise that not all IK is based on unfounded myths and beliefs. During the orientation workshop they classified their cultural beliefs and practices about lightning as scientific, non-scientific and not sure (see Appendix D: Table D3). This represents a critical shift in their collective ZPDs as they were also able to identify and discuss the scientific principles behind different cultural practices followed during the making of *umqombothi* and drew the mind and concept maps to unpack IK and show the links between IK and science. The teachers also collectively identified practical experiments that can be taught using *oshikundu.* Their understanding of IK shifted from everyday knowledge to scientific knowledge.

Those teachers who had not specialised in science like Sisekho had their content knowledge broadened through the assistance of their peers who became the MKOs (Vygotsky, 1978). This revelation comes as new knowledge in that it draws our attention to the need to treat teachers as people with individual differences, which include educational backgrounds and different learning needs when conducting continuous professional development. This distinction is often not made in many professional development programmes and interventionist studies on IK which tend to treat teachers as a homogenous group with the same learning needs. Jacob (2015) described such an approach as a 'one-size-fits all' approach.

When this shift in attitude is juxtaposed against their agency, it was accompanied by the development of what Mukute and Lotz-Sisitka (2012) called, "A yes-we-can mentality". The resistance and criticism that characterised their responses in phase one turned to a positive attitude towards IK and a willingness to integrate it in science lessons. It can be argued that the intervention helped the teachers to resolve the *tool vs object* tension in their subconscious because the teachers began to envision how they could integrate IK in their science lessons. They began to see that even though there are some myths and beliefs in IK, there is also science embedded in some beliefs and practices.

This study also found that the teachers learnt how to conduct practical demonstration lessons using easily accessible resources such as plants, plastic bottles, oshiphithitho, oshikundu, umqombothi and many others. However, there was not much evidence to reveal that they had learnt the PEEOE approach that we taught them (Asheela et a., 2021).

Another important finding is that contrary to the position held in much of STEM literature that women are not interested in science, this study demonstrated that women can be motivated to learn science if science teaching is located within their traditional domain of influence such as food preparation. For instance, during both practical demonstration lessons by MaMngwevu and MaNdlovu, women were the most active students. They asked questions, argued and explained what is done during the preparation of *umqombothi* and sang songs such as Umakothi wadidiyela (referring to the stirring the *umqomboth*i). Men only seemed to start taking an interest when the *umqombothi* was ready for consumption.

Thus, this study has shown that the integration of IK in science education can potentially solve the long-standing debate on how to make science accessible to women by drawing on IK that falls within the traditional roles performed by women. The use of kitchen chemistry, the brewing of *umqombothi* and *oshikundu* seem to be appealing to the women who participated in this study. Their excitement, participation and cognitive engagement was above that of their male counterparts.

10.4.3 Findings from the new activity

The last phase of this study which I called the new activity, aimed at understanding how the teachers enacted and envisioned the integration of IK in science lessons. It also aimed at understanding how the contradictions identified in the explorative phase were resolved. The results from this phase revealed that if teachers are given back the agency to tackle the challenges that they face in their workplaces they can generate novel ideas and support each other's learning. For instance, when the teachers were asked to collaboratively design lessons, at first they did not know how to make use of the IK they identified. However, when each group presented their lesson plans to the class, they criticised each other, argued, discussed and collaboratively drew the links between the IK and the concepts presented. The knowledge generated during such discussions would not have been possible for any expert using the cascade model to generate. One can argue that the presentation session allowed, what I will call, the 'cross-pollination' of ideas.

Another important finding of this study is that if teachers are given the opportunity to go and test what they learn during in-service training and reflect upon their experiences, they can generate new and innovative ideas and teaching strategies. For instance, when the teachers were asked to share their experiences during the "How I teach session" and discuss how they would improve on what they did, that is when the most significant changes in their understanding of how to integrate IK in science lessons emerged. For instance, group four envisioned using the burning of firewood to teach about the birth, life and death of stars. They pointed out that this topic was very difficult to teach to young learners because their prior knowledge of the concepts of birth, life, and death cause misconception. For instance, the teachers in this study said that some of their learners sometimes ask questions like if stars die where are they buried? This question shows how this topic can be confusing to young learners who try to apply their knowledge of death to this topic. Moreover, stars are extra-terrestrial bodies that cannot be brought to the classroom. This finding is an important contribution to new knowledge because many studies often recommend the integration of learners' IK without acknowledging that some IK can be a source of misconceptions.

The sharing of this example during lesson presentation led the class to extrapolate this to another topic and suggested that the burning of firewood can also be used to illustrate what a chemical reaction is. The evolution of such ideas shows not only the shift in their collective ZPD but also the change in their collective agency. For example, the teachers presented in Section 9.2 went to their schools and tested what they learnt during the orientation workshop. It is important to note that their approach to practical activities does not deviate from the traditional recipe approach even though the teachers tried to be learner centred. However, when the teachers were asked to collectively reflect upon their experiences of integrating IK, that is when the huge leap forward discussed above occurred. Their teaching strategies and representations shifted from the prescriptive to an innovative mode where they became more creative and adventurous.

10.5 New Knowledge

The first contribution to new knowledge in this study is that instead of blaming teachers for their lack of PCK to integrate IK in science teaching like many studies have done, this study has explored how to support teachers to integrate IK in their teaching. As already explained in the literature review, many studies in IK found that teachers struggle to integrate IK in their science lessons (Aikenhead, 1996; Mothwa, 2011; Shizha, 2007). However, the tendency has been to put the blame on teachers and their Eurocentric educational backgrounds without paying attention to what can be done to equip teachers with the necessary PCK to integrate IK. Thus, this study shifts our attention from focusing on teachers' deficiencies to exploring how to support them to integrate IK in their science teaching.

Although academics such as Le Grange (2016) made useful suggestions on how to decolonise the tertiary education curriculum, not much research has been done yet on how to decolonise the tertiary science education curriculum through the integration of IK. The tendency has been to focus on junior secondary and high school science curriculum. Thus, it can be argued that the study's second contribution to new knowledge is to shift the IK-science debate to the tertiary education space, where it explored the possibilities of decolonising teacher education by integrating IK.

Thirdly, the study demonstrated how continuous professional development programmes informed by teachers' learning needs can be conducted. Unlike the cascade model that is followed in South Africa, this study started by identifying teachers learning needs (see Section

7.4). Drawing from the mirror data from the explorative phase, the study explored how to support teachers to unpack the curriculum; elicit and integrate learners' prior knowledge in a multicultural classroom; tap into the community experts' funds of knowledge; use easily accessible resources to teach science; and co-design exemplar lessons that integrate IK. In this way the study responded to the tension between curriculum formulation and curriculum implementation.

The findings of this study have demonstrated that the mere physical presence of the CAPS document in many schools is not enough of a guarantee that teachers will use it. Teachers need to be equipped with the relevant knowledge and skills to enable them to unpack the curriculum and implement it. In other words, they need epistemological access to the curriculum for them to be able to implement it. For instance, some teachers in this study revealed that they used to rely on textbooks and treated the CAPS document just like any other document. None of the studies that I came across so far focused on supporting teachers on how to unpack the curriculum and how to integrate IK in science teaching. It seems as if there is a general assumption that if the CAPS curriculum is made available in schools, teachers will automatically use it in their teaching. This assumption was proven wrong in this study as many teachers were not aware of how to unpack the curriculum and how to integrate IK in their teaching. Some of them were not even aware that there is a policy that requires them to integrate IK.

Hence, it can be argued that the fourth contribution of this study is that it explored possible ways of supporting teachers with the conceptual tools necessary for them to unpack the CAPS curriculum and implement the IK-science policy. Mavhunga and Rollnick's (2013) TSPCK components were used as tools of analysis with which the teachers unpacked the curriculum and developed exemplar lessons that integrated IK. What is new knowledge is that while Mavhunga and Rollnick's (2013) TSPCK is usually used as an assessment tool to understand a teacher's PCK, in this study it was used as a translation device to unpack the curriculum and build lessons that integrated IK. Shulman's (1987) seminal work reminds us that teachers need to think through the subject matter prior to the actual teaching.

The fifth contribution of this study to new knowledge is that it challenged the cascade model and demonstrated that if teachers are given back the agency to resolve the contradictions that confront them in their workplaces, they can generate novel solutions to such challenges. The study has shown that continuous professional development for teachers should not be a once-off event that is discontinuous and disjointed. This intervention stretched over a period of two years in which teachers shared their experiences, reflected on their teaching, and explored new ways of teaching science. What this study did differently from the cascade model was to create room for teachers to work reflexively. While the change laboratory envisaged in CHAT tends to place reflection towards the end of the change laboratory cycle, in this study teachers were asked to reflect after every workshop. By so doing, the teachers were able to identify the things that they did well and to improve on those that they did not do well.

The sixth contribution of this study is that it exposed the tension between Eurocentric and the Afrocentric interpretation of what is ethical conduct. In this regard, the study challenged conventionally accepted research procedures and showed that in some instances they are actually unethical in the eyes of the indigenous people if they are not carefully implemented. A case in point is the statement "*You can withdraw at any given time if you want*" which needs to be carefully rephrased and explained so that it becomes palatable to people from Ubuntu-based cultures. Research methodology books often recommend that researchers should be sensitive to people's interpretations of what is ethically acceptable.

What emerged in Chapter Five of this study revealed that the blind application of Eurocentric ethics can in some cases be unethical if the ethical principles in question are not in tandem with the local interpretation of what is ethically correct. By challenging the Eurocentric ethics, this study may have opened up possibilities for further studies on this aspect which is often taken for granted. Additionally, it also stretched the understanding of ethics, by including the benefits that accrued to participants by virtue of their participation in this study. The emphasis on ethics has always been about the harm that the researcher can do to the participants. Rarely would you find anyone who thinks of the research as something that benefited the participants.

Another contribution to new knowledge of this study is that it promoted reflective practice. As already pointed out in the literature review, one of the major weaknesses of the cascade model is that it does not give teachers the opportunity to experiment with the new knowledge and reflect upon their practices. That is, the top-down nature of the cascade model leaves no room for teachers to learn from their mistakes.

The last contribution to new knowledge of this study is that it has shown how universities can decolonise their curriculum through what Seehawer (2021) calls the bottom-up decolonisation and dialogue between indigenous knowledge and westernised science (Seehawer & Breidlid, 2021). Unlike many studies, this study invited community experts to teach BEd Natural Sciences in-service teachers in the university space. The invitation of community members to teach science at university level constitutes new knowledge because rarely would you find a study that recognises expert community members as knowledgeable people who can contribute their expertise to science education, let alone teach science teachers and lecturers.

10.6 Limitations of the Study

One if the limitations of this study is that it was a case study confined to one institution and one cohort of BEd Natural Sciences students, which means that its outcomes cannot be generalised (Cohen et al., 2018). Perhaps, a bigger sample would have yielded results that would be generalisable. Another limitation is that I had no access to the real classroom situations to observe how the teachers integrated IK in their science lessons due to the ethical restrictions as already explained in Chapter Five. It would have been ideal for me to conduct class visits and see how each teacher integrated IK in their science lessons. In that way I would have been able to assist the teachers with concrete examples from their lessons on how they might go about integrating IK. In this study we had to rely on the teachers' reflections of how they integrated IK in their science lessons as evidence that they tried out what they had learnt in their own classrooms. While this yielded valuable information, there was no way to confirm whether what the teachers said was true or false. Moreover, this study was conducted over a very short time period. The study had to be completed within the three-year period, of which only one year was dedicated to the intervention because of funds as explained in Section 5.3. This study could probably create more learning opportunities for the BEd Natural Science in-service teachers if it had been implemented throughout their three years of training. Additionally, a post intervention follow-up in their schools would have also enabled me to offer the much needed post intervention support to the teachers and attend to their individual learning needs.

Perhaps such studies should be conducted as longitudinal studies over a long period of time so as to see the teachers' professional development as time goes.

10.7 My Reflections

The sad news about this study was that we lost one of the most active participants MaMoyo (the teacher from Zimbabwe) due to the Coronavirus since this study coincided with the Coronavirus outbreak which literally brought the world to a standstill. MaMoyo (her clan name) contributed tremendously to this study. She was the one who presented the co-designed lesson as T3, on behalf of group 3 and during the focus group interview, she is the one who mentioned that IK was integrated in their Zimbabwean curriculum which enabled me to compare. May her soul rest in peace.

I also lost my aunt without whose support I would not have made it this far. This, and the bad news from my colleagues, friends, family, the radio, television, and the social media made the research journey depressing. There was no cure and the virus was threatening to wipe out humanity because it was killing people in thousands per day. I felt hopeless and emotionally drained because every day we were bombarded with sad and depressing news. I began to see the prospect that I would never see my family again since the borders were closed and I was living in South Africa while my family was in Zimbabwe. I had no one to talk to and I missed the social connection with real people. Thanks to my supervisor Professor Kenneth Mulungisi Ngcoza who stood by me through thick and thin and gave me the moral support that I so badly needed. I am also grateful to my family, my friends particularly Solomon Alyhafi and Sisy Thabisa Booi for constantly checking on me and giving financial support when I badly needed it.

Because the outbreak occurred at the beginning of the year, the university had to migrate to online teaching which induced pressure on already stressed students and lecturers. I was both a student and lecturer since I was enrolled as a fulltime student and a part-time lecturer. As lecturers, we were expected to prepare and submit to our coordinators, three weeks' work in advance. This included the lesson plans, the reading materials, power point presentations, video clips and many others. For me this meant that I had prepare work for nine weeks because I was teaching three courses from three coordinators. This was also draining and by the time things began to change for the better, I was suffering from computer fatigue. My brain would simply shut down and I would feel sleepy each time I opened the computer.

10.8 Recommendations

In light of the above findings and limitations, I make the following recommendations:

10.8.1 A learner-centred approach to teacher education

The purpose of this study was to explore how to support BEd Natural Science in-service teachers to develop exemplar science lessons that integrate IK and easily accessible resources. In light of the findings of this study, I recommend a learner centred approach where the continuous professional development is informed by the trainee learning needs. This study has shown that teachers are able to initiate their own learning and support each other's learning if they are given back the agency to actively lead their own learning. Instead of following the cascade model, the in-service training workshops offered by the department of basic education and universities should be informed by the teachers' (who in this case are the learners) needs. In other words, the department of basic education should first find out the needs of teachers and design CPD programmes that enable teachers to generate their own solutions to the challenges that they face in their workplaces. Such programmes should promote the professional networks recommended by Ngcoza and Southwood (2019) so that teachers can continuously support each other even after attending the workshops. Jacobs' (2015) major critique of the current CPD is that it is fragmented, discontinuous, and haphazardly done. As a result it fails to achieve its intended objectives.

10.8.2 Cross pollination of and dialogue between knowledges

I also recommend that universities and schools should create their own teaching by inviting expert community members to share their IK. The outcomes of this study revealed that while science teachers and lecturers may be experts in science, they are novices when it comes to IK. Instead, it is the community members who are experts and more knowledgeable because they are the custodians of such cultural heritage. Thus, if the IK-science policy is to be successful, universities and schools should reach out and work hand-in-hand with communities to elicit IK. I argue that it is through this cross-pollination of ideas that the IK-science policy can be achieved.

10.8.3 Coordinated effort by all stakeholders

The task of integrating IK in science education is not something that should be left to teachers alone. Instead, it requires the coordinated effort of the different stakeholders involved in education. To achieve this, the department of basic education, teacher education institutions, textbook writers, schools, and communities should work together to ensure that the implementation of the IK is successful. In light of this, I recommend that the department of basic education (as the rule making activity system) should ensure that the teachers are properly trained and equipped with the relevant knowledge and skills that will enable them to implement its policies by spelling out its expectations to teachers' training colleges or universities. At the same time, its own continuous development programs should be informed by teachers' learning needs. To achieve this, they need to abandon the top-down approach and adopt a bottom-up approach in which teachers are given back the agency as recommended by Seehawer (2021).

10.8.4 The need to develop modules on how to unpack IK and science

One of the contradictions that surfaced in this study is that IK is not documented. To resolve this, textbook writers should reach out to expert community members to elicit the IK to integrate in science textbooks. In the same manner, universities and schools should also reach out to community experts to seek their assistance in their efforts to integrate IK. For all this to happen more studies of this nature should be conducted.

10.9 Conclusion

> There are many who increasingly believe that through self-organisation and small ruptures, we can actually create myriad of "tipping points" that may lead to deep alterations in the direction that both the continent and the planet take. (Mbembe, 2021, p. 10)

Membe's (2021) quote above seems to resonate well with the goal of my study whose focus was on supporting the BEd Natural Sciences in-service teachers on how to integrate IK and use easily accessible resources in their teaching. Using a bottom-up decolonisation approach, the study tapped into the cultural heritage of expert community members who did practical demonstrations on making *umqombothi* and *oshikundu* to support teachers to develop exemplar lessons that integrated IK. Through these practical demonstrations, the science teachers were able to identify the science concepts embedded in these indigenous practices. That is, other ways of knowing were embraced through what Seehawer and Breidlid (2021) referred to as dialogue between knowledges. Put differently, IK and WS are not mutually exclusive and oppostional; instead, they can co-exist and complement one another.

Notwithstanding, this study revealed that although many teachers support the integration of IK in science lessons they seem to lack the PCK to do so. This brought to the surface the contradictions embedded in science education which are caused by the lack of cooperation among the different stakeholder activity systems. In light of this, it is my contention that teachers should be empowered holistically on how to unpack the curriculum, how to tap into learners' prior knowledge in multicultural classrooms, how to tap into community experts' IK, how to unpack and link IK and science, and how to integrate IK in their teaching.

Finally, the study established that teachers are able to creatively generate new ideas on how to integrate IK and use easily accessible resources in teaching science if they are given back the agency to do so. Hence, the study recommends continuing professional development that is not imposed from above, but one that originates and is driven by the teachers' learning needs.

REFERENCES

Abend, G. (2008). "The meaning of theory." Sociological theory . In R. A. Swanson (Ed.), *Theory building in applied disciplines* (pp. 173-199). Berrett-Koehler Publishers.

Afonso-Nhalevilo, A. (2013). Rethinking the history of inclusion of IKS in school curricula: Endeavoring to legitimate the subject. *International Journal of Science and Mathematics Education, 11*(1), 23-42.

Agunbiade, E., Ngcoza, K., Jawahar, K., & Sewry, J. (2017). An exploratory study of the relationship between learners' attitudes towards learning science and characteristics of an afterschool science club. *African Journal of Research in Mathematics, Science and Technology Education, 21*(3), 271–281.

Aikenhead, G. S. (1996). Science education: Border crossing into the sub-culture of science. *Studies in Science Education*, 1-57.

Aikenhead, G. S., & Jegede, O. J. (1999). Cross-cultural science education: A cognitive explanation of a cultural phenomenon. *Journal of Research in Science Teaching, 36*(3), 269-287.

Asheela, E. N. (2017)). *An intervention on how using easily accessible resources to carry out hands-on practical activities in science influences science teachers' conceptual development and dispositions* [Unpublished master's thesis]. Education Department, Rhodes University, Grahamstown.

Asheela, E., Ngcoza, K. M., & Sewry, J. (2021). The use of easily accessible resources during hands-on practical activities in rural under-resourced Namibian schools. In U. Ramnarain (Ed.), *School science practical work in* Africa: *Experiences and Challenges* (pp. 14-31). Routledge.

Ball, D. L., Thames, M. H., & Phelps, G. (2008). Content knowledge for teaching: What makes it special? *Journal of Teacher Education, 59*(5), 389-407.

Bantwini, B. D. (2010). How teachers perceive the new curriculum: Lessons from a school district in the Eastern Cape Province, South Africa. *International Journal of Educational Development, 30*, 83-90.

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

Basu, S. J., & Barton, A. C. (2007). Developing a Sustained interest in science among urban minority youth. *Journal of Research in Science Teaching , 44*, 466-489.

Battiste, M. (2005). Indigenous knowledge: Foundations for first nations. *International Journal of Indigenous Education Scholarship, 1*, 1-17.

Bayar, A. (2014). The components of effective professional development activities in terms of teachers' perspective. *International Online Journal of Educational Sciences, 6*(2), 319-327.

Bednarz, N., & Proulx, J. (2009). Knowing and using mathematics in teaching: Conceptual and epistemological clarifications. *For the Learning of Mathematics, 29*(3), 11-17.

Beer, J. D., & van Wyk, B. (2011). Doing an ethnographical survey in life science classroom. *The American Biology Teacher, 73*(2), 90-97.

Bertram, C., & Christiansen, I. (2015). *Understanding research.* Van Schaik Publishers.

Bertram, C., & Christiansen, I. (2020). *Understanding research.* Van Schaik Publishers.

Bett, H. K. (2016). The cascade model of teachers' continuing professional development in Kenya: A time for change? *Cogent Education, 3*(1).

Botha, L. (2011). Mixing methods as a process towards indigenous methodologies. *International Journal of Social Research Methodology, 14*, 313-325.

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

Bowen, G. A. (2009). Document analysis as a qalitative research method. *Qualitatvie Research Journal, 9*(2), 27-40.

Breidlid, A. (2013). *Education, indigenous knowledges, and development in the global South: Contesting knowledges for a sustainable future*. Routledge.

Brodie, K. (2013). The power of professional learning communities. *Education as Change, 17*(1), 5-18.

Carter, C., Lapum, J. L., Lavallee, L. F., & Martin, L. S. (2014). Explicating positionality: A journey of dialogical and reflexive storytelling. *International Journal of Qualitative Methods*, *13*(1), 362-376.

Chaiklin, S. (2003). *The zone of proximal development in Vygotsky's analysis of learning and instruction*. Cambridge University Press.

Chappell, P. J. (2012). A sociocultural account of the role of imitation in instructed second language learning. *Journal of Linguistics and Language Teaching, 3*(1), 61-99.

Chauraya, M., & Brodie, K. (2017). Learning in professional learning communities: Shifts in mathematics teachers' practices. *African Journal of Research in Mathematics, Science and Technology Education, 21*(3), 223-233.

Chikamori, K., Tanimura, C., & Ueno, M. (2019). Transformational model of education for sustainable development (TMESD) as a learning process of socialization. *Journal of Critical Realism, 18*(4), 420-436.

Chikunda, C. (2013). *Exploring and expanding capabilities, sustainability and gender justice in science teacher education: Case studies in Zimbabwe and South Africa* [Unpublished PhD thesis]. Education Department, Rhodes University, Grahamstown.

Chilisa, B. (2012). *Indigenous research methodologies*. Sage Publications.

Clegg, S. (2001). Theorising the machine: Gender, education and computing. *Gender and Education, 13* (3), 307-324.

Cobern, W. W., & Loving, C. C. (2001). Defining "science"in a multicultural world: Implications for science education. *Science Education, 85*, 50-67.

Cocks, M. L., Alexander, J., & Dold, T. (2012). Inkcubeko nendalo: A bio-cultural diversity schools education project in South Africa and its implications for inclusive indigenous knowledge systems (IKS) sustainability. *Journal of Education for Sustainable Development, 6*(2), 241-252.

Cohen, L., Manion, L., & Morrison, K. (2011). *Research methods in education* (7th ed.). Routledge.

Cohen, L., Manion, L., & Morrison, K. (2018). *Research methods in education* (8th ed.). Routledge.

Cole, M. (1988). Cross-cultural research in the sociohistorical tradition. *Human Development, 31*(3), 137-157.

Cole, M. (1996). *Cultural psychology: A once and future discipline.* The Belknap Press of Harvard University Press.

Cresswell, J. (2013). *Qualitative inquiry and research design: Choosing among five approaches.* Sage Publications.

Creswell, J. (2014). *Research design: Qualitative, quantitative and mixed methods.* Sage.

Creswell, J. W., & Creswell, D. J. (2018). Mixed methods research: Developments, debates, and dilemmas. *Research in Organizations: Foundations and Methods of Inquiry*, 315-326.

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

Carlson, J., & Daehler, K. R. (2019). The refined consensus model of pedagogical content knowledge in science education. In A. C. Hume (Ed.), *Repositioning pedagogical content knowledge in teachers' knowledge for teaching science* (pp. 77-92). Springer.

Carter, C., Lapum, J. L., Lavallee, L. F., & Martin, L. S. (2014). Explicating positionality: A journey of dialogical and reflexive storytelling. *International Journal of Qualitative Methods,* 13(1). 362-376.

Charamba, E. (2020). Translanguaging in a Multilingual Class: a study of the Relation between students' languages and Epistemological access in Science. *International Journal of Science Education, 41*(11), 1779-1798.

Cohen, L., Manion, L., & Morrison, K. (2011). *Research methods in education* (7th ed.). Routledge.

Cohen, L., Manion, L., & Morrison, K. (2018). *Research methods in education* (8th ed.). Routledge.

Correia, C. F., & Harrison, C. (2020). Teachers' beliefs about inquiry-based learning and its impact on formative assessment practice. *Research in Science & Technological Education, 38*(3), 355-376.

Creese, A., & Blackledge, A. (2010). Translanguaging in the bilingual classroom: A pedagogy for learning and teaching? *The modern language journal, 94*(1), 103-115.

Cresswell, J. (2013). *Qualitative inquiry and research design: Choosing among five approaches.* Sage Publications.

Cresswell, J. (2014). *Research design: Qualitative, quantitative and mixed methods.* Thousand Oaks: Sage Publications.

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

Deci, E. L., & Ryan, R. M. (1995). Human autonomy. In E. L. Deci & R. M. Ryan (Eds.), *In efficacy, agency, and self-esteem* (pp. 31-49). Springer.

De Clercq, F., & Phiri, R. (2013). The challenges of school-based teacher developments initiatives in South Africa and the potential of cluster teaching. *Perspectives in Education, 31*(1), 77-86.

Denzin, N. K., & Lincoln, Y. S. (2008). *The landscape of qualitative research.* Sage Publications.

Department of Basic Education. (2011). *National Curriculum Statement (NCS).* Government Printer.

Dichaba, M. A., & Mokhele, M. L. (2012). Does the cascade model work work ofr teacher training/analysis of teachers' experiences. *International Journal of Education , 4*, 249-254.

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

Donato, R. (1994). *Collective scaffolding in second language learning.* Ablex.

Dziva, D., Mpofu, V., & Kusure, P. (2011). Teachers' conception of indigenous knowledge in science curriculum in the context of Mberengwa district, Zimbabwe. *African Journal of Education and Technology, 1*(3), 88-102.

Duff, S. E. (2020). *Linda Chisholm. Between worlds: German missionaries and the transition from mission to bantu education in South Africa*. Oxford University Press.

Edwards, A. (2011). *Cultural historical activity theory*. British Educational Research Association.

Emeagwali, G. (2014). Intersections between Africa's indigenous knowledge systems and history. In G. Emeagwali & G. J. Dei (Eds.), *African indigenous knowledge and the disciplines, anti-colonial educational perspectives for transformative change* (pp. 1-17). Sense Publishers.

Emeagwali, G., & Shizha, E. (2016). Interconnecting history, African indigenous knowledge systems and science. In G. Emeagwali & E. Shizha (Eds.), *African indigenous knowledge and the sciences: Journeys into the past and present* (pp. 3-11). Sense Publishers.

Engeström, Y. (1987). *Learning by expanding: An activity theoretical approach to developmental research*. Orienta-Konsultit.

Engeström, Y. (1999). *Innovative learning in work teams: Analyzing cycles of knowledge creation in practice.* Cambridge University Press.

Engeström, Y. (2000). Activity theory as a framework for analyzing and. *Ergonomics, 43*(7), 960-974.

Engeström, Y. (2001). Expansive learning at work: towards an activity-theoretical reconceptualization. *Journal of Education and Work, 14*(1), 133-156.

Engeström, Y. K. (2007). Beyond discontinuity: Expansive organizational learning. *Management Learning, 38*(3), 319-336.

Engeström, Y. (2011). From design experiments to formative interventions. *Theory & Psychology, 21*(5), 598-628.

Engeström, Y. (2015). *Learning by expanding: An activity-theoretical approach to develop mental research*. Cambridge University Press.

Engeström, Y., & Sannino, A. (2010). Studies of expansive learning: Foundations, findings and future challenges. *Educational Research Review, 5*, 1-24.

Engestrom, Y., & Sannino, A. (2011). Discursive manifestations of contradictions in organizational change efforts: A methodological framework. *Journal of Organizational Change Management, 24*(3), 368-387.

Englert, C. S., Mariage, T. V., & Dunsmore, K. (2006). *Tenets of sociocultural theory in writing instruction research.* Guilford Press.

Englert, C. S., Mariage, T. V., & Dunsmore, K. (2006). *Tenets of sociocultural theory in writing instruction research.* In C. A. MacArther, S. Graham, & J. Fitzgerald (Eds.). Guilford Press.

Foot, K. A. (2014). Cultural historical activity theory: Exploring a theory to inform practice and research. *Journal of Human Behaviour in Social Environment*, *24*(3), 329-347.

Gade, C. (2012). What is ubuntu,? Different interpretations among South Africans of African descent. *South African Journal of Philosophy, 31*(3), 484-503.

Gathumbi, A. W., Mungai, N. J., & Hintze, D. L. (2013). Towards comprehensive professional development of teachers: The case of Kenya. *International Journal of Process Education, 5*(1).

Geddis, A., & Wood, E. (1997). Transforming subject matter and managing dilemmas: case study in teacher education. *Teaching and Teacher Education, 13*(6), 611-626.

Geldenhuys, J. L., & Oosthuizen, L. C. (2015). Challenges influencing teachers' involvment in continous professional development: A South African perspective. *Teaching and Teacher Education, 51*, 203-212.

Gess-Newsome, J. (2015). A model of teacher professional knowledge and skill includingPCK: Results of the thinking from the PCK Summit. In A. Hume, R. Cooper, & A. Borowski (Eds.), *Repositioning pedagogical content knowledge in teachers'knowledge for teaching science* (p. 79). Springer.

Govender, N. (2014). Re-envisioning pedagogy for African higher education: Students' status of science and IKS via argumentation discourses. *Alternation, 12*, 358-384.

Grill, B. (2003). *Ach, Afrika. Berichte aus dem Inneren eines Kontinents.* Siedler.

Guskey, T. R. (1994). Results - Results oriented professional development. In search of an optimal mix of effective practises. *Journal of Staff Development, 15*(4), 42-50.

Gwekwerere, Y. (2016). Schooling and the African child: Bridging African epistemology and Eurocentric physical sciences. In G. Emeagwali & E. Shizha (Eds.), *African indigenous knowledge and the sciences: Journeys into the past and present* (pp.33-46). Sense Publishers.

Haapasaari, A., Engeström, Y., & Kerosuo, H. (2016). The emergence of learners' transformative agency in a change laboratory intervention. *Journal of Education and Work, 29*(2), 232-262.

Harrell, M. (2016). On the possibility of a feminist philosophy of physics. In M. C. Amoretti & N. Vassallo (eds.), *Meta-philosophical reflection on feminist philosophies of science* (pp. 15-34). Springer.

Harrison, G., & Muthivhi, A. (2013). Mediating self-regulation in kindergarten classrooms: An exploratory case study of early childhood education in South Africa. *The Journal of Education, 57*, 79-102.

Hart, C. (2018). *Doing a literature review: Releasing the research imagination* (2nd ed.). Sage Publications.

Hashondili. (2020). E*xploring working with Grade 6 Elementary Agricultural Science teachers on how to integrate local knowledge in food preservation* [Unpublished master's thesis]. Education Department, Rhodes University, Makhanda.

Hawkins, B. (2008). Using sociocultural theory to examine the context(s) of language learning and teaching. *Studies in Applied Linguistics & TESOL, 8*(1).

Hedges, H., Cullen, J., & Jordan, B. (2011). Early years curriculum: Funds of knowledge as a conceptual framework for children's interests. *Journal of Curriculum Studies, 43*(2), 185-205.

Held, M. E. (2019). Decolonizing research paradigms in the context of settler colonialism: An unsettling, mutual, and collaborative effort. *International Journal of Qualitative Methods, 18*.

Heleta, S. (2016). Decolonization of higher education: Dismantling epistemic violence and Eurocentrism in South Africa. *Transformation in Higher Education, 1*(1).

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

Hodson, D. (1990). A critical look at practical work in school Science. *Practical Work in School Science, 70*(256).

Hodson, D. (2009). *Teaching and learning about science: Language, theories, methods, history, traditions and values*. Sense Publishers.

Holmes, A. G. (2020). Researcher positionality–A consideration of its influence and place in qualitative research–A new researcher guide. *Shanlax International Journal of Education, 8*(4), 1-10.

Hord, M. S. (1997). Professional learning communities: Communities of continuous inquiry and improvement. *Professional Learning Communities*, 1-71.

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

Igwenagu, C. (2016). *Fundamentals of research methodology and data collection.* LAP Lambert Academic Publishing.

Iqbal, J. (2015). *The women whom science forgot.* BBC.

Isaacs, A. N., Pyett, P., Oakley-Browne, M., Gruis, H., & Waples-Crowe, P. (2010). Barriers and facilitators to the utilization of adult mental health services by Australia's Indigenous people: Seeking a way forward. *International Journal for Mental Health Nursing, 19*(2), 75-82.

Iseke, J. (2013). Indigenous storytelling as research. *International Review of Qualitative Research, 6*(4), 559-577.

Jacobs, K. R. (2015). *The classroom implementation of indegenous knowledge in the science curriculum teachers in the Western Cape province, South Africa* [Unpublished PhD thesis]. Faculty of Education, University of Cape Town, Cape Town.

Jansen, J. D. (1998). Curriculum reform in South Africa: A critical analysis of outcomes-based education. *Cambridge Journal of Education, 28*, 321-333.

Kalu, U. (2018). *Oral storytelling and intergenerational learning among Abam people* [Unpublished master's thesis]. Faculty of Graduate Studies and Research, University of Regina, Saskatchewan.

Karalis, T. (2016). Cascade approach to training: Theoretical issues and practical application in non-formal education. *Journal of Education and Social Policy, 3*(2), 104-108.

Karanasios, S., Riisla, K., & Simeonova, B. (2017). Exploring the use of contradictions in activity theory studies. An interdisciplinary review. Loughborough University. *Conference contribution*. https://hdl.handle.net/2134/26026

Karlsson, A., Larsson, P. N., & Jakobsson, A. (2019). Multilingual students' use of translanguaging in science classrooms. *International Journal of Science Education, 41*(15), 2049-2069.

Keane, M., Khupe, C., & Muza, B. (2016). It matters who you are: Indigenous knowledge research and researchers. *Education as Change , 20*(2), 145-162.

Keane, M., Khupe, C., & Seehawer, M. (2017). Decolonising methodology: Who benefits from indigenous knowledge research? *Educational Research for Social Change, 1*, 12-24.

Keikelame, M. J., & Swartz, L. (2019). Decolonising research methodologies: Lessons from a qualitative research project. *Global Health Action, 12*(1).

Kelly, A. M. (2016). Social cognitive perspective of gender disparities in undergraduate physics. *Physical Review Physics Education Research, 12*, 1-13.

Khupe, C. (2014). *Indigenous knowledge and school science: Possibilities for integration* [Unpublished PhD thesis]. School of Education, University of the Witwatersrand, Johannesburg.

Khupe, C., & Keane, M. (2017). Towards an african education research methodology: Decolonising. *Educational Research for Social Change (ERSC), 6*(1), 25-37.

Kibirige, I., & van Rooyen, H. (2006). Enriching science teaching through the inclusion of indigenous knowledge. Indigenous knowledge in the science classroom. *Teaching Science in the OBE Classroom* (pp. 235-247). Macmillan.

Kind, V. (2009). Pedagogical content knowledge in science education: Perspectives and potential for progress. *Studies in Science Education, 45*(2), 169-204.

Kuhlane, Z. (2011). A*n investigation into the benefits of integrating learners' prior everyday knowledge and experiences during the teaching and learning of acids and bases in Grade 7: A case study* [Unpublished master's thesis]. Education Department, Rhodes University, Grahamstown.

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

Le Grange, L. (2007). Interating western and indigenous knowledge systems: The Basis for effective science education in South Africa? *International Review of Education, 53*, 577–591.

Le Grange, L. (2008). Challenges for enacting an indigenised science curriculum: A reply to Ogunniyi and Ogawa. *South African Journal Of Higher Education, 22*(4), 817-826.

Le Grange, L. (2014). Currere's active force and the Africanisation of the university curriculum. *South African Journal of Higher Education, 28*(4), 1283–1294.

Le Grange, L. (2016). Decolonising the university curriculum. *South African Journal of Higher Education, 30*(2), 1011-3487.

Le Grange, L., du Preez, P., & Blignaut, S. (2020). Decolonising the university curriculum or deconial-washing? A multiple case study. *Journal of Education*, *80*, 25-48. doi:http://dx.org/10.17159/2520-9868/i80a02

Leont'ev, A. N. (1981). *Problems of the development of the mind.* Progress.

Loucks-Horsley, S., Stiles, K. E., Mundry, S., NLove, & Hewson, P. W. (2010). *Designing professional development for teachers of science and mathematics.* Corwin.

Lumsden, K. (2012). 'You Are what you research': Researcher partisanship and the sociology of the 'underdog'. *Qualitative Research, 13*(1), 3-18.

Lichtman, M. (2010). *Understanding and evaluating qualitative educational research.* Sage Publications.

Mapara, J. (2009). Indigenous knowledge systems in Zimbabwe: Juxtaposing postdoctoral theory. *The Journal of Pan African Studies, 3*(1), 139-155.

Mapfumo, A. K. (2016). *Exploring how grade 12 Physical Sciences learners make sense of the concepts of work and energy* [Unpublished master's thesis]. Education Department, Rhodes University, Grahamstown.

Marginson, S., & Dang, T. K. (2016). Vygotsky's sociocultural theory in the context of globalization. *Asian Pacific Journal of Education, 37*(1), 11-129.

Maselwa, M. R., & Ngcoza, K. M. (2003). 'Hands–on', 'minds–on' and 'words–on' practical activities in electrostatics: Towards conceptual understanding. In D. Fisher, & T. Marsh (Eds.). *Proceedings of the Third International Conference on Science, Mathematics and Technology Education* (pp. 649-659). Rhodes University, East London Campus, South Africa.

Mateus, V., & Ngcoza, K. M. (2019). The making of clay pots and its relevance to school science: Reclaiming knowledge in the cultural practice of Ovawambo people in Namibia. *Indilinga African Journal of Indigenous Knowledge Systems, 18*(1).

Mavhunga, E., & Kibirige, K. (2018). Tapping the tacit knowledge of playfield swings to learn physics: A case study of childhood reflections by pre-service teachers. *African Journal of Research in Mathematics, Science and Technology Education, 22*(2), 221-230.

Mavhunga, E., & Rollnick, M. (2013). Improving PCK of chemical equilibrium in pre-service teachers. *African Journal of Research in Mathematics, Science and Technology Education, 17*(2), 113-125.

Mavhunga, E., Ibrahim, B., Makomosela, Q., & Rollnick, R. (2016). Student teachers' competence to transfer strategies for developing PCK for electric circuits to another Physical Sciences topic. *African Journal of Research in Mathematics, Science and Technology Education, 20*(3), 299-213.

Mavuru, L., & Ramnarain, U. (2017). Teachers' knowledge and views on the use of learners' socio-cultural background in teaching Natural sciences in grade 9 township classes. *African Journal of Research in Mathematics, Science and Technology Education, 21*(2), 176-186.

Mavuru, L., & Ramnarain, U. (2020). Learners' socio-cultural backgrounds and science teaching and learning: A case study of township schools in South Africa. *Cultural Studies of Science Education, 15*, 1067-1095.

Mawere, M. (2015). Indigenous knowledge and public education in sub-Saharan Africa. *Africa Spectrum, 50*(2), 57-71.

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

Mazibe, E. N., Coetzee, C., & Gaigher, E. (2020). A comparison between reported and enacted pedagogical content knowledge (PCK) about graphs of motion. *Research in Science Education, 50*, 941-964 .

Maciejewski, W., Tortora, C., & Bragelman, J. (2021). Beyond skill: Students' dispositions towards math. *Journal of Developmental Education, 44*(2), 18-25.

MacSwan, J. (2019). A multilingual perspective on translanguaging. *Decolonizing Foreign Language Education*, 186-219.

Maton, K., & Chen, R. T-H. (2016). LCT in qualitative research: Creating a translation device for studying constructivist pedagogy. In K. Maton, S. Hood & S. Shay (Eds.), *Knowledge-building: Educational studies in legitimation code theory* (pp. 27-48). Routledge.

Mbembe, A. (2016). Decolonising the university: New directions. *Arts & Humanities in Higher Education , 15*(1), 29-45.

Mbembe, A. (2021). *Out of the Dark: Essays on Decolonization*. Columbia University Press.

McKinley, E. (2005). Locating the global: culture, language and science education for indigenous students. *International Journal of Science Education, 27*(2), 227-241.

McMillan, J. H., & Schumacher, S. (2010). *Research in education: Evidence based inquiry.* (6th ed.). Addison-Wisley Longman.

McRobbie, C., & Tobin, K. (1997). A social constructivist perspective on learning environments. *International Journal of Science Education, 19*(2), 193-208.

Merriam, S. B. (2009). *Qualitative research: A guide to design and implementation.* Jossey-Bass.

Mhakure, D., & Otulaja, F. S. (2017). *Culturally-responsive pedagogy in Science Education: Narrowing the divde between indigenous and scientific knowledge.* In F. S. Otulaja & M. B. Ogunniyi (Eds.), *The World of Science Education: Handbook of Research in Science Education in Sub-Saharan Africa* (pp. 81-100). Sense Publishers.

Miettinen, R. (2001). Artifact mediation in Dewey and in cultural historical activity theory. *Mind, Culture, and Activity, 8*(4), 297-308.

Miller, H. P. (2011). *Theories of developmental psychology* (5th ed.). Worth.

Mothwa, M. M. (2011). *Teachers' experiences of incorporating indigenous knowledge in the Life Sciences classroom* [Unpublished master's thesis]. Faculty of Education, University of Johannesburg, Johannesburg.

Moyo, S. (2013). Indigenous knowledge systems and attitudes towards male infertility in Mhondoro-Ngezi, Zimbabwe. *Culture, Health & Sexuality, 15*(6), 667-679.

Msimanga, A., & Lelliott, A. (2014). Talking science in multilingual contexts in South Africa: Possibilities and challenges for engagement in learners home languages in high school classrooms. *International Journal of Science Education, 36*(7), 1159-1183.

Mukute, M., & Lotz-Sisitka, H. (2012). Working with cultural historical activity theory and critical realism to investigate and expand farmer learning in Southern Africa. *Mind, Culture and Activity, 19*(4), 342-367.

Mukwambo, M. (2013). Trainee teachers' experiences using contextual teaching and learning: Implications for incorporation of indigenous knowledge in instructional design. *Pedagogical Research, 1*(1).

Mukwambo, M. (2017). *Exploring and expanding situated cognition in teaching science concepts: The nexus of Indigenouis knowledge and Western modern science* [Unpublished doctoral thesis]. Education Department, Rhodes University, Grahamstown.

Mukwambo, M., Ngcoza, K., & C, C. (2014). Africanisation, ubuntu and IKS: A learner-centred approach. In C. Okeke, M. van Wyk & N. Phasha (Eds.), *Schooling, society and inclusive education: An African perspective* (pp. 65-80). Oxford University Press.

Mukwambo, M., Ramasike, L., & Ngcoza, K. (2018). An analysis of language use in analogical indigenous knowledge presented in science texts. *International Journal of Innovation in Science and Mathematics Education*, *26*(2).

Mushonga, M. (2005). Curfew and the 'man in the middle' in Zimbabwe's war of liberation with special reference to the eastern Areas of Zimbabwe, 1977–1980. In C. Hendricks and L. Lushaba, (eds.), *From national liberation to democratic renaissance in southern Africa* (pp. 171-190). CODESRIA.

Mutanho, C. (2016). *Understanding how the incorporation of indigenous knowledge (IK) enables or constrains the teaching and learning of alcoholic fermentation in Life Sciences in Grade 11* [Unpublished master's thesis]. Education Department, Rhodes University, Grahamstown.

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

Ndlovu-Gatsheni, S. (2017). Decolonising research methodology must include undoing its dirty history. *Journal of Public Administration*, *52*(1).

Ndlovu-Gatsheni, S. J. (2020). The cognitive empire, politics of knowledge and African intellectual productions: Reflections on struggles forepistemic freedom and resurgence of decolonisation in the twenty-first century. *Third World Quarterly*, 1-20.

Ngcoza, K. M. (2007). *Science teachers' transformative and continuous professional development: A journey towards capacity-building and reflexive practice* [Unpublished doctoral thesis]. Education Department, Rhodes University, Grahamstown.

Ngcoza, K. M., & Southwood, S. (2015). Professional development networks: From transmission to co-construction. *Perspectives in Education, 33*(1), 4-14.

Ngcoza, K., & Southwood, S. (2019). Webs of development: professional networks as spaces for learning. *Pythagoras, 40*(1).

Nhase, Z. (2019). *An exploration of how grade 3 Foundation phase teachers develop basic scientific process skills using inquiry-based approach in their classrooms* [Unpublished doctoral thesis]. Education Department, Rhodes University, Grahamstown.

Nieuwenhuis, J. (2007). Qualitative research designs and data gahtering techniques. In K Maree (ed.), *First steps in research* (pp. 70-97). Van Schaik.

Nuntsu, S. N. (2020). *Mobilising stories about cultural beliefs and practices on traditional foods to contextualise the topic on nutrition in a Grade 6 township class* [Unpublished master's thesis]. Education Department, Rhodes University, Makhanda.

Nussbaum, B. (2003). Ubuntu: Reflections of a South African on our common humanity. Reflections. *The SoL Journal, 4*(4), 21-26.

Nussbaumer, D. (2012). An overview of cultural historical activity theory (CHAT) use in the classroom research 2000 to 2009. *Educational Review, 64*(1), 37-55.

Nyamnjoh, B. F. (2016). *#RhodesMustFall Nibbling at the Resilient Colonialsim in South Africa.* Langaa Research & Publishing Common Initiative Group.

O'Connell, T. S., & Dyment, J. E. (2011). Health and physical education pre-service teacher perceptions of journals as a reflective tool in experience-based learning. *European Physical Education Review, 17*(2), 135-151.

Odora-Hoppers, C. A. (2002). *Indigenous knowledge and the integration of knowledge systems: Towards a philosophy of articulation.* New Africa Books.

Oeftering, T., Davis, C. A., Ngcoza, K., & Nhase, Z. (2020). “Fees must fall” – South African student protests in the context of (informal) citizenship education. (T. Oeftering, M. Gloe, & T. Thieme, Eds.) *Votum. Beiträge zur politischen Bildung und Politikwissenschaft, 4*, 187-200.

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

Ogunniyi, M. B. (2018). Indigenization of the curriculum: The prospects and the challenges. In L. M. Semali & A. Singambi (Eds.), *Proceedings of the 4th Annual Conference of the African Association for the Study of Indigenous Knowledge Systems* (pp. 2-16). Moshi, Kilimanjaro, Tanzania: AASIKS.

Ogunniyi, M. B. (2020). Tapping the potential of ubuntu for a science that promotes social justice and moral responsibility. In H. L. Yacoubian (Ed.), *Nature of science for social justice. Science: Philosophy, history and education.* Springer.

Ogunniyi, M. B., & 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.

Oloruntegbe, K. O., & Ikpe, A. (2011). Eco-cultural factors in students' ability to relate science concepts learned at school and experiences at home; implications for Chemistry education. *Journal of Chemical Education, 88*(3), 266-271.

Ono, Y., & Ferreira, J. (2010). A Case Study of continuing teacher professional development through lesson study in South Africa. *South African Journal of Education, 20*, 59-74.

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*, 1–12.

Palincsar, A. S. (1998). Keeping the metaphor of scaffolding fresh – A response to C. Addison Stone’s ‘The metaphor of scaffolding: Its utility for the field of learning disabilities'. *Journal of Learning Disabilities, 31*(4), 370–373.

Petrou, M., & Goulding, M. (2011). Conceptualising teachers' mathematical knowledge in teaching. In T. Rowland & K. Ruthven (Eds.), *Mathematical knowledge in teaching* (pp. 9-25) (Vol. 50). Springer.

Probyn, M. (2009). 'Smuggling the vernacular into the classroom': Conflicts and tensions in classroom codeswitching in township/rural schools in South Africa'. *International Journal of Bilingual Education and Bilingualism, 12*(2), 123-136.

Ramnarain, U. (2021). Inquiry-based learning in South African schools. In U. Ramnarain (Ed.), *School science practical work in Africa: Experiences and challenges* (pp. 1–14). Routledge.

Ramnarain, U., & Hlatshwayo, M. (2018). "Teachers' beliefs and attitudes about inquiry-based learning in rural school district in South Africa. *South African Journal of Education, 38* (1), 1–10.

Rehman, A. A., & Alharthi, K. (2016). An introduction to research paradigms. *International Journal of Educational Investigations, 3*(8), 51-59.

Richards, J. (1998). *Beyond training: perspectives on language teacher education.* Cambridge University Press.

Rojas-Drummond, S., Torreblanca, O., & Pedraza, H. (2013). Dialogic scaffolding': Enhancing learning and understanding in collaborative contexts. *Learning, Culture and Social Interaction, 2*(1), 11-21.

Roschelle, J. (1995). *Learning in interactive environments: Prior knowledge and new experience.* American Association of Museums.

Rosser, S. V. (1993). Female friendly science: Including women in curricular content and pedagogy in science. *The Journal of General Education, 42*(3), 191-220.

Rowlands, S. (2003). Vygotsky and the ZPD: Have we got it right? *Research in Mathematics Education, 5*(1), 155-170.

Ruch, G. (2014). Beneficence in psycho-social research and the role of containment. *Qualitative Social Work, 13*(4), 522-538.

Sandelowski, M. (2018). A reluctant but necessary rebuttal to a rebuttal. *Journal of Mixed Methods Research, 12*(4), 363-365.

Sannino, A. (2008). Experiencing conversations: bridging the gap between discourse and activity. *Journal for the Theory of Social Behaviour, 38*(3), 267-291.

Sannino, A. (2011). Activity theory as an activist and interventionist theory. *Theory & Psychology, 21*(5), 571-597.

Sannino, A. (2015). The principle of double simulation: A path to volional action. *Learning, Culture and Social Interaction, 6*, 1-15.

Sannino, A., Engeström, Y., & Lemos, M. (2016). (2016). Formative interventions for expansive learning and transformative agency. *Journal of the Learning Sciences, 25* (4), 599-633.

Scotland, J. (2012). Exploring the philosophical underpinnings of research: Relating ontology and epistemology to the methodology and methods of the scientific, interpretive, and critical research paradigms. *English Language Teaching, 5*(9), 9-16.

Sedlacek, K., & Sedova, M. (2017). How many are talking? The role of collectivity in dialogic teaching. *International Journal of Educational Research, 85*, 99-108.

Seehawer, M. K. (2018). Decolonising research in a Sub-Saharan African context: exploring Ubuntu as a foundation for research methodology, ethics and agenda. *International Journal of Social Research Methodology, 21*(4), 453-466.

Seehawer, M. (2021). *Exploring how South African science teachers can integrate students' indigenous knowledges in their regular teaching: Approaching bottom-up decolonisation through participatory action research* [Unpublished doctroral thesis]. Faculty of Education and International Studies, OsloMet-Oslo Metropolitan University.

Seehawer, M., & Breidlid, A. (2021). Dialogue between epistemologies as quality education: Integrating knolwedges in Sub-Saharan African classrooms to foster sustainability learning and contextually relevant education. *Social Sciences & Humanities Open,* 1-8.

Shabani, K. (2016). Application of Vygotsky's sociocultural approach for teachers' professional development. *Cogent Education, 3*, 2-10.

Shava, S., & O'Donoghue, R. (2014). *Teaching indigenous knowledge and technology. Natural sciences and technology grades 4-6*. Fundisa for Change Programme. Environmental Learning Research Centre, Rhodes University, Grahamstown

Shetunyenga, S. F. (2020). I*ntegrating local knowledge when mediating learning of food preservation in a Namibian multicultural Grade 6 class* [Unpublished master's thesis]. Education Department, Rhodes University, Grahamstown.

Shinana, E., Ngcoza, K. M., & Mavhunga, E. (2021). Development of teachers' PCK for a scientific inquiry-based teaching approach in Namibia's rural schools. *African Journal of Research in Mathematics, Science and Technology Education*, 1-12.

Shizha, E. (2007). Critical analysis of problems encountered in incorporating indigenous knowledge in science teaching by primary school teachers in Zimbabwe. *The Alberta Journal of Educational Research, 53*(3), 302-319.

Shizha, E. (2013). Reclaiming our indigenous voices: The problem with postcolonial sub-Saharan African school curriculum. *Journal of Indigenous Social Development, 2*(1).

Shulman, L. S. (1986). *Those who understand: Knowledge growth in teaching.* Educational Researcher.

Shulman, L. S. (1987). Knowledge and teaching foundations of the new reform. *Harvard Educational Review, 57*(1), 1-22.

Simon, R. M., & Nene, K. (2018). The gender gap in physical and life sciences: masculinity, femininity, occupational values, and chilly climate. *Sociological Spectrum, 38*(5), 346-369.

Simpson, L. B. (2014). Land as pedagogy: Nishnaabeg intelligence and rebellious transformation. *Decolonization: Indigeneity, 3*(3), 1-25.

Skelton, T. (2001). *Cross-cultural research: Issues of power, positionality and 'race'.* Arnold.

Smith, L. T. (1999). *Decolonizing methodologies: Research and indigenous peoples.* London: Zed Books.

Smith, L. T. (2012). *Decolonizing methodologies: Research and indigenous people* (2nd ed.) Zed Books.

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

Steele, D. F. (2001). Using sociocultural theory to teach mathematics: A Vygotskian perspective. *School Science and Mathematics, 101*(8), 404-416.

Stevenson, R. B., Brody, M., Dillon, J., & Wals, A. (2013). *International handbook of research on environmental education.* Routledge.

Stott, D. (2016). Making sense of the ZPD: An organising framework for mathematics education research. *African Journal of Research in Mathematics, Science and Technology Education, 20*(1), 25-34.

Suarez, A., Specht, M., Prinsen, F., Kalz, M., & Ternier, S. (2018). A review of the types of mobile activities in mobile inquiry-based learning. *Computers & Education, 118*, 38-55.

Taylor, D. L., & Cameroon, A. (2016). Valuing IKS in successive South African Physical Sciences curriculum. *African Journal of Research in Mathematics, Sciences and Technology Education, 20*(1), 35-44.

Terr Blanche, M., Durrheim, K., & Painter, D. (2006). Research in practice applied methods for social sciences (2nd ed.). Cape Town: UCT Press.

Thessin, R. A. (2010). *A qualitative study of teachers' work in professional learning commmunities in a small urban district* [Unpublished PhD thesis]. Harvard Univeristy.

Thomas, G. (2013). *How to do your research project: A guide to students in education and applied social sciences.* Sage Publications.

Tracy, S. J. (2019). *Qualitative research methods: Collecting evidence, crafting analysis, communicating impact.* John Wiley & Sons.

Tutu, D. M. (1999). *No future without forgiveness.* Rider.

Tzou, C., Meixi, Suárez, E., Bell, P., LaBonte, D., Starks, E., & Bang, M. (2019). Storywork in STEM-art: Making, materiality and robotics within everyday acts of indigenous presence and resurgence. *Cognition and Instruction*, *37*(3), 306-326.

Van de Pol, J., Volman, M., & Beishuzen, J. (2010). Scaffolding in teacher-student interaction: A decade of research. *Educational Psychology Review, 22*, 271-296.

VanGrieken, K., Meredith, C., Parker, T., & Kyndt, E. (2017). Teacher Communities as a context for professional development: A systematic review. *Teaching and Teacher Education, 61*, 47-59.

Verenikina, I. (2003). Understanding scaffolding and the ZPD in educational research. *International Educational Research Conference (AARE-NZARE)*, Auckland, New Zealand.

Vhurumuku, E., & Molekekche, 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.

Vokwana, N., Rollnick, M., & Mavhunga, E. (2021). Enacted topic specific pedagogical content knowledge: a case of rural out of field natural science teachers in the Eastern Cape province of South Africa. *The 29th Annual Conference of the Southern African Association for Research in Mathematics, Science and Technology Education* (p.317)

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes.* Harvard University Press.

Walker, A. (1996). Professional Development in Hong Kong Primary Schools: Beliefs, practices and church. *Journal of Education and Teaching, 22*(2), 197-212.

Webb, P. (2013). Xhosa indigenous knowledge: stakeholder awareness, value, and choice. *International Journal of Science and Mathematics Education, 11*, 89-110.

Wenger, E. (1998). *Community of practice. Learning, meaning and identity.* University of Cambridge Press.

Wenger, E., McDermott, R., & Snyder, W. M. (2002). *A guide to managing knowledge: Cultivating communities of practice.* Havard Business School Press.

Wessels, M. (2012). The Khoisan Origins of the Interconnected World View in Antjie Krog's Begging to be Black. *Current Writing, 24*(2), 186-197.

Wood, D., Bruner, S., & Ross, J. (1976). The role of tutoring in problem solving. *Child Psychol. Psychiatry, 17*, 89-100.

Wright, C., & Riley, A. (2021). Mitigating the need for resiliency for Black girls: reimagining the cultural brokering through a lens of science as white property. *Cultural Studies of Science Education*, *16*(1), 495-500.

Yin, R. K. (2018). *Case study research & applications* (6th ed.). Sage Publications.

APPENDICES

Appendix A: Ethical clearance

RHODES UNIVERSITY
Where leaders learn

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NHREC Registration no. REC-241114-045

25 June 2019

Chrispen Mutanho

Reference Number: 2019-0242-520

Email: g12M5588@campus.ru.ac.za

Dear chrispen mutanho

Title: An intervention on how to integrate indigenous knowledge in science lessons, An intervention on how to integrate indigenous knowledge in science lessons

Principal Investigator: Prof Kenneth Mulungisi Ngcoza

Collaborators: Mr Chrispen Mutanho ,

This letter confirms that the above research proposal has been reviewed and APPROVED by the Rhodes University Ethical Standards Committee (RUESC) – Human Ethics (HE) committee.

Approval has been granted for 1 year. An annual progress report will be required in order to renew approval for an additional period. You will receive an email notifying when the annual report is due.

Please ensure that the ethical standards committee is notified should any substantive change(s) be made, for whatever reason, during the research process. This includes changes in investigators. Please also ensure that a brief report is submitted to the ethics committee on completion of the research. The purpose of this report is to indicate whether the research was conducted successfully, if any aspects could not be completed, or if any problems arose that the ethical standards committee should be aware of. If a thesis or dissertation arising from this research is submitted to the library's electronic theses and dissertations (ETD) repository, please notify the committee of the date of submission and/or any reference or cataloging number allocated. Sincerely

Prof Joanna Dames

Chair: Human Ethics sub-committee, RUESC- HE

Appendix B: Table in Chapter Two (B1)

Table B1: Women who made tremendous contributions to science

Name	Contribution to science	Recognition
Marie Curie	Physicist and Chemist who discovered radiation which led to the development of x rays	Won a Nobel Prize Was turned down for the membership of the prestigious French Academie des Science in 1911.
Dorothy Hodgkin	Crystallographer who mapped out the structure of penicillin	Won a Nobel Prize in 1964 (First and only British woman to have won the Copley Medal)
Esther Lederberg	Microbiologist whose ground-breaking research on genetics laid the foundation for the modern understanding of genetics.	Assisted her husband Joshua Lederberg to win a Nobel Prize in 1958 but was never acknowledged
Rosalin Franklin	Pioneer X-ray crystallography Her image of the DNA molecule led to the modern understanding of DNA (one of the biggest scientific breakthroughs of the 20th century)	Instead it was James Watson, Francis Crick and Maurice Wikins who got a Nobel Prize in 1962
Ida Tacke	Made a huge contribution in atomic physics. She was the first person to open the idea of nuclear fission. She discovered the two artificial elements rhenium and masurium on the periodic table.	Was credited for discovering rhenium. Her evidence was ignored until Perrier and Serge artificially created masurium. Carlos Perrier and Emilio Serge are credited for discovering masurium.
Lise Meitner	Her work in nuclear physics led to the nuclear fission which ultimately led to the creation of the atomic bomb.	She worked many years with Otto Hahn who went on to publish their work and won a Nobel Prize in 1907 and did not acknowledge her. The element Meitnerium was named after her.

Chieng-Shiung Wu	Worked in the Manhattan Project and participated in the development of the atomic bomb. She was asked by Tsung-Dao Lee and Chen Nin Yang to disprove the law of parity and her experiments turned it upside down.	In 1957 Lee and Yang won a Nobel Prize for their work.
Henrietta Leavitt	Discovered the law of Period luminosity which allows scientists to far away a star is from the Earth.	No recognition was made

Appendix C: Tables in Chapter Six (C1-C3)

Table C1: Teachers' experiences, attitudes, and professional insights

Code	Category	Sub theme	Theme
Q1F1;Q1F3; Q1F4	It made us eager to learn; excited; interested, lifted our curiosity	Increased interest in science	Motivation/affective value of IK
Q1F1; Q1F2; Q1F3; Q1F5; Q1F 1; Q5F2; Q5F2; Q5M4; Q6M2; QM3; Q4M2; Q4M4	It made science easier to understand; Pupils learn easily when teachers move from concrete to abstract, from known to unknown	Simplifying science by teaching from known to unknown	Promotes teaching and learning with understanding
Q4F3; Q4F4; Q4F1 Q4F4	Science can be for all, majority can pass science, it can be meaningful to rura l children, easily accessed to everyone. Quest to decolonize the curriculum,	Making science accessible for all learners	Equality, Decolonization, Inclusivity and Social justice
Q4F4; Q4M4; Q4M2 Q4M2; Q4M4 Q5F2 Q5M4 Q6M1; Q6 F2	Making science more meaningful, Linking to everyday life, students tend to change from their ways to the scientific ways of doing things Contribution to socio-economic growth and sustainable development.	Bridging the gap between home and school science	*Relevance to real life (Orulegbe and Ice, 2011)*

.Q6F1; Q6F2; Q6(h) F3: Q6(h) F4: Q6M1; Q6M2;	IKS is about re- opening	Redressing colonial imbalances	Redressing colonial imbalances

Table C2: Contradictions within the science education activity

Element	**Statement from respondent**	**Identified contradictions**	**Related literature**
Rule	*Integration of IK* Lack of clarity as to how IK can be integrated. Science and IK contradict each other. IK is not examinable IK is not documented	Object vs rule: rule not well articulated. No clarity as to how the object can be achieved. Tool vs object: (tool uses different axiology, ontology and epistemology). Rule vs object: (rule not enforced through examinations). Rule vs tool: (tool not documented to preserve and make it available to curriculum implementers). Lack of support to make rule implementable).	Tension between the intended and implemented curriculum (Ngcoza and Southernwood, 2015). (Le Grange, 2007; Webb, 2013; Hodson, 1990) Lack of literature (Botha, 2012)
Subjects	Teachers not trained to integrate IK. Received Eurocentric education that denigrated IK. Lack confidence Some had negative attitudes	Subject vs tool: subjects lack conceptual tools to implement policy to achieve the object. Subject vs object: Subject not sure of his/her ability to apply tool to achieve the object Subject vs tool: historicity of object and tool impacts on subject's perception of tool.	(Aikenhead & Jegede, 1999; Emeagwali, 2014; Le Grange, 2007)
Mediational tools	Not examinable to assess the success of its implementation. Eurocentric textbooks	Rule vs object: lack of enforcement of IK policy through examinations.	Botha (2012)

	No/little examples of IK Diversity of IK	Tool vs object: IK not integrated in the tools used in teaching science. Teachers lack the ability to handle IK d iversity in a multicultural classroom	
Rules	Lack of clarity, No examples Won't be able to complete the syllabus More politically driven than educational	Intra-rule contradiction: CAPS curriculum stipulates that IK should be integrated in science lessons but does not clarify how this can be achieved. Politically driven statement of intent which is not easily translatable in pedagogical terms. It is an examination centred curriculum. Highly regulated curriculum with specific content having to be covered at specific times of the year. Little room for teacher autonomy.	Jacobs (2015); Mothwa (2011)
Community	Community members are secretive about their IK and are not willing to share.	Teachers lack the expertise to tap into community experts' funds of knowledge. Community experts who are the custodians of IK are left out in curriculum designing and implementation. Both the Department of Education, textbook writers, teacher education institutions and schools do not consult or elicit community members expertise in order to implement an IK based curriculum The is little evidence of coordination among stakeholders in the education system (this is further elaborated in inter-systemic tensions presented in table below).	
Division of labour	The Department of Basic Education is the rule making activity designs the curriculum. Teacher education institutions train	The Department of Basic Education which is the rule making activity system mandated to design the curriculum used the top down approach in designing the curriculum. There is lack of	Jacob (2015); Ngcoza (2007); Ngcoza and Southwood (2015).

	teachers giving the both conceptual and pedagogical insights on important educational matters. The schools are the curriculum (rule) implementers. They interpret the curriculum and translate it into pedagogical approaches that they use in their classrooms. To do so they need conceptual tools that will enable them to identify and integrate IK in their teaching. It selects knowledge	consultation with other stake holders. Teacher education institutions which are the subject producing institutions are not equipping teachers with the necessary PCK to be enable them to implement an IK based curriculum. their curriculum is still Eurocentric. The science teachers (subjects) are not given enough support to integrate IK in their science lessons (e.g. refusal to share IK by community experts). Community experts are hardly invited to contribute their knowledge to the learning of their children by schools, teachers training institutions and textbook writers despite the fact that they are the custodians and experts in IK. Different stakeholders tend to work in silos.	

Table C3: Contradictions from the *historicity* of science education in South Africa

Respondent	**Response**	**Type of contradiction**
Q1b F2	Its only now that we use indigenous knowledge as part of our curriculum.	Tool vs object: Subjects past experiences do not resonate with the expectation to integrate IK. (historicity vs expectation)
Q1 M1	The teachers and lecturers barely incorporated the IK and it was not even stipulated on the curriculum.	Subject vs tool (although expected to integrate IK (DBE, 2011) subject did not experience the integration of IK in his own learning
Q1(h) M3	I knew nothing about this inclusion	Subject vs tool (although the integration of IK, this responded was not aware of its existence)
Q1M5:	I honestly have nothing that I can remember in those years. I can not recall any.	Subject vs tool (although expected to integrate IK (DBE, 2011) subject did not remember how IK was integrated if it was integrated in his own learning.

Appendix D: Tables in Chapter Seven (D1-D4)

Table D1: Showing how the teachers unpacked the CAPS curriculum using the different TSPCK

	Prior knowledge	**What is difficult & Misconceptions**	**Curriculum salience**	**Representations**
Group 1	Human beings use certain plants as their medicines or herbs. Certain plants are believed to attract lightning. Certain plants are associated with attraction of wealth. Certain plants are believed to destruction of family or siblings. Certain clan names are associated with certain animals like baboons to Amamfene. Certain animals are not to be around the household unless something is wrong and a ritual must be performed	Learners do not understand scientific terminology. Some concepts are difficult to teach without necessary laboratory equipment such as microscopes e.g. plant and animal cells, or micro-organisms. Learners do not understand that plants are also living because their concept of living is based on characteristics such as moving, breathing eating.	Progression: There is no progression on the topic Sources of Energy. This concept is introduced in Grade seven but nothing is mentioned in Grade eight. Some textbooks are not aligned to the CAPS curriculum.	Use the plants and animals in environment to teach biodiversity. Learners need to learn through practical work
Group 2: Matter and Materials		In chemical reactions presentation is different from that of CAPS. Learners must first work with the equations and later go to general equations whereas in CAPS, they deal with general equation and thereafter do examples. The concepts taught in this topic are abstract and difficult to explain to second language speakers. For instance, we have no Xhosa words for different types of gases like Oxygen, Nitrogen,	In some topics there is progression from one grade to the other even though they may skip one grade? In CAPS the Atomic mass is not mentioned but they mention the mass number, but the book mentions that. What is in the book helps learners to understand what is meant by	

		Carbon dioxide or words foe Atoms, isotopes etc. .	ISOTOPES? In chemical reactions presentation is different from that of CAPS. Learners must first work with the equations and later go to general equations whereas in CAPS, they deal with general equation and thereafter do examples. In CAPS there are no demonstrations included for certain sections, yet the book gives us pictures to make learners to have an idea of what is said CAPS does not include the applications of the reaction, but the book does.	
Group 3	Children already know about the sun as the source of energy because they experience it.	Content gap- due to lack of science teachers, there is always a gap, even though the teachers teach science, because most of them are not trained and developed to do science.	Types of bonds are not mentioned in CAPS in grade 9 yet they will help learners to understand formation of compounds	Using charts and diagrams, video, and experiments.
Group 4	About the sun: Learners know that the sun gives heat and light. The sun rises and set, it rises in the East and sets in the West. About the seasons: The learners only know that there is	Learners find the concepts in the strand Planet Earth and Beyond very difficult to understand because you cannot prove it. For instance they cannot believe that is the Earth that is moving and not the sun because they see the sun rising in the east and setting in the west every day. They also cannot understand the birth, life and death of stars	There is progression of content taught in one grade to another	Using textbooks, videos, diagrams and textbooks Use learners to represent the sun and the different planets. Use diagrams and illustrations

	summer and winter. In winter it is very cold and in summer it is hot.	because these concepts are misleading when related to everyday life.		on the chalk and Talk

Table D2: Teachers' cultural beliefs in the discussions were classified in a table

SCIENTIFIC	NON-SCIENTIFIC	NOT SURE
Switching off appliances	no running no eating with milk	Certain plants in the home prevent lightning from striking
Stay away from water	Cover shiny objects	some plants must not be in the home as they attract it
Try and find shelter. But not under trees	Mushrooms that grow after a thunderstorm are poisonous	Eggs must be covered with ash to avoid rotting
Do not cover yourself with an umbrella	Elderly women sit down and cover themselves with traditional blanket	Protect yourself by getting a traditional healer to do rituals
	Elderly women remove their head scarves and shout curses to drive lightning away	Removal of faeces from a victim's rectum helps to save them
	Traditional ceremony to remove 'eggs' or else it will strike again	
	People make it to hurt their adversaries	
	Doors or windows are kept open and an olive stick placed at the door to allow lightning to go out	
	Twins can stop a thunderstorm and it obeys	

	Herbalists test each other showing off their powers by making lightning	
	Some people differentiate between natural lightning and one that has been made to hurt an enemy	

Table D3: Evidence teachers' shift in perception

Shift	**Evident statement**
Expanded view of IK	*My own view was that elders were doing science unaware, for example, my grandmother used to put a car tyre on top of the house, believing that when lighting strike this tyre, and nothing will be in danger because car tyre is an insulator.* *It was also noted that during the discussion, some beliefs were scientific, others non-scientific and others were difficult to classify. During the feedback session we compiled the following table* *Some of the things that are said are scientific like covering shinny things because shinny things or metals are good conductors of electricity. And that of sitting in a row and along the wall because light travels in straight line.* *These cultural beliefs can be of much help in Natural Science classroom if we classify them as which ones are scientific and which ones are not.*
Positive views towards diversity	*I have learnt how to work in multicultural classrooms concerning Science and IK. Respecting every culture can help in Natural Science. Learners will value each and every culture without any judgement. I have learnt that you must know CAPS document. (T4)* *It is so fascinating because we are from different cultures and we learn the above things from our parents. (T3)* *During January session we worked in groups analysing the CAPS curriculum document and also discussing cultural beliefs about lightning. This session was so interesting to me because we shared different ideas because we are come from different places therefore our language and terminology is different. For example, other teachers come from Pondoland. (T1)*
Commitment to integrate local or IK	*It is going to make my lessons easy as I will be starting from the known to the unknown. This will make know that learners are not empty slates. So I must always use their knowledge in every lesson. This will also promote respect for their elders as some information comes from them.* *I will first ask the learners about the information that they know or heard from parents about lightning then introduce the topic in matter and material.*
Taking action implementing what has been learnt	*When I came back to my school, I gave my learners task to go to their families asking cultural beliefs about lightning. They came up with same ideas as ours, the only thing different others were sounded as myths.* *When I got to my school, I decided to try it with my learners. These are the photos of my class.*

Role of indigenous languages in teaching science	*Ibali lomntu omkhulu kwilali yethu*
Expanded view of the curriculum as a teaching tool	*In January sessions I gained a lot in analysing CAPS document in groups. It was not very easy at first as some instructions were difficult to follow. I have learnt that it is easy to work through CAPS document if you work as a group. Some topics which are not easy to understand when working as an individual are easily unpacked when you work as a group.* *I have learnt that you must know CAPS document. I used to rely on textbooks. Before going to textbooks for more information about a certain topic, start with CAPS document.*
IK as enjoyable	*It is so fascinating*
Realization that not all IK is myth	*Some IK was science.*

Appendix E: Table in Chapter Eight (E1)

Table E1: The teachers' expanded views on the link between IK and Science

Observed Practice	Everyday explanations	Misconceptions	Scientific explanation that emerged
Soaking of cereal grains	To make malt To germinate Soaking provides water for shooting If seed is not soaked it will not produce results	To increase the surface area We let the cotyledons of the seed to be swollen which is favourable for germination	When making malt, maize/sorghum/millet grains are soaked to activate the enzyme zymase which will breakdown starch in the grains to maltose through anaerobic respiration. The grain (seed) contains a dormant embryo which starts to grow once the energy stored in the seed as starch is made available to it.
Grinding malt	To make the particles smaller To have fine grain that are easy to cook. Fine particles are easier to cook. It works faster than using unground millet	Maize is ground into powder for reducing surface area. Grinding is a way of preserving food.	Grinding breaks down the grain into many smaller particles thereby increasing the surface area exposed to the active enzymes.
Estimate measurements	For the umqombothi to taste nice ad not to be overdone, sour or taste bad. Incorrect measurements will cause the beer not to boil (ferment).	To conduct a fair test. One ingredient should not take advantage of the others.	Measurements are important in chemistry as elements react in given proportions. In the case of alcoholic fermentation inaccurate measurements may result in overproduction of acids or slow rate of fermentation.
Cooling the porridge	To set the porridge to be ready for fermentation. For it to work best.	Evaporation is not the intended result	Fermentation may not take place because enzymes denature due to high temperature

	To make sure that it is heat free. Not to burn malt. It will quickly turn sour.		
Covering the container	So that *uzokwazi ukubila.* To speed up the process of fermentation So that the beer can *boil* (ferment). The beer becomes *istshodo* (sour *mqobothi*). *Uzoba umncu* (It will turn sour)	Bacteria needs warm conditions. Yeast is treated as a bacteria and not a fungi.	Yeast is a fungus that thrives under dark, warm and moist/wet conditions. Covering the container helps to maintain warm conditions
Placing the container on top of dry cow dung	To make it work		For insulation purposes because enzymes become inactive in cold conditions. Preventing heat loss
Leaving some residue in the container	So that when making the next brew the umqombothi can easily boil (ferment). The residue is called isiswenye/intsipho. It becomes umlumiso which can be used to prepare the next brew.		The residue contains yeast which then speeds up the chemical reaction (fermentation) in the next brew. In other words the residue acts as a catalyst of the next brew.
Use of plastic or clay containers	Metal containers make the umqombothi to lose its taste.		Plastic and clay are generally poor conductors of heat so they allow the process of fermentation to occur slowly. Umqombothi is acidic so it will corrode the metal container and that will make it lose its taste. (Acids corrode metals).

			If you put umqombothi in a metal container, the part that is in contact with umqombothi becomes shiny (due to the corrosive effect of umqombothi).
Sour taste: If umqombothi stays covered for a long time it turns sour	Elders add water to umqombothi if it is too sour (ivanya/intsipho) to make it drinkable		The breakdown of the glucose molecule during the alcoholic fermentation releases CO_2 which forms the bubbles we see in *umqombothi*. If it is closed the CO_2 will react with water and form carbonic acid. Too much carbonic acid causes the beer to be sour.

Appendix F: Table from Chapter Nine (F1)

Table F1: Comparison between the teachers' TSPCK in the first and second presentations

	First presentation	Second presentation
Prior knowledge	Stars shine at night. The son moves across the sky.	The teachers used the learners' everyday experience of lighting fire from firewood.
What is difficult for learners to understand	Not mentioned	The concept of the birth, life and death of stars is difficult to teach because stars are extra-terrestrial bodies that can not be brought to the lab. On the other hand, relating this topic to learners' prior knowledge of birth, life and death as it relates to biology is misleading and often cause misconceptions.
Curriculum saliency (content covered)	The teachers would explain that stars exist for a finite period of time. Stars form inside huge clouds of gas called nebulae. Nebulae is pulled together by gravity and slowly collapses. During the contraction, the nebulae heat up. Once the temperature is high enough a nuclear fusion reaction begins. The fusion changes Hydrogen to Helium. The reaction radiates large amounts of heat into space.	Instead of focusing on presenting the scientific facts, the teachers use the analogy of the burning fire to illustrate the birth, life, and death of stars. This will then make it easier for the learners to understand when they explain how the star burns.
Representations	Wall charts, cell phones, smart gadgets	The analogy of a burning fire.
Teaching strategies	• Content centred: the emphasis was on presenting to the learners the scientific facts on this topic. • No practical activity was proposed. • Learner involvement is minimal.	• Learner centred: The emphasis was on making learners understand the meaning of the concepts birth, life and death of stars. • A practical drawn from learns' prior knowledge was be used as an analogy (Ramasike, 2019) to illustrate the meaning of birth, life, and death of a star. • Learners would be involved in the collection of easily accessible resources. • The group considered what is difficult for learners to understand. They realize that while prior knowledge is often regarded as an enabler of learning, in some cases it can be a source of misconceptions e.g. the biological meaning of birth, life and death of stars is not applicable to the birth, life and death of stars. • The group uses learners' local or indigenous knowledge to enhance learning.

		• Learners develop scientific skills such as observing, recording, reporting.

Appendix G: TSPCK translation device

Table G1:TSPCK Translation device (Adapted from Mavhunga et al., 2016, pp. 312-313)

COMPONENTS	DESCRIPTION	LP^{--} (Weak)	LP^{-} (Moderate)	LP^{+} (Strong)	LP^{++} (Very strong)	Comment
Learner Prior Knowledge (PK)	Includes what was taught in the previous grade or lesson. Includes common learner misconceptions known in a topic. This also includes everyday knowledge from home and community	No identification or no acknowledgement or no consideration of learners' prior knowledge or misconceptions; no attempt to address the learners' misconceptions.	Identifies prior knowledge or misconceptions; provides standardized definition as a means to counteract the misconception; no evidence of drawing on other TSPCK.	Identifies prior knowledge or misconceptions; provides standardized knowledge as definition; expands and re-phrases explanations using one other component of TSPCK interactively.	Identifies prior knowledge or misconceptions; provides standardized knowledge as definition; expands and re-phrases explanation correctly; confronts misconceptions or confirms accurate understanding drawing on two or more other components of TSPCK interactively.	

		CS^{--} (Weak)	**CS^{-} (Moderate)**	**CS^{+} (Strong)**	**CS^{++} (Very strong)**	
Curriculum Saliency	Refers to the identification of the most important meaning of major concepts of a topic, without which understanding of the topic would be difficult for learners. It also includes the knowledge to logically sequence the learning and knowledge of pre-concepts needed prior to teaching a topic	Identified concepts are a mix of Big ideas and subordinate ideas; identified pre-concepts are far from topic; sequencing no value due to mixed concepts; reasons given are generic benefit of education.	Identifies at least 3 Big ideas; not all 3 Big ideas and subordinate ideas identified; identified pre-concepts are far from the current topic; suggested sequencing has one or two illogical placing of Big ideas; reasons exclude conceptual considerations and show no evidence of drawing on other TSPCK components.	Identifies at least 3 Big ideas; subordinate concepts correctly identified for all Big ideas; identifies pre-concepts relevant to the topic; provides logical sequence; reasons given for importance of the topic include reference to conceptual scaffolding/sequential development draws on other TSPCK components, e.g., what makes topic difficult.	Identifies at least 3 Big ideas; subordinate concepts correctly identified for all Big ideas with explanatory notes; identifies pre-concepts relevant to the topic and explanatory notes given; provides logical sequence of all Big ideas and with logical reasons; reasons given for importance of the topic include reference to conceptual scaffolding/sequential development draws on other TSPCK components, e.g., what makes topic difficult.	

		WDU^{--} (Weak)	**WDU^{-} (Moderate)**	**WDU^{+} (Strong)**	**WDU^{++} (Very strong)**	
What is Difficult to Understand (WDU)	Refers to gatekeeping concepts which are difficult to understand often because they cause conflict with previously established understanding	Identifies broad topics without reason and specifying the actual subordinate sub-concepts that are problematic	Identifies specific concepts but provides broad generic reasons such as abstract concepts.	Identifies specific concepts leading to learner difficulty; reasons given relate to one other TSPCK component.	Identifies specific concepts with reasons linking to specific gate keeping concepts and to TSPCK components such as prior knowledge and aspects of curricular saliency.	
		RP^{--} (Weak)	**RP^{-} (Moderate)**	**RP^{+} (Strong)**	**RP^{++} (Very strong)**	
Representations (RP)	Refers to a combination of representations at macro, symbol and sub-microscopic levels that may be	Limited to use of only macroscopic representation (analogies, demos etc.) with no explanation of specific links to the concepts represented	Use of macroscopic representation (analogies, demos etc.) and use of scientific symbolic representation without explanatory notes to	Use of macroscopic representation (analogies, demos etc.) and use of scientific symbolic representation with explanatory notes linking the two representations to	Use of macroscopic or symbolic representation with sub-microscopic representation to enforce a specific aspect; Explicit link with other components of TSPCK, e.g., emphasis	

	employed to support an explanation		make the links to the aspects of the concept being explained.	the aspect(s) of the concept being explained; use of above combination of representations with reference to one other TSPCK components, e.g., prior knowledge.	on core aspect of CK demonstrated in the representations and learner prior knowledge.	
		CST^{--} (Weak)	**CST^{-} (Moderate)**	**CST^{+} (Strong)**	**CST^{++} (Very strong)**	
Conceptual Teaching Strategies	Refers to teaching strategies derived from the considerations made from the other four components and excludes general teaching methodologies	No evidence of acknowledgement of learner prior knowledge and misconceptions; lacks aspects of curriculum saliency; use of representations limited to macroscopic or symbolic scientific symbolic representation.	Acknowledges learner misconceptions verbally with no corresponding confrontation strategy; lacks aspects of curriculum saliency; use of macroscopic or symbolic representation with no linking explanatory notes.	Considers confirmation/confrontation of learner prior knowledge and/or misconceptions; considers at least one aspect related to curriculum saliency, e.g., sequencing or what not to discuss yet or emphasis of important aspects; uses at least two different levels of representation to enable understanding.	Considers learner prior knowledge and evidence of confrontation of misconceptions; considers at least two aspect related to curriculum saliency, e.g., sequencing or what not to discuss yet or emphasis of important aspects; uses either the macroscopic or symbolic representation with sub-microscopic	

					representation to enable understanding.	

Appendix H: Consent letters

<u>Letter to the BEd Natural Sciences Teachers</u>

15 May 2019

Dear Research Participant

Re: Participation in my research on the integration of Indigenous knowledge (IK) in the teaching of science.

I am kindly asking you to participate in my study aimed at exploring how to support BEd science teachers to develop model lessons that integrate IK.

The study will be conducted in **three** phases. The first phase requires you to complete a questionnaire and be interviewed on your understanding, experiences and attitudes towards the integration of IK in Science education after which you will attend **Workshop one** to orient you to the study. The **second phase** will be the intervention, comprising of two practical demonstrations lessons on how to develop model lessons integrating IK on the making of *umqobmothi* and *Oshikundu* followed by two workshops to co-develop model lessons that integrate IK, reflect and modify them. In phase three you will be asked to develop your own model lesson plans on other topics, following the example of fermentation shown to you during the intervention.

May I with your permission, take a video and audio record the practical demonstration lessons so that I can analyze them at my spare time? Your participation in this research study is highly appreciated and is completely voluntary which means that you can withdraw at any time if you wish to do so. The data collected in this study will not be used for any other purposes that are non- academic. Your identity participant and views or contributions will be treated as highly confidential and will not be disclosed to anyone without your consent.

Yours sincerely

Mutanho Chrispen

DECLARATION BY PARTICIPANT

I agree to participate in the research and I understand that I am free to withdraw at any time.

Signature…………………………………………………………………………...

<u>Letter to facilitator or lecturer</u>

15 May 2019

Dear Sir

Re: <u>Participation in my study as facilitator of learning and a critical friend.</u>

I write to kindly ask you to assist me in my study as a facilitator of learning and a critical friend.

My study seeks to explore how to support BEd Natural Sciences in-service teachers to develop model lessons that integrate IK. The study will be conducted in **three** phases. The first phase requires the BEd Natural Sciences in-service teachers to complete a questionnaire and I will interview four volunteers from among them, to find out their understanding, experiences and attitudes towards the integration of IK in Science lessons. This will be followed by a workshop to orient them to the study.

The **second phase** involves an intervention comprising of two practical demonstrations lessons on how to make *umqobmothi* and *Oshikundu* to be conducted by two community members (***IK experts***) on the practice of making these two beverages. It is during these practical demonstration lessons that I am kindly asking you to assist me by facilitating learning while I will be a participant observer. A colleague of mine will (***with your consent***), video-record the proceedings. The demonstration lessons will be followed by two workshops to co-develop model lessons that integrate, reflect and modify them. You will then then become my critical friend as I work with the teachers helping each other to co-develop lessons using what they learnt on fermentation as an example.

May I with your permission, take videos and audio record the practical demonstration lessons so that I can analyze them at my spare time?

Your participation in this research study is highly appreciated and is completely voluntary which means that you can withdraw at any time if you wish to do so. I assure you that the data collected in this study will not be used for any other purposes outside its intended purpose. However, should need be, the information will not be released to the third parties without your permission. Your identity and that of other participants will be treated as confidential and will remain anonymous.

Yours sincerely

Mutanho Chrispen

DECLARATION BY PARTICIPANT

I agree to participate in the research and I understand that I am free to withdraw at any time.

Signature…………………………………………………………………………...

<u>Letter to critical friend</u>

15 May 2019

Dear Sir/Madam

Re: <u>Participation in research on the integration of Indigenous knowledge in the teaching of science as a critical friend.</u>

I write to kindly ask you to participate in my study. My research area is Exploring how to support BEd science teachers to develop model lessons that integrate IK.

The study will be conducted in **three** phases. The **second phase** involves an intervention comprising of two practical demonstrations lessons on how to develop model lessons integrating IK on the making of *umqobmothi* and *Oshikundu.* Being someone knowledgeable about the practice of making *umqobmothi/oshikundu,* I will ask you to demonstrate to our Student teachers how umqombothi/oshikundu is made.

Your participation in this research study will be highly appreciated and is completely voluntary which means that you can withdraw at any time if you wish to do so. The data collected in this study will only be used for academic purposes and shall not be released to anyone else without your consent. I also ask for your permission to take videos and audio-record the demonstration lessons so that I can be able to analyze the lessons at my own spare time. Your identity, views or contributions will be treated with a high degree of confidentiality and anonymity.

Yours sincerely

Mutanho Chrispen

DECLARATION BY PARTICIPANT

I agree to participate in the research and I understand that I am free to withdraw at any time.

Signature…………………………………………………………………...

Letter to the community member 1 (Ik experts: *oshikundu*) [English version]

15 May 2019

Dear Sir/Madam

Re: Participation in research on the integration of Indigenous knowledge in the teaching of science as a critical friend.

I write to kindly ask you to participate in my study. My research area is Exploring how to support BEd science teachers to develop model lessons that integrate IK.

The study will be conducted in **three** phases. The **second phase** involves an intervention comprising of two practical demonstrations lessons on how to develop model lessons integrating IK on the making of *umqobmothi* and *Oshikundu.* Being someone knowledgeable about the practice of making *umqobmothi/oshikundu,* I will ask you to demonstrate to our Student teachers how umqombothi/oshikundu is made.

Your participation in this research study will be highly appreciated and is completely voluntary which means that you can withdraw at any time if you wish to do so. The data collected in this study will only be used for academic purposes and shall not be released to anyone else without your consent. I also ask for your permission to take videos of the practical demonstration lessons so that I can be able to analyze the lessons at my own spare time. Your identity, views or contributions will be treated with a high degree of confidentiality and anonymity.

Yours sincerely

Mutanho Chrispen

DECLARATION BY PARTICIPANT

I agree to participate in the research and I understand that I am free to withdraw at any time.

Signature…………………………………………………………………...

Letter to the community members (IK experts) [*Oshiwambu* translation]

15 May 2019

Komundali omu fi ma ne kwa

Re: okukufa ombinga mo shi nya nga dalwa onghe tu na oku longifa uu nongo wo mu fululwa kalo oku longa ounongononi.

Onda pendula eshi wa ita vela oku ku fa ombinga mo shi nyanga ndalwa she li hongo eli. Oshi nya nga dalwa shange ota shi tale nghe ova longwa longi (BED science) ta va kwafwa opo va ndule oku ndu kapo eetundi ta ndi longifa oma ndilandilo nou nongo wo mufuululwakalo oku longa ou nongononi.

Oshinyangadalwa eshi oshili mee ndondo dili natu. Mo nghatu yo tete, ova longwa long iota va ka nyamukula o mapilo pa mbapila na amwe yoo opa kanya. Eundekolavo no maluundo avo kombinga yok u longifa ounongo wo mu fyuululwakalo oku longa ounongononi. Mo ndondo onivali, o va longwa long iota v aka uulikilwa onghee oshikundu no umgobmothi ha shi ningwa. Ova longwa long iota v aka kwafwa yoo nghe ee tundi tandi longifa iinima yo lundi olo tayi longe kindwa.

Omufimanekwa, onde ku pumbwa neh opo uka kwafenge nounongo woye ekutu ulikile onghe oshikundu hashi ndunga. Eku fo mbinga mohinya ngadalwa eshi okuliyamba, no to ndulu okulikufamo shama wuundite inopumbwa vali oku ku fa ombinga. Ekufombinga loye ota li ka la lili me holeko.

Woye

Chrispen Mutanho

DECLARATION BY PARTICIPANT

I agree to participate in the research and I understand that I am free to withdraw at any time.

Signature…………………………………………………………………………...

<u>Letter to the community member 1 (IK expert: *umqombothi*): [English version]</u>

15 May 2019

Dear Sir/Madam

Re: <u>Participation in research on the integration of Indigenous knowledge in the teaching of science as a critical friend.</u>

I write to kindly ask you to participate in my study. My research area is Exploring how to support BEd science teachers to develop model lessons that integrate IK.

The study will be conducted in **three** phases. The **second phase** involves an intervention comprising of two practical demonstrations lessons on how to develop model lessons integrating IK on the making of *umqobmothi* and *Oshikundu.* Being someone knowledgeable about the practice of making *umqobmothi/oshikundu,* I will ask you to demonstrate to our Student teachers how umqombothi/oshikundu is made.

Your participation in this research study will be highly appreciated and is completely voluntary which means that you can withdraw at any time if you wish to do so. The data collected in this study will only be used for academic purposes and shall not be released to anyone else without your consent. I also ask for your permission to take videos of the practical demonstration lessons so that I can be able to analyze the lessons at my own spare time. Your identity, views or contributions will be treated with a high degree of confidentiality and anonymity.

Yours sincerely

Mutanho Chrispen

DECLARATION BY PARTICIPANT

I agree to participate in the research and I understand that I am free to withdraw at any time.

Name…………………………………………………………………………….

Signature…………………………………………………………………………...

Contact number…………………………………………………………………

Letter to the community member 1 (IK expert: *umqombothi*): [Xhosa version]

15 May 2019

Imbalelwano nomhlali eluntwini (Ingcaphephe ekwenzeni *Umqomboth*i)

Mzali obekekileyo,

Ndicela ukuba ube yinxalenye kuphando ulunxulumene nezifundo zam apha eDyunivesithi yase Rhodes. Uphando lwam lunxulumene nokuphanda ukuba ootitshala abenza izifundo zeBEd kwezeNzuluwazi ukuba bakwazi ukubandakanya ekufundiseni ulwazi nencubeko efumaneka eluntwini nasekuhlaleni ngokubanzi.

Oluphando luzathatha izigaba ezithathu. Isigaba sesibini sinxulumene nokubonisa abafundi ukuba umqombothi ne oshikundu zenziwa njani nina. Injongo yoku kukubonisa nokuphanda ngolwazi olufumaneka kweziziselo zozibini. Ndiyazithoba ndikucela ke ukuba ubonise abababafundi ukuba ingaba umqombothi wanziwa njani na.

Ndakuvuyiswa yinxaxheba yakho koluphando ukuze abafundi kwakunye nathi sibe nokuphuhlisa ulwazi lethu ukuze sikwazi ukubanika umdla abantwana xa sibafundisa. Imithetho yeDyunivesithi ke iyababopheleli abathathi nxaxheba into ethetha ukuba banakho ukurhoxa nanini na xa befuna. Ndiyakuqinisekisa nakanjalo ukuba ulwazi olufumaneke kulophando aliyakunikwa nabanina ngaphandle kwemvume yakho. Ukanti, igama lakho aliyikuchazwa esidlangaleleni ngaphandle kwemvume yakho. Siye ke safumanisa ukuba masenze uphando lokuba sazi ukuba yintoni eyenza umdla nendlela abacinga ngayo abantwana xa beyinxalenye kusenziwa uphando nzulu kwizifundo zenzululwazi ingakumbi kwizinto zaselunxwemeni.

Ukuba unombuzo malunga noluphando, nceda uqhagamishelane nam kolu cingo 0718633112, (nhotamu49@yahoo.com) okanye uProf. Ken Ngcoza (k.ngcoza@ru.ac.za) (046-6037269) okwiSebe lwezeMfundo eRhodes Dyunivesithi.

Ndiyakucela kananjalo ukuba uncede uzalise esi siqendu silandelayo.

Maz'enethole!

Umzali: (EXPERT COMMUNITY MEMBER)

Mna mzali ka …………………………….ndiyavuma/ andivumi umntwana wam abe koluphando

Igama …………………………………………………………………………………………….

Tyikitya………………………………………………………………………….....................................

Appendix I: Research instruments

QUESTIONNAIRE

The purpose of this questionnaire is to get to know your experiences and perspectives on the inclusion of local/traditional/indigenous knowledge in science lessons. The information obtained in this questionnaire will be anonymous and your name will not be used. Please answer all the questions as freely and honestly as you wish.

PART A: BIOGRAPHICAL INFORMATION OF TEACHERS AND SCHOOLS

1. Gender

Male	**Female**

2. Age group (Tick one box)

20 - 25 yrs	**26 – 30**	**31 – 35**	**36 - 40**	**41 – 45**	**46 – 50**	**Above 50**

3. Ethnicity (tick the correct one)

Xhosa	**Zulu**	**Sotho**	**Tswana**	**Coloured**	**Others**

4. Qualifications (tick the qualifications you have)

JSTC	**STD**	**BSc**	**BA**	**HONS**	**MEd**	**PhD**	**Other**

5. School location where you teach (tick one)

Urban	**Rural**	**Semi-urban**	**Semi-Rural**

6. Teaching Experience in Natural Sciences/Physical Sciences/Life Sciences/Agricultural Science and total teaching experience?

Teaching experience in	**Grade**	**Total teaching experience**
Natural Sciences/Physical Science/Life Science (Choose one)		

7. Religion…………………………………………………………………………………

PART B: TEACHERS' EXPERIENCES AND PERSPECTIVES

1. What were your past **<u>experiences</u>** on the inclusion of local/traditional/indigenous knowledge during sciences lessons?

(a) When you were taught as a **learner at school**?

………

………

(b) When you were taught as a **student at tertiary level** (College, Technikon or University)?

………

………

2. What are your **experiences** of teaching science in your classroom?

………

………

………

3. What do you **understand** by the term local/traditional/indigenous knowledge?

………

………

4. What are your **<u>views</u>** on the inclusion of local/traditional/indigenous knowledge in science lessons?

………

………

5. What **factors** do you think influence your **views** on the inclusion of local/traditional/indigenous knowledge in sciences lessons?

………

………

6. (a) What do you think what could be the **<u>benefits</u>** of including local/traditional/indigenous knowledge in science lessons?

………

………

(b) What do you think could be the **<u>challenges</u>** for including local/traditional/indigenous knowledge in sciences lessons?

………

………

7. What do you think what could be the reasons why **<u>other</u>** science teachers

(a) **Include** local/traditional/indigenous knowledge during their lessons?
(b) Do **not include** local/traditional/indigenous knowledge in their lessons?

………

8. What else would you like to share with me regarding the inclusion of local/traditional/indigenous knowledge in science lessons?

………

SEMI-STRUCTURED INTERVIEW SCHEDULE

1. Could you please tell me what were your experiences of being taught science
   (a) As a learner at school?
   (b) As a student at tertiary level (College, technikon or university)?

2. Could you please tell me your experiences of integrating IK in your Science lessons?

3. What do you understand by the term local/traditional/indigenous knowledge?

4. What are your views on the inclusion of local/traditional/indigenous knowledge in science lessons?

5. (a) What do you think what could be the **benefits** of including local/traditional/indigenous knowledge in science lessons?

   (b) What do you think could be the **challenges** for including local/traditional/indigenous knowledge in sciences lessons?

6. What else would you like to share with me regarding the inclusion of local/traditional/indigenous knowledge in science lessons?

Appendix J; Learners' cultural beliefs about lightning

Table Cultural Practices followed due to lightning

Beliefs in isiXhosa	English TRANSLATION
Nazi izimvo zabafundi malunga nezulu: 1. Intombazana ayiyinxibi ibhulukhwe xa lizongoma izulu. 2. Umntu odlalwe yinkosi, ungcwatyelwa kwindawo yexhwayelo ngoko nangoko, akasiwa emkhenceni. Umngcwabo wakhe uhanjelwa ngamadoda kuphela. 3. Imfuyo edlalwe lizulu ayityiwa, iyombelwa. 4. Okulalwa kwiqonga eliphezulu (ebhedini). 5. Akutyiwa kwanto xa lizongoma. 6. Ukuthintela ukuba lingadlali izulu, kuthsiswa impepho 7. Zonke izinto ezimenyezelayo kufuneka ukuba zigqunywe. 8. Akuhanjwa emva kwemfuyo. 9. Kubekwa ivili lemoto phezulu kwendlu ukwenzela ukuba ungadluli umbane. 10. Amanzi awaphathwa kwaye awasentyenziswa. 11. Ukuba ngaba indlu itshiswe lizulu, kufuneka ukuba kucinywe ngobisi hayi ngamanzi. Amanzi ayawuphemba umlilo. 12. Kukho inkolo ethi bayakwazi ukulithumela izulu lithsabalalise abantu okanye imizi.	Since all the learners are from the same locality, their cultural beliefs about lightning are almost the same. 1. A girl does not wear a trouser when there is thunderstorm. 2. A person killed by lightning, is buried on the scene, without being taken to the mortuary. Only men are allowed to his funeral. 3. Livestock strike by lightning is uneaten, it is buried on the scene. 4. Incense is burned when there is lightning. 5. There is a strong belief that some people, especially traditional healers can make lightning to kill someone. 6. If a house has been burnt by lightning, it is recommended that one must use milk to extinguish fire, as water will ignite the fire. 7. Do not touch or use water when there is lightning, because water appears to be shiny and shiny objects attract lightning. 8. If one moves around the village, one will notice that there are car tyres on top of the roofs, it is believed that the car tyre will prevent lightning from striking the house. 9. Avoid moving behind livestock. 10. Cover all shiny objects and switch off all electric appliances. It is recommended that one must not sleep on the bed, they must wake up and sleep on the floor.

This is what the learners had to say about their cultural beliefs about lightning:

1.

Protection against lightning

2. Switching off electrical appliances: -

3. Burning of impepo

4. Stay away from trees

5. Stay away from livestock

6. Put car tyres on top of the roof

7. There are plants that prevent lightning

8. Lightning can be created by humans. Some people, especially in rural areas have a belief that someone (sangoma/amaxhwele) can make lightning to strike a person.

9. Use of milk to extinguish fire that has been caused by lightning: - If a house has been struck by lightning and caught fire due to witchcraft, it is believed that it should be extinguished by milk not water.

10. Open windows: - Windows should be opened when there is lightning, so that the lightning bolt can enter and be able to leave the house.

11. Do not stand or sleep

12. Do not eat anything milk or sour milk when there is lightning: -

13. Cover all shiny surfaces like mirrors: - there is a strong belief in Black African communities that all shiny objects should be covered when there is lightning as they believe that shiny objects attract lightning.

14. Cover the eggs so that they cannot rot

15. Making fire

16. Performing noisy things when thunder is coming.