Cultivating Culturally Responsive Teaching: Leveraging Indigenous Technological Practices in Namibian Secondary School Science

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By

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by

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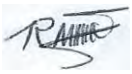
DECLARATION

I, **Rauha Tufilonghenda Mika (15M8769),** declare that this thesis is my original work and it has not been beforehand submitted in any form for examination at any other university for degree purposes. Ideas and citations used in this study and derived from other people have been acknowledged and referenced.



Signature Date: June 2025

DEDICATION

I dedicate my thesis work to my husband, Paulus Mika and my mother, Rauna Shafa. A special word of gratitude goes to them for their encouragement and support. To my daughter, Beatha Ndinelao Mika, I dedicate this piece of hard work to you.

I also dedicate this thesis to my friends and fellow scholars who have supported me throughout my PhD journey. I will always appreciate Beatha Hailundu and Johanna Haimene for encouraging and supporting me in my studies. May God bless you!

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ABSTRACT

The integration of Indigenous knowledge into science education is a heated debate that has been ongoing in many parts of the world for many years. However, in the Namibian science curriculum, there seems to be a lack of clarity on possible Indigenous technological practices that can be integrated into science teaching. Instead, the technology that is emphasised is modernised or Western technologies. This is compounded by the fact that the continuing professional development programmes offered by the Ministry of Education for science teachers are often not aligned with the teachers' needs. They are imposed from above and are inconsistent and inadequate to meet their needs. It is against this backdrop that I conducted a formative interventionist case study to support grade 11 chemistry teachers in co-developing and enacting exemplar science lessons that integrated traditional marula oil extraction.

This study was underpinned by the transformative and Indigenous research paradigms. It was also informed by Engeström's cultural-historical activity theory as the theoretical framework. In addition, Mavhunga and Rollnick's topic-specific pedagogical content knowledge components were used as analytical frameworks. The study focused on working *with* chemistry teachers and tapping into the cultural heritage of Indigenous knowledge custodians to improve the teachers' cultural knowledge brokerage and hence their pedagogical content knowledge. The research emphasised integrating Indigenous technological practices which evolve around recognising and engaging the learners' home cultural background practices intended to localise the science curriculum.

This study is a qualitative case study which followed transformative expansive learning processes. Data were generated using semi-structured interviews, change laboratory workshops, participatory observations, and journal reflections. The study's findings revealed that the teachers involved in this study went through a shift in their agency – from a limited state of negative and resistant views towards integrating Indigenous technological practices to an expanded view with positive, committed, and accommodative attitudes. Moreover, their participation in change laboratory workshops enabled them to enhance their learners' conceptual understanding, experimental techniques, and scientific skills. The major contribution of this study to new knowledge is indigenising curriculum through mobilising the indigenous technological practice of marula oil extraction. Methodologically, the study also contributed to the new knowledge regarding the participation of Indigenous knowledge custodians in a professional learning community as facilitators resulting in the shift in understanding and perspectives of Indigenous knowledge and technology.

The study concluded that the indigenous technological practice of marula oil extraction was an effective cultural tool for mediating teaching and learning of the grade 11 chemistry concepts. The study thus recommends that teachers should work in collaboration with Indigenous knowledge brokers to learn more about Indigenous technological practices that can be integrated into their teaching. Teachers' professional development and professional learning communities should, therefore, integrate these. This study further recommends that textbook writers should include and cite more examples of Indigenous technological practices and how to integrate them into science teaching. This might assist in promoting culturally responsive teaching in science classrooms.

Keywords: Organic chemistry; Indigenous technological practices; Indigenous knowledge; cultural knowledge brokerage; culturally responsive teaching; expansive learning; cultural-historical activity theory; and topic-specific pedagogical content knowledge

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LIST OF ABBREVIATIONS AND/OR ACRONYMS

CHAT	Cultural-Historical Activity Theory
IK	Indigenous Knowledge
IKC	Indigenous Knowledge Custodian
PATT	Pupils' Attitudes towards Technology
PCK	Pedagogical Content Knowledge
PLC	Professional Learning Communities
TSPCK	Topic-Specific Pedagogical Content Knowledge

CHAPTER ONE: SITUATING THE STUDY

> For a long time, there has been a debate about teaching Indigenous knowledge and the benefits that come with it. Simultaneously, the debate over curriculum transformation and Africanisation has made it critical for scholars and students alike to seriously consider Indigenous knowledge as a catalyst in education that can empower communities to participate in educational development. This respects diversity and recognises the challenge of Western Eurocentric forms of universal knowledge hegemony. (Kugara et al., 2022, p. 11)

1.1 Introduction

In this chapter, I situate the study I carried out in the Okahandja circuit, Otjozondjupa region of Namibia. Its focus was to mobilise and establish an understanding of how integrating Indigenous Technological Practices in chemistry teaching could contribute to science teaching. The use of marula Indigenous technological practices oil extraction was used in exemplar lessons to teach scientific processes, experimental techniques, and chemical reactions. The two topics that were taught used culturally responsive pedagogy when mediating chemistry.

This study was prompted by my master's research findings that science teachers struggle to integrate Indigenous knowledge (IK) into science lessons. It was also prompted by inadequate and inconsistent teachers' professional development in culturally responsive teaching of science subjects (Cocks et al., 2012; Haimene, 2023; McCarty & Lee, 2014; Mhakure & Otulaja, 2017). Furthermore, as highlighted in the epigraph, the study was motivated by the context of a community that has [1]IK custodians who possess knowledge of cultural practices that have the potential to be used in grade 11 chemistry lessons. Yet historically, the manifestation of contradiction is that colonialism and apartheid marginalised these IK custodians from the education system, resulting in their voices being silenced (Freire, 1970; Hove et al., 2014).

[1] Elders from the community who have expertise in traditional practices and Indigenous Knowledge, Technology, Engineering, and Mathematics are referred to as IK custodians in this study. They are thus regarded as custodians or repositories of the cultural heritage that has been passed on to them by their parents or community members.

My contention in this study, therefore, is that regardless of their education, IK custodians have the potential to contribute to the school activity system. It is against this backdrop that I tapped into their cultural heritage to enable the science teachers to become cultural knowledge brokers (Simasiku, 2022; Wynatt et al., 2017) who are culturally responsive or sensitive (Haimene, 2023; Mhakure & Otulaja, 2017). Moreover, I endeavoured to operationalise what two-eyed-seeing (Hatcher et al., 2009; Gilbert et al., 2020) and two-ways-knowing (Michie et al., 2023) mean. In this regard, Mavuru and Ramnarain (2020) emphasise the importance of considering learners' diverse sociocultural backgrounds.

Firstly, I start outlining the context of the study by looking at the Namibian curriculum, how Indigenous ways of knowing are viewed in Africa, and the nature of continuing professional development activities provided in Namibia. Secondly, I share my personal life history, including how I was taught IK by my grandmother and became a culturally responsive individual. Thirdly, I highlight my positionality and reflexivity as a researcher, set out the problem statement, the significance of the study, the research gap in the Namibian context, the research goals and the research questions. Finally, I outline the theoretical and analytical frameworks that informed the study and define the key concepts used in this thesis.

1.2 Context of the Study

The Namibian National Curriculum for Basic Education (Ministry of Education, Arts and Culture, 2016) emphasises the study of material technologies, believing that this can contribute to the foundation of a knowledge-based society. This is critical in developing learners' scientific knowledge, skills, creativity and innovation during teaching and learning. Based on the zone's report for 2011 on improving quality and equity in Namibian education, classroom lesson observations of different subjects revealed that there was a need for improvement in the quality of teaching. One way of doing this is through the integration of IK, which, scholars such as Shinana et al. (2021), Liveve (2022), and Simasiku (2022), and others view as a positive step towards making science accessible to learners from diverse sociocultural backgrounds (Mavuru & Ramnarain, 2020).

However, while the Namibian Ministry of Education supports the integration of IK, research shows that many teachers tend to struggle to integrate IK into their science lessons. From a cultural-historical activity theory perspective, this could be surmised to be a tension between the rule and the subjects that is a manifestation of a contradiction (Engeström, 2001; Haapasaari et al., 2016). In their studies, Mothwa (2011) and subsequently Mutanho (2021) attributed this failure to the *historicity* of the science education activity system in Africa, during the colonial era, where IK was denigrated and treated as non-scientific, ancient knowledge that was not worthy knowing.

In the context of the Namibian curriculum, another tension or dilemma is that teachers are expected to contextualise scientific knowledge by using local examples from learners' everyday lives (Gwekwerere, 2016; Shinana et al., 2021), including IK, and yet they are not trained or supported to do so. Gumbo (2016) stresses that many teachers teach in Indigenous or multicultural contexts. Yet, they are poorly prepared to do so as they simply turn a blind eye to integrating pedagogical perspectives that recognise Indigenous learners during their teaching. This draws some African scholars to argue that the science that is taught in African schools does not carry an African identity. In addition, some scholars have criticised the dominance of Western epistemologies in African education and hence advocated the integration of IK (Breidlid, 2013; Emeagwali & Shizha, 2016; Odora-Hoppers, 2002; Shizha, 2016). It seems that these scholars and Mukwambo et al. (2014) are proposing the Africanisation or indigenisation of the curriculum; moreover, they criticise that the technology used in science teaching is modernised.

As a result, Indigenous technological ways of knowing are not recognised by teachers (Mawere, 2014; Seehawer, 2018; Semali & Kincheloe, 1999). That is, the technology used in science teaching and continuing professional development seems to be modernised. Yet, Maluleka et al. (2006) cautioned that Indigenous technological practices, with their long history, cannot be ignored. Instead, it should be assigned a more prominent place in the curriculum. For instance, traditional skills and techniques are used in the production of arts, crafts, weaving and brewing, among others, that represent Indigenous technologies in Africa (Shinana et al., 2021; Shizha, 2016).

Similarly, Breidlid and Botha (2015) averred that IK offers interesting possibilities for including alternative forms of cultural activities in learning and teaching practices. In their study conducted in Namibia, for instance, Shinana et al. (2021) used the indigenous technological practice of making [2]*oshikundu*, an easily accessible resource to promote inquiry-based approaches in rural schools. The study's focus was to uncover changes in the life science teachers' knowledge of topic-specific pedagogical content knowledge (TSPCK) components (Mavhunga & Rollnick, 2013) after they participated in an explicit intervention that leveraged Indigenous technological practices. Before the intervention, the teachers' knowledge of various TSPCK components was established and seemed inadequate for scientific inquiry. They further demonstrated changes in knowledge of conceptual teaching strategies and learners' prior knowledge by appreciating the use of the Indigenous technological practices of making *oshikundu* to teach school science.

It is notable, however, that the decline in Indigenous technological practices has been influenced by the impact of not only colonialism but also globalisation (Mawere, 2014). Accordingly, some scholars have noted with concern that IK and Indigenous technological practices are facing the threat of extinction (Nweke, 2024). Indigenous technological practices are facing the threat of extinction, carrying significant weight, reflecting ongoing struggles against globalisation, modernisation, and cultural erosion. In some cases, these are replaced and overshadowed by foreign technologies (brought from developed countries), which, sadly, do not take cognisance of the IK system of African people (Ogunniyi, 2007a, 2018). Therefore, the preservation of IK and Indigenous technological practices should not be ignored but rather seen as a dynamic process of adaptation and recognition. Indigenous knowledge (IK) Custodians must be empowered to teach and evolve their practices, ensuring they remain relevant in today's fast-changing world. Strengthening educational programmes and community-led initiatives can be key in safeguarding these traditions from extinction.

Concurring, Fernández-Llamazares et al. (2021) noted that globalisation, government policies, colonialism and other rapid social-ecological changes seem to threaten the relationships between Indigenous peoples and local communities and their environments, thereby challenging the continuity and dynamism of Indigenous and local knowledge. For instance, the findings of physical science classroom lesson observations for the Otjozondjupa Directorate of Education, Arts and Culture (2012) concluded that most science teachers observed faced pedagogical

[2] *Oshikundu* is a Namibian traditional soft drink made from fermented *mahangu* flour and malted sorghum mixed with water. It has a short life span and should be consumed on the same day or, preferably, within eight hours of being made.

challenges in integrating learners' sociocultural backgrounds. From a South African perspective, Mavuru and Ramnarain (2020) contended that teachers must develop strategies to integrate Indigenous and Western knowledge into their teaching.

In essence, Mavuru (2019) argued that due to urbanisation, foreign value systems may threaten, modify, enhance, replace, or corrupt the cherished value systems of an Indigenous group of people. In the same vein, Ngcoza (2019) observed that most IK practices have receded in rural areas, and in many cases, have been lost to urban Indigenous populations due to exposure to Western livelihood systems and practices. As a result, urban Indigenous generations have suffered and are disadvantaged in terms of acquiring IK. This is due, in part, to a lack of exposure to their cultural heritage, which could assist them in understanding the modern scientific curriculum better.

Considering these arguments, I contend that there is a need to mobilise Indigenous technological practices in schools. Moreover, higher education institutions need to indigenise the science curriculum in what Mutanho (2021) sees as the decolonisation of the higher education science curriculum. However, Mutanho (2021) cautions that decolonisation does not mean we should do away with Western knowledge. Instead, he concurs with Seehawer (2018) and Seehawer and Breidlid (2021) that these knowledges should complement one another in a dialogic manner.

As noted in the above epigraph, IK is regarded as a catalyst in education that can empower communities to participate in educational development. Likewise, in this study, integrating Indigenous technological practices is an approach that can sensitise and empower teachers to maximise innovation in teaching through leveraging professional learning communities. These professional learning communities are regarded as powerful platforms or spaces for teachers' development and as sites where deep learning among teachers takes place (Brodie, 2013; Chauraya & Brodie, 2018; Ngcoza & Southwood, 2019). Ngcoza and Southwood (2019) refer to such spaces as 'webs of development', and such spaces resonate with the intentions of this study.

However, the continuing professional development activities provided in Namibia tend to be based more on the acquisition of modernised science content knowledge and teaching methods, which only prepare teachers to integrate modern technological practices into their science teaching. As a result, research shows that many teachers have limited pedagogical content knowledge and skills (Shinana et al., 2021; Shulman, 1986) to implement a culturally relevant curriculum (Haimene, 2023; Josua et al., 2022; Kambeyo et al., 2023) that takes into consideration learners' sociocultural backgrounds, as espoused by Mavuru and Ramnarain (2020).

Ngcoza and Southwood (2015) view this as a tension between the intended and the implemented curriculum. That is, the tension is between what teachers teach and what they are expected to teach. They further posit that how teachers are taught tends to inhibit innovation in teaching and learning. In the Namibian context, this tension could be attributed in part to a lack of continuing professional development and support for teachers. It is against this backdrop that this study explored and established an understanding of how integrating Indigenous technological practices can contribute to science teaching and how professional learning communities expand or constrain such integration.

Extending on Wenger's (1999) seminal work, Chauraya and Brodie (2018) share three dimensions of PLCs, namely, the *joint enterprise* – based on collective action towards learning; secondly, *mutual engagement* – focusing on sharing understanding, reflections, and collective decision-making; and thirdly, *shared repertoire* – which has to do with shared ways of addressing problems, new meaning, and ways of improving practice. Herein lies the importance of this study, that is, to make science subject matter comprehensible (Shulman, 1987), relevant, and accessible to their learners (Gwekwerere, 2016) in a community of practice (Wenger, 1999).

According to the African Union Agenda 2063, science, technology, and innovation should be a driver for resolving economic and social challenges deterring the progress of Southern African countries (Hooli & Jauhiainen, 2018). Therefore, the Namibian Education Department wants to promote technologies in science teaching and learning. In an attempt to address this, Namibia's target is to strengthen cooperation between the public and private sectors to develop a knowledge-based and innovative society where existing and new knowledge is developed to bring about industrialisation. For instance, the Namibian Long-term National Development Plan: Vision 2030 demands that the basic education curriculum be reviewed, and the teaching of Mathematics, science, and technology should be strengthened at all levels (Ministry of Education, Arts and Culture, 2021).

Likewise, extending on Aikenhead and Jegede's (1999) seminal work on border crossing, Snively and Williams (2008) understand that it entails teaching traditional IK in parallel with Western science. Considering her context in South Africa, however, Godlo (2024) characterises border crossing as a river crossing in her study since schools and communities separated by them. Gumbo (2016) highlighted that authentic problems in learners' environments can be addressed through indigenous technological practice integration which can be a practice of hope that can bridge the gap between the home and school. Concurring, Mhakure and Otulaja (2017) referred to such pedagogies as being *culturally responsive* or *sensitive,* whereby learners' sociocultural contexts are considered, as reiterated by Mavuru and Ramnarain (2020). This resonates with the Namibian revised National Curriculum for Basic Education (Ministry of Education, Arts and Culture, 2016), which proposes that effective teaching should embrace the learners' prior everyday knowledge (Kuhlane, 2011) and IK to bring about a knowledge-based society. In this study, Indigenous technological practices are regarded as prior everyday knowledge, and the Namibian National Indigenous Knowledge Systems Council promotes IK with elements of technologies.

Essentially, the National Indigenous Knowledge Systems Council was established in 2004 to enhance, recognise, develop and promote the value and role of IK and technologies for development. Through collaboration between the National Indigenous Knowledge System Council and the Ministry of Higher Education, Technology and Innovation, the National Commission on Research, Science and Technology was established as a state-owned enterprise with the primary role of promoting, coordinating, monitoring, and developing research, science, and technology in Namibia. The National Commission on Research, Science and Technology, with various stakeholders, has successfully facilitated the development of the National Programmes on Research, Science, Technology, and Innovation.

To operationalise the National Programmes on Research, Science, Technology and Innovation, the National Commission on Research, Science and Technology, and the National Indigenous Knowledge Science, Technology, Engineering and Mathematics Council are mandated to oversee the development of the national IK system agenda for Namibia. In 2015, the University of Namibia hosted the African Association for the Study of Indigenous Knowledge Systems to ensure the sustainability of this project. I had the honour of attending and presenting at this conference, which I found very informative. Currently, the Ministry of Higher Education, Technology and Innovation acknowledges the South African Department of Science and Innovation as a valuable partner, through a bilateral agreement, for advisory and technical contributions towards developing the Namibian Indigenous Knowledge System Policy.

This background motivated me to carry out a master's research project in which I explored an intervention for integrating IK into grade 9 physical science lessons. The findings of my study revealed that integrating IK has the potential to have positive results in science teaching. However, there is a need for teacher empowerment through study groups, participating in professional learning communities, attending workshops, and sharing ideas on how they can improve their content and pedagogical content knowledge (Mika, 2019). As explained earlier, through professional learning communities, empowerment spaces can be created whereby teachers can discuss the possibilities for integrating IK.

Despite the plethora of studies on IK integration into education (Abah et al., 2015; Adeyeye & Mason, 2020; Amuthenu, 2023; Seehawer, 2018), there has been little discussion on Indigenous technological practices integration in the curriculum (Gumbo, 2015). In the Namibian context, for instance, I did not come across science workshops that integrate Indigenous technological practices. Instead, the workshops that are provided typically focus more on modern technologies, such as the use of information communication technology and modern laboratory apparatus to teach science. It could be surmised, therefore, that the nature of professional development in Namibia seems to exclude Indigenous technological ways of knowing. Yet, I believe there is a place for Indigenous technological practices as a context-based mediating cultural tool for teaching and learning science. This study sought to surface this tension or dilemma or conflict, which is a manifestation of contradictions as espoused by Engeström (2001).

At the time of the study, I was a senior education officer for professional development in the region. I designed an intervention where I worked with the grade 11 chemistry teachers in the Okahandja circuit, focusing on investigating how Indigenous technological practices can be used to create empowerment spaces for teachers to develop positive dispositions towards what Mukwambo (2016) refers to as contextualised teaching and learning in science. Integrating Indigenous technological practices into science teaching seems to harness modern scientific knowledge for Indigenous technological advancement. In essence, I conducted a case study with grade 11 chemistry teachers and community members and developed exemplar lessons that integrated Indigenous technological practices. Three IK custodians demonstrated the traditional ways of extracting marula oil (*odjove*), which were intended to assist teachers in designing exemplar science lessons that integrated Indigenous technologies.

This intervention was subsequently used to guide and support the chemistry teachers in developing their own exemplar lessons that integrated Indigenous technological practices into other topics in science. Herein lies the importance of expansive learning in this study (Sannino et al., 2016). Expansive learning is developed when some individuals involved in a collective activity transform an activity system through the reconceptualisation of the object and the motive of the activity, embracing possibilities to learn and grow (Engeström, 2003). This is what proponents of cultural-historical activity theory (CHAT) believe: that contradictions perpetuate development.

1.3 My Personal and Professional Life Story – Does It Matter Who I Am in This Study?

As the author of this work, I situated myself in the study by sharing my life experiences and upbringing to enable the reader to understand how these experiences have shaped my worldview. I have been a physical science, life science, and biology teacher for eight years and a senior education officer for professional development for nine years. This experience has exposed me to the challenges that teachers and learners face in teaching and learning science.

I will begin by highlighting the tensions, dilemmas or conflicts in my childhood background and academic journey that prompted me to do this study. I am the third child born into a family of five (two girls and three boys). I grew up with my mother, aunts, grandparents, siblings, and other children in a rural area. Growing up with my grandmother and grandfather was something that I have always cherished. I remember my grandmother being multi-talented and skilled; she had excellent agricultural skills and was an expert at weaving baskets, making clay pots, designing clothes, making *ombike* with various dried fruits, making traditional drinks, and extracting oil from Indigenous seeds (Nyamakuti, 2021).

All such cultural practices are regarded as Indigenous technologies in this study. Her expertise benefited not only her household members but also the community at large. She used to teach us cultural practices, values, and traditions and imparted the importance of this knowledge being transmitted to the next generation (Kibirige & Van Rooyen, 2006). I am so proud of her and regard her as an IK Custodian. Thus, from a young age, I developed a passion for culture, and I learned many cultural practices from her through demonstrations and observations. To reflect on this, one can say that I became a culturally responsive individual (Haimene, 2023) at a very young age.

However, when I attended school, from the primary to the secondary level, teaching and learning were dominated by teacher-centred approaches. There was no consideration of our prior everyday knowledge (Kuhlane, 2011) or sociocultural background (Karabuz & Ogan-Bekiroglu, 2020; Mavuru & Ramnarain, 2020) during teaching and learning. Instead, teachers were regarded as the sole sources of knowledge and, in some cases, openly denigrated IK practices. I can say my experience was no different from other African children, such as Mutanho (2021) and Chinua Achebe (1986), whose experiences are neatly summed up in Simpson's (2014, p. 6) reflection when he said:

> 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 I used to like science subjects at school, there was no link between my cultural heritage and school science. I felt alienated because my cultural experiences were neglected, and teaching and learning were done according to the Western knowledge system. Mutanho (2021) calls this teaching science in a decontextualised manner. This resonates with Semali and Kincheloe (1999) and Mawere (2014), who argue that IK and Indigenous ways of knowing are not recognised. However, I cannot blame my teachers because, at that time, the curriculum was not yet transformed into being learner-centred and culturally responsive.

When I completed my secondary education, I was admitted to university and studied for a Diploma in Secondary School Science Education. Things changed for the better because, during our training, the concept of learner-centredness and learners' prior knowledge was introduced, and we were trained to acknowledge learners' prior knowledge (Mavhunga & Rollnick, 2013). However, no reference was made to prior everyday knowledge (Kuhlane, 2011), which could be in the form of IK (Liveve, 2022; Mutanho, 2021; Simasiku, 2022).

A few years later, I registered for an honours degree in science education at Rhodes University. This higher education institution introduced me to the integration of IK in science education, thereby boosting my cultural responsiveness in teaching. Therefore, when I started teaching, I always made a concerted effort to consider the learners' prior knowledge (Mavhunga & Rollnick,

2013) and cultural heritage. However, as I taught at different schools, I observed that most teachers were not culturally responsive in their teaching. That is, teachers seemed to struggle to integrate Indigenous technological practices into their teaching.

After eight years of teaching, I became a senior education officer responsible for teachers' professional development in the region. Through lesson observations and the regional teachers' needs assessments and analyses, it became clear that teachers' workshops were inadequate and inconsistent. In many cases, they did not achieve the intended outcomes. This sparked my interest in exploring ways of improving science education by integrating Indigenous technologies into teacher education.

In 2017 and 2018, I studied for a master's degree in science education at Rhodes University. I wanted to understand expansive shifts in teachers' understanding and practices after going through an intervention on the integration of local knowledge in grade 9 physical science lessons. With this intervention, we used local knowledge and easily accessible materials to teach the concept of neutralisation and testing the acidity and alkalinity of substances. Learners were interested and eager and participated actively in these lessons as they were familiar with the materials used by their local communities.

It appeared that both teachers and learners were amazed, and according to them, the practical activities conducted were all about technologies in teaching and learning. This developed my curiosity to understand how to support teachers to become culturally responsive and integrate Indigenous technologies when teaching science.

1.4 My Positionality and Reflexivity

Positionality speaks to how researchers locate themselves in research by acknowledging personal positions that have the potential to influence the research, considering how they view themselves and how others view them, and acknowledging that the research might be influenced by themselves and by the research context (Holmes, 2020). I am a researcher, and by profession, I am a senior education officer and hold a position of authority. My occupational role is to conduct teachers' professional needs analyses and liaise with different stakeholders to meet these needs. I, therefore, coordinate, organise and facilitate continuing professional development activities, like workshops for teachers, based on effective curriculum implementation, instructional methods, material development and the induction of novice teachers. In addition, I am a qualified science teacher and left teaching when I moved to the position of senior education officer. I was aware, therefore, that my position might influence the participants, and I considered how participants might perceive me.

This positionality created a conflict in my role in the study as I viewed myself as an insider and an outsider. I was an insider on one hand since I came from the same region as my participants. As science teachers, we shared the same interest in science education and the common goal of making science accessible to all learners. On the other hand, I saw myself as an outsider, as currently I am no longer teaching but involved in curriculum development and implementation. In Vygotskian terms, I could be called the more knowledgeable other since I am a PhD researcher and an education officer. This created a power gradient that needed to be resolved in my study.

To ameliorate this, I had to fall back on Ubuntu, firstly creating a friendly working environment based on the notion of mutual benefit. Thus, during the research process, I had to redefine and adjust my occupational role from a position of authority to a co-learner. This dissolved the power dynamics mentioned above and enabled me to create room for participants to freely lead discussions and take actions. I made it clear that in this study, I was a learner who wanted to learn something with them so that my position would not limit their contributions and that they should be free and honest. This made me a co-participant researcher and co-constructor of knowledge.

This is related to what Engeström (2011) emphasised when he noted that researchers should not introduce or propose concepts but rather create a condition for their emergence. At the beginning of my research journey, I was sceptical about how to go about this. However, the application of Ubuntu made life easy, and after the orientation workshop discussions, participants felt at ease and began to willingly lead discussions and share their learning experiences.

Furthermore, I viewed my context as an activity system of a professional learning community, positioning myself as a researcher and participant. I understood that in any given activity system, the community is likely to hold different views and divergent interests, which may give rise to tensions or dilemmas or conflicts that might manifest in contradictions (Engeström, 2001). During the workshop discussions, I adopted the CHAT framework to view, explain, and analyse these manifestations of contradictions as a potential source of change and transformation rather than a hindrance. I then promoted and guided expansive learning cycles for the participants. I observed that some tensions or conflicts emerged between activity system, such as between teachers within the school context and the IK custodians. This study believes that contradictions precipitate development.

For instance, during the presentation and workshop for Indigenous technological practices embedded in the cultural heritage of community members, slight tensions arose in the division of labour among the science teachers (as the learners) and the community members (as Indigenous technological practices experts and facilitators). Initially, community members felt that they were not qualified enough to be regarded as facilitators and teachers. My role as a formative interventionist researcher was based on the spirit of Ubuntu. Community members understand Ubuntu to mean that our success in education can be achieved if we value others by sharing views, experiences, knowledge, and expertise. I was, therefore, identifying tensions within the activity system and presenting them to participants for discussions and reflections, and in this way, a better understanding was achieved. As a result, the community members who are referred to as IK custodians in this study took full charge of facilitating the workshop presentations, and there was an even division of labour among themselves and the teachers.

I was also cognisant of the fact that my presence as a senior education officer in lesson observations and the community of practice participatory observations might lead teachers to think that I may report them to the education directorate. To ameliorate this and consistent with the Ubuntu philosophy, I humbled myself, positioning myself as a co-learner. I was conscious of power dynamics concerning the professional learning community, teachers, and learners. Even though creating and maintaining trust is a challenging exercise, the issue of honesty and trust came up as I worked with my participants openly and talked about the critical issues of positionality and ethics. In this regard, Islam et al. (2021) advocate the importance of the researcher having good communication skills and a virtuous attitude to maintain a research community based on complementary relationships and trust. This requires researchers to be reflexive (Holmes, 2020).

Reflexivity is central to a social learning approach, which involves continuously reflecting on what you have learnt and taking action to improve whatever you are doing because of that reflection (Cundill et al., 2014; Holmes, 2020). Moreover, reflexivity is critical since power relations between the researcher and participants are acknowledged as a potential factor that may influence the quality of the data generated (Greene, 2014; Merriam et al., 2001; Merriam & Tisdell, 2015).

Hence, in this study, reflections on actions were made throughout the research process. I used a reflexive approach to reflect introspectively on my values, thoughts, and actions and to modify (when necessary) them following the field of practice. At some stages, however, I experienced inconsistencies and dilemmas based on time constraints and the absence of some participants due to other important commitments. So, open discussions, trust, and reflections helped us greatly to re-strategise wisely without changing our research focus.

Like Haimene's study (2023), observations and reflections were made, and participants learned from one another while I led and directed the research activities. Reflexive knowledge was needed to deal with any complexities arising during the research process. Moreover, I played a role in developing a better understanding of social interactions and social structures within activity system and among participants, and in sharing with them their aspirations that the study may contribute to improving their practices. Participants were interested in the interactive development of collective transformative agency. Haapasaari et al. (2016) define transformative agency as a dynamic, long-lasting process of learning and development that evolves through interaction.

Notably, conflict and tension surfaced regarding the use of pseudonyms in this interventionist study. This brought issues of honesty and trust into focus, but I was open to talking about positionality and ethics. In terms of ethics and anonymity concerning African Indigenous culture, at first, I randomly coded my participants from TA up to TG. One of the participants was, necessarily, coded TB. Her reaction to the coding was very negative, as TB is the abbreviation for tuberculosis. She said:

> *Our culture taught us to be honest, we were and still are part of this research, for example, I was a translator and a critical friend and we are proud of all that we have done throughout the research process.*

TB questioned, "*Why should we hide our identities? Why can't we use our real names*?" It could be surmised that by making her voice heard, TB exhibited transformative agency (Sannino et al., 2016); something that is critical in interventionist studies.

As a result, we discussed and reflected on this issue, and the participants indicated they would be more comfortable using pseudonyms of their own choice or their real names, as they had contributed to the co-construction of knowledge in this study. Reflexive knowledge is needed to be able to deal with complexities that may arise during the research process. This study acknowledges that positionality, reflexivity, and ethical issues in education are complex and interrelated and that they should be considered as situational, relative, contextual, and dynamic. Therefore, mutual understanding between the researcher and the participants was needed to develop a flexible approach that could be adapted in a manner that both the researcher and the participants might benefit from.

The issue of randomly coding my participants from TA up to TG surfaced tension regarding the use of pseudonyms, which seems to be the dominant Eurocentric ethical protocol over marginalised Afrocentric ethical frameworks. This leads to several challenges in a diverse society. Eurocentric ethics often prioritise individualism, rigid objectivity, and universal applicability, which can overshadow the communal, relational, and context-specific ethics rooted in African traditions (Toendepi & Cele, 2024). This imbalance risks distorting the values and worldviews of African societies, erasing IK systems, and reinforcing historical inequalities. This research acknowledges that there is a significant danger in the ethical misrepresentation of African traditions and cultures. On the other hand, by using research frameworks that impose Eurocentric ethical protocols without considering Afrocentric values, Indigenous communities may be subjected to moral standards that conflict with their realities. This contributes to ethical imperialism, where Western ideals dictate what is regarded as acceptable, disregarding Indigenous ways of knowing, problem-solving, and moral reasoning (Miller, 2024).

In an inclusive ethical landscape, it is essential to challenge the dominance of Eurocentric ethical protocols and create space for Afrocentric perspectives. In this way, ethical frameworks should acknowledge the significance of African knowledge systems, community-based approaches, and culturally grounded moral principles (Battiste, 2011; Smith, 2012). By embracing Afrocentric ethics alongside Eurocentric perspectives, societies can foster more equitable and culturally relevant decision-making processes that respect the diversity of worldviews. The integration of Afrocentric ethics into global discussions on ethical governance, education, and research is not only necessary for justice but also enriches ethical discourse with diverse insights that strengthen social harmony and collective well-being.

This research was conducted in collaboration with community members, and I understood that the research participants' dignity factors, such as gender, culture, ethnicity, language, and welfare, were important. Blanche et al. (2014) stressed that researchers and the research methods used should be sensitive to the community's values, cultural traditions, and practices. The principles of Ubuntu helped me to humble myself during the research process. The initial expectation was that one female community member would facilitate the presentation; however, on the day, two females and one male facilitator and other community members contributed to the session. We were curious to meet the male facilitator since marula oil extraction is culturally believed to be a female activity. The male facilitator indicated that this is simply a cultural belief and that anyone can extract marula oil.

The research participants and I enabled humble togetherness by generating significant instructional methods for teaching and learning. The participants and the researcher were co-learners because none of us knew how to integrate Indigenous technological practices into science lessons. Even though I was a PhD scholar, I made it clear to the participants that I was not a more knowledgeable other but a co-learner. As I explained the ethics protocol and the participants' right to withdraw from the research at any time, the principle of humble togetherness manifested; the participants' views were that pulling out of the research would not sit well with their cultural norms and values. Individuals exist through community (Seehawer, 2018), and the aspects of caring, sympathising, and positively working with others strongly influenced participation in the research.

I was cognisant that the cultural heritage and Indigenous technological practices of marula oil extraction are intellectual property that must be protected, acknowledged, and cited the same way as other items, such as textbooks and question papers. I continuously reflected on my research context to see if there were any unveiled or potential risks to the participants. I explained the goals and objectives of the study to them. As the primary investigator, I was mindful of my position in that I served a dual role as both a senior to the teachers at the regional level and a researcher. I positioned myself as a co-learner in this study, in that I was doing this research *with* the participants rather than on them (Ngcoza & Southwood, 2015). I also used tools such as logbooks for field notes to support my reflexivity.

1.5 Statement of the Problem

For effective curriculum implementation to take place, teachers should be equipped with the necessary skills to support quality teaching and learning. In Namibia, the integration of IK (including Indigenous technological practices) and the use of easily accessible materials in science teaching and learning is a policy requirement stipulated in the national curriculum (Asheela et al., 2021; Hashondili, 2020; Ministry of Education, Arts & Culture, 2016; Neporo, 2022; Ndevahoma, 2019; Nikodemus, 2017; Shinana et al., 2021). To achieve this, teachers need to have the skills to develop and adapt materials to suit the multi-ability groups of learners found in most classrooms in Namibia. In this regard, Haapasaari et al. (2016) believe that in today's working life, employees need to be creative, present initiatives, and contribute to innovative solutions through critical reflection.

However, although the national curriculum encourages teachers to integrate learners' IK, it does not explicitly guide or support them on how to put this into practice. Moreover, the revised Namibian curriculum is silent on Indigenous technological practices, yet they are crucial components of the IK system. Technology is critical to implementing 21st-century courses, and curricula cannot function well without it (Mothowanaga & Gladwin, 2021). In my opinion, science teachers should be exposed not only to modern technologies or modern technological practices but also to Indigenous technological practices. Heugh et al. (2021) emphasise the notion of trans-knowledge pedagogy in their science lessons. That is, more professional learning communities are needed to expand and broaden the integration of Indigenous technologies in teaching and learning.

1.6 Rationale and Significance of the Study

The rationale of this study was to explore and establish an understanding of how the integration of Indigenous technological practices can support teachers in contributing to science teaching. In addition, the study wanted to establish whether professional learning communities can expand or constrain such integration. The research focused on exploring the food production and preservation technologies that constitute Indigenous technological practices and determining their role in science education. The research emphasised the integration of Indigenous technological practices that recognise and engage the learners' home cultural background practices, which seemed to localise the curriculum and contribute towards education for sustainable development.

The significance of this study, therefore, is that it might provide an opportunity for innovation in teaching and the modernisation of traditional technology; in this way, the technological advancement of Indigenous technological practices might be enhanced. As noted by Ngcoza and Southwood (2019), the study created an empowerment space for the teachers to shape their teaching practices towards equity and inclusive education that embraces both modern technological practices and Indigenous technological practices through collaboration and co-learning. Inclusive education is regarded as the best basic education approach to teaching and learning, as emphasised by the Namibian National Curriculum for Basic Education (Ministry of Education, Arts and Culture, 2016). Thus, the study improved my technical skills in how to run workshops for teachers, empowering them to ensure quality education through professional learning communities. It also enhanced teachers' creativity in co-developing learning and teaching support materials grounded in Indigenous technological practices.

The study further created a space of new knowledge in terms of new teaching and learning strategies and approaches to tapping into the cultural heritage of community members (Mutanho, 2021). In this way, Eurocentric and indigenised curricula were amalgamated. Integrating IK systems with Western knowledge might give students an "opportunity to compare and contrast different forms of knowledge for their good and that of the society of which they are part" (Mawere, 2015, p. 62). Seehawer and Breidlid (2021) refer to this as a 'dialogue between epistemologies', regarded as a critical and constructive interaction that allows knowledge to coexist, complement, contradict, or express itself without one knowledge dominating. This study is significant as it identified and sought to close the knowledge gap between the modern technological practice and indigenous technological practice knowledge systems. The study might also inform curriculum developers, implementers, textbook writers, and researchers to explore integrating more Indigenous technological practices into Namibian science teaching.

1.7 Research Goals and Questions

The goals of this study were to:

- Support grade 11 chemistry teachers in learning how to integrate Indigenous technological practices into science teaching and learning.

- Explore how the integration of Indigenous technological practices could contribute (or not) to science teaching and how professional learning communities could be expanded or constrained by such integration.

The following research questions were formulated as follows:

1. What were grade 11 chemistry teachers' pedagogical insights regarding integrating Indigenous technological practices into science teaching and what contradictions emerged?
2. What contradictions regarding the integration of Indigenous technological practices surfaced when grade 11 chemistry teachers co-analysed the curriculum documents and textbooks?
3. How did the practical demonstrations on traditional marula oil extraction by the Indigenous knowledge custodians enable and/or constrain the grade 11 chemistry teachers from becoming cultural knowledge brokers?
4. What expansive learning opportunities were created (or not) when the grade 11 chemistry teachers co-developed exemplar lessons that integrated traditional marula oil extraction and other Indigenous technological practices?
5. How did grade 11 chemistry teachers enact and reflect on the exemplar lessons which integrated traditional marula oil extraction and other Indigenous technological practices in their classrooms?

1.8 Theoretical and Analytical Framework

Engeström's CHAT informed the study as an overarching theoretical framework. In addition, Mavhunga and Rollnick's TSPCK was used as an analytical framework. I will now briefly discuss these below.

1.8.1 The cultural-historical activity theory

It is situated within the sociocultural theory (Vygotsky, 1978) and can be used to analyse complexities within and surrounding academic activities to achieve a specific object and outcome (Behrend, 2014). The CHAT framework is based on the relational interaction between human beings and their social environment. It acknowledges the significance of the social aspect of mediating learning and that individual or group interactions and actions are rooted in an activity social system. This study used the CHAT framework because it has components that fit well in examining cultural human activities (the indigenous technological practice of oil extraction), uncovering tensions and contradictions that may arise from the activity system and how they can influence spaces of learning.

In essence, CHAT views learning as a socially, culturally mediated, and historically connected process (Engeström, 2000, 2001) of interacting factors within activity systems. This suggests that teaching and learning are human activities. To explore and understand these better, CHAT can unpack how they are influenced by factors such as subjects, objects, rules, tools, community, and division of labour. In the context of my study, the *subjects* were grade 11 chemistry teachers; the *object* was the integration of the indigenous technological practice of marula oil extraction (*odjove*); the *tools* were the cultural teaching and learning support materials, language, symbols, and teaching strategies; the *rules* were the curriculum, policies, cultural norms and values; the *community* consisted of chemistry teachers, IK custodians, and education officers; and *division of labour* had to do with the different roles played by the community members.

Notably, CHAT has progressed through three generations that build upon one another (Nussbaumer, 2012). The first Engeström generation is grounded in the notion of individual subjects and actions within a certain context. It highlighted the importance of individual action within complex, dynamic, and contradictory relationships with collective action and the subject concerning its community, the rules that govern the activity, and the division of labour among the various actors intersecting with the subject (Isaacs, 2019). The second generation is a collective activity that Engeström (2001) viewed as a human activity system of complex interacting factors such as subjects, objects, mediating tools, rules, community, and division of labour.

This second generation is not flexible to outside factors influencing the activity of the system. The third generation encompasses numerous activities in a system that look at how people, communities, historical contexts, and interactions develop a social activity network of the system with common objects and contradictions (Engeström, 1987, 2001). Engeström's second generation of activity theory builds on Vygotsky's original concept of mediated action and Leont'ev's work on collective activity. This generation introduces the concept of an activity system which includes multiple components such as the subject, object, tools, rules, community, and division of labour (Engeström, 1987). The activity system model emphasises the interactions between these components and how they collectively influence human behaviour and learning. The second generation acknowledges the sociohistorical context of activities and the importance of understanding the broader environment in which activities occur.

The third generation acknowledges that human activities are influenced by multiple interacting activity systems for a common goal or object, in this case, teaching science. The third generation of activity theory, developed by Engeström, extends the second generation by focusing on the interactions between multiple activity systems. This generation introduces the concept of "runaway objects," which are complex, dynamic objects that extend beyond the control of individual actors or groups. The third generation emphasises the importance of understanding the interconnectedness of different activity systems and how contradictions and tensions within and between these systems drive expansive learning and innovation (Engeström, 2001). This approach aims to provide a more comprehensive understanding of the contextualised relationship between individuals and their environment.

In this study, CHAT provided the theoretical framework from which the language of description and the analysis tools were drawn (Mutanho, 2021). CHAT was complemented with pedagogical content knowledge (PCK), which speaks to pedagogical issues, content knowledge, curriculum salience and learners' prior knowledge (Mavhunga & Rollnick, 2013).

1.8.2 Topic-specific pedagogical content knowledge

Shulman (1986), a psychologist and scholar of teacher education, developed the notion of PCK as a response to what he saw as a challenging discrepancy between knowledge of the subject and knowledge of teaching and education. Shulman (1987) maintained that effective teachers' education should include a set of strategies to deliver it. He then created the third domain of knowledge, which has to do with strategies for teaching a particular subject based on how learners view the subject, why some topics are easy or difficult, and how to structure the topics so that students can make sense of what is taught. He stressed that when subject content knowledge and pedagogy are joined, they create a knowledge space called PCK. Concurring, du Plessis and Muzaffar (2010) referred to this as 'teaching within a pedagogical milieu'.

With PCK, teachers can interpret the subject matter and use different strategies to present and make it understandable to learners. In the context of my study, it is hoped that the teachers might be able to understand the integration of Indigenous technological practices into their science teaching. However, PCK is not adequate to be used as an analytical tool on its own; as Widodo (2017) suggested, PCK is more focused on how subject knowledge can be enhanced pedagogically to ensure better understanding for the learners. In other words, PCK does not directly link the learners' learning as it is viewed and focuses more on the teachers' perspective. One of the criticisms of PCK is that it is not a learning theory (Kind, 2009) but rather a teaching theory. Scholars such as Park and Chen (2012) and Geddis and Wood (1997) established a version of understanding that PCK is topic-specific and includes components such as learners' prior knowledge, curricular saliency, what makes a topic easy or difficult to understand, representations, and conceptual teaching strategies. Mavhunga and Rollnick (2013) and Mavhunga et al. (2016) acknowledged, extended, and adapted the seminal work of Park and Chen (2012) and Geddis and Wood (1997) in stating that PCK should be topic-specific since teachers cannot use the same teaching strategies for different lessons in their teaching. Hence, they created the concept of TSPCK (Mavhunga & Rollnick, 2013) and the refined consensus model of PCK.

1.9 Definition of Key Concepts

Below are some of the key concepts used in the thesis.

Cultural knowledge brokerage

Cultural brokers are the individuals who bridge the cultural gap and navigate between people of different cultural groups or with different cultural systems. Cultural brokerage could serve as a potential teacher professional development tool to foster reciprocal learning across cultural borders (Lai et al., 2019; Simasiku, 2022; Wyatt et al., 2017). A brokerage lens could be used to examine how multicultural schools contribute to the creative performance of culturally diverse teams (Levy et al., 2019). This study acknowledges cultural brokerage as a mediating tool for indigenous technological practice integration in a multicultural setting.

Culturally responsive teaching

In this study, culturally responsive teaching is an inclusive approach that uses learners' sociocultural experiences as a tool for effective teaching and learning. A culturally responsive teacher embraces the learners' cultural knowledge of the learners and acknowledges that there are multiple ways of knowing. It enables teachers to contextualise the teaching content by acknowledging the learners' cultural capital and supporting the learners intellectually. A culturally responsive teacher has a critical understanding of how their learners' cultural backgrounds impact their education. Culturally responsive teaching is also referred to as 'culturally congruent teaching', 'culturally appropriate teaching', and 'culturally sustaining pedagogy' (Gay, 2018; Haimene, 2023; Hernandez & Burrows, 2021). In this study, the indigenous technological practice integration of marula oil extraction into grade 11 chemistry teaching is a culturally responsive teaching method viewed as a critical approach to inclusive quality teaching and learning.

Expansive learning

This is initiated when some individuals involved in a collective activity take the action of transforming an activity system through the reconceptualisation of the object and the motive of activity, embracing a radically wider horizon of possibilities than in the previous activity mode (Engeström, 2003). Expansive learning involves creating new knowledge and new practices for a newly emerging activity, that is, learning embedded in and constitutive of the qualitative transformation of the entire activity system.

Indigenous knowledge

This is the term given to the form of knowledge that seems more prominent in traditional societies, not documented, and passed on from generation to generation. It is context-specific knowledge that communities have developed over centuries that has allowed them to live in their environment, often for long periods. Also referred to as 'local' knowledge, IK is a set of perceptions, information and behaviours that guide local community members in how best to use their natural resources (Ngulube, 2016).

Indigenous technological practices

These practices refer to the technological knowledge and skills transmitted from past Indigenous people to the present generation to meet their needs and wants through investigating, designing, and developing products. One example of Indigenous technologies in action today can be witnessed in the different approaches to medicine.

Modern technological practices

Modern technological practices are types of technology that allow machinery to become more complex to make the work easier. It is the advancement of old technology with new additions and modifications. These practices use multifunctional devices such as smartphones, smart watches, computers, televisions, and robots. Modern educational technology can provide virtual attendance, live chat, and classroom presentations to computers through text, audio, or video to educate the learners.

Professional learning community

Professional learning communities are groups that work on improving their work practices and processes on an ongoing basis, with the notion that there is always a way to deliver a better outcome. In a professional learning community, the focus is on the outcome of the desired results. Members judge the community's effectiveness based on shared objectives. The members of professional learning communities work together to research and bring in new ideas and strategies. In this study, the professional learning community – consisting of the IK custodians, the grade 11 chemistry teachers, and me – was a social platform where we learned from one another to improve the quality of teaching and learning. These professional learning communities help educators have a constructive dialogue based on shared norms, beliefs, and values that allow teachers to analyse individual and collective performances. My study also allowed teachers to share, observe, and discuss each other's practices and approaches.

Transformative agency

Transformative agency is a critical phase for the creation of new ideas in the changing world of work that requires collective activity, outside support and recognition of the development outcomes (Kerosuo, 2017). The concept of transformative agency contains three necessary elements, namely a situation of contradictory motives, the construction of an auxiliary stimulus means and practical action to transform the situation with the help of the auxiliary stimulus means (Engeström & Sannino, 2020). In this study, transformative agency co-develops with the development of new work practices through learning. The development of agency is actively taken up by everyone (Stetsenko, 2019). In the change laboratory, although the researchers encouraged everyone to actively participate in the discussion, there were still differences in individual participation.

Transformative learning

This is an experience that causes a shift in an individual's perspective or attitude because of constructive meaning; the shift comes from deep and constructive learning, or it results in deep and constructive meaning. Transformative learning is used by students and others to improve learning. It is based on a learning theory propounded by Mezirow (1978, 1991, 2000) and proposes that learning is the process of making new interpretations based on the meaning derived from the experience. This means that rather than focusing on surface experiences, transformative learning challenges the simplicity behind learning. Transformative learning supports the critical ways through which learners consciously make meaning of their lives, beyond just learning a concept and leaving it at that.

Two-eyed-seeing

This is the educational, holistic approach of bringing together the strengths of Indigenous and Western knowledge to benefit two different parties. In this study, two-eyed seeing is regarded as a legitimate decolonial approach to the teaching and learning of science, whereby both Indigenous technologies and modern technologies are viewed as equally important. The two-eyed-seeing approach values collective over individual action and collaborative learning or co-learning (Bartlett et al., 2012). In this study, two-eyed-seeing is used to create space for both Indigenous ways of knowing and Western ways of knowing to come together to enhance effective teaching and learning (Seehawer & Breidlid, 2021; Smith, 2020).

Two-ways -thinking

This approach to science teaching and learning believes that there are two ways of knowing and learning. In this study, these are regarded as Indigenous and Western ways of knowing. Indigenous ways of knowing and learning can be included in the science curriculum (Michie et al., 2018, 2021, 2023). The two-ways-thinking approach to education is used to bring Namibian Indigenous cultural practices, traditional knowledge, and Western science together to teach science.

1.10 Thesis Outline

This thesis contains nine chapters that are delineated as follows.

Chapter One

This chapter focused on situating the study. It introduced the contextual background of the research, the significance of the study, the research gaps, and the opportunities to contribute new knowledge. It presented the issues of ethics, positionality, and reflexivity, focusing on the ethical issues that emerged during the research study. It also presented the research questions, introduced the theories that guided the study, and provided brief presentations on the key concepts used in the study.

Chapter Two

This chapter presents a literature review on aspects of Indigenous technologies. The chapter starts with discussions on Indigenous technological practices and modern technological practices before moving on to perspectives on educational technologies and curriculum, approaches and challenges to integrating Indigenous technological practices into teaching, and the professional development of teachers in Namibia.

Chapter Three

Chapter Three discusses the theoretical framework and presents the theoretical lenses that informed the study, namely, Engeström's CHAT and Mavhunga and Rollnick's TSPCK.

Chapter Four

The chapter discusses the research methodology employed in this study, the paradigm, and the research design. The chapter describes the transformative and Indigenous research paradigms used in the study. Within the Indigenous research paradigm, the Ubuntu perspective was followed. The chapter also presents the data collection tools that were used in this research, which were semi-structured interviews, workshop discussions, document analysis, observations, stimulated recall interviews, and reflections. It concludes with discussions on the validity and trustworthiness of the study.

Chapter Five

This chapter focuses on the data gathered from semi-structured interviews during the pre-intervention phase that looked at grade 11 chemistry teachers' pedagogical insights on the integration of Indigenous technological practices in science teaching. The chapter reflects on how this constituted mirror data (Engeström, 2001), which informed our change laboratory workshops.

Chapter Six

Chapter Six looks at the data gathered from the orientation workshop and document analysis focused on orienting participants. In the workshop, we looked at what lessons grade 11 chemistry teachers could learn (or not) through co-analysing curriculum documents.

Chapter Seven

Data gathered from community presentations during the intervention and expansion phase is the focus of Chapter Seven. This data presented the idea of tapping into community expertise to determine what expansive learning spaces were created for grade 11 chemistry teachers during the presentations by IK custodians on the technological practice of oil extraction. The chapter also looks at participatory learning, observations, and reflections.

Chapter Eight

Chapter Eight concentrates on the data gathered from co-lesson planning, classroom observations and reflections during the implementation and post-intervention phases. The chapter shows how grade 11 chemistry teachers co-developed exemplar lessons that integrated the indigenous technological practice of oil production and other Indigenous practices. It also examines how grade 11 chemistry teachers mediated the learning of exemplar lessons that integrated Indigenous technological practices into their classrooms.

Chapter Nine

This chapter summarises the findings and recommendations, and a conclusion to the study. It also looks at the reflective spaces, the new knowledge created by the study and the challenges encountered.

1.11 Chapter Summary

In this chapter, I positioned my study by looking at the Namibian context of Indigenous technologies. It started with a brief overview of the Namibian broad national curriculum (Ministry of Education, Arts and Culture, 2016) and what it says about educational technologies. It then provided the views of different scholars regarding modern and Indigenous epistemological ways of knowing. As the author of this work, in this chapter, I situated myself in the study by sharing my life experiences and upbringing to enable the reader to understand how these experiences have shaped my worldview. The chapter also discussed my positionality and reflexivity as the researcher, the statement of the problem, the significance of the study, the definition of the key terms and an outline of the thesis. The next chapter describes the literature review relevant to my study on integrating Indigenous technological practices into science lessons.

CHAPTER TWO: LITERATURE SYNTHESIS

> Teachers who serve diverse students must navigate two 'worlds'. One world is that of standardized curricula and pedagogy and the other is culturally relevant education. To effectively navigate these worlds, teachers need assistance from 'cultural brokers'. This can be done by employing cultural expertise whereby a cultural broker uses his or her experience to facilitate or broker change. With culturally relevant pedagogy, power is more evenly distributed across the classroom, the teacher is viewed as a constructor of knowledge, and the curriculum is modified to help make links to students' backgrounds and establish relevancy. (Wyatt et al., 2017, p. 96)

2.1 Introduction

Literature synthesis is a discussion of important research previously done in the research field, whereby every piece of research should relate to research that has come before it (Bertram & Christiansen, 2020). In this chapter, firstly, I discuss the Indigenous technologies used in marula oil extraction and some possible topics in the Namibian science curriculum where the lessons can be mediated concerning the traditional extraction of marula oil. Secondly, I discuss the perspectives of educational technologies, indigenous technological practice integration and curriculum, and approaches to integrating Indigenous technologies. Finally, the chapter looks at the challenges of integrating Indigenous technological practices, the nature of professional development in Namibia, and professional learning communities.

2.2 Indigenous Technological Practice of Marula Oil Extraction

Marula oil is derived from the kernels of the marula tree (*Sclerocarya birrea*), native to sub-Saharan Africa. The extraction and processing of this oil involve several careful steps to preserve its beneficial properties. Cheikhyoussef (2018) stated that Namibia has a rich biodiversity of plant species, of which a great variety is used for food, cosmetics and medicinal applications, and the knowledge of the quality and composition of these oils can be used in value-added product development strategies and improved marketing of Indigenous resources. Marula oil is a Southern African Indigenous oil extracted from the nuts inside the marula tree seeds. It is a pure natural oil commonly used as a delicacy in northern Namibia and is honoured and treated as a symbol of respect for guests. It is scientifically proven that marula oil is rich in amino acids, vitamins and minerals for good nutrition and healthy skin and eyes. Marula oil is called '*odjove*' in Oshiwambo. The marula tree is locally known as Omugongo in Oshiwambo and is of great social, cultural and economic importance to the rural communities of southern Africa and, in particular, to the Aawambo communities in the northern part of Namibia (Nyamakuti, 2021).

Harvesting and processing of marula fruits, juice and oil involve a series of technological processes. For instance, marula fruits are traditionally harvested manually by local communities, who collect the ripe fruits after they fall from wild-growing trees. The outer flesh is removed through traditional labour and is often consumed locally or used in the production of beverages and jams (Hlangwani et al., 2023; Tapiwa, 2019). According to this study, this is a simple technology, but one that is highly labour intensive.

Oil extraction involves Indigenous technological methods of cold pressing, which Hlangwani et al. (2023) explain as a mechanical extraction process that involves applying pressure to the kernels without using heat or chemicals, preserved to ensure the oil's natural properties and bioactive compounds. In this study, cold pressing is regarded as an Indigenous intermediate technological method used for producing high-quality marula oil.

In many developing countries, seed oils are replacing animal fats because of health concerns and costs. In Namibia, marula oil is traditionally made in households, and a few small enterprises produce the cold-pressed version. It is very popular in the international community for use in cosmetic formulations. The oil possesses quality characteristics, making it suitable for food and cosmetic applications. Marula oil holds great economic importance for Namibia and can be an asset for development to improve the livelihoods of local communities and support food security initiatives. In line with this, Cheikhyoussef (2018) noted that seed oil production from Indigenous sources has economic importance for Namibia and is an asset for improving the livelihoods of local communities (Thompson & Scoones, 2009).

This is supported by Hlangwani et al. (2023), who alluded that marula oil production emphasises sustainability and community empowerment through initiatives focusing on wild-harvesting methods that do not disrupt local epistemology and involve rural communities, particularly women, in the supply chain. This study acknowledged, therefore, that the cultural practices of marula oil extraction not only ensured a sustainable supply of marula oil but also contributed to the economic upliftment and livelihoods of these communities (Thompson & Scoones, 2009).

Essentially, some locally produced vegetable oils, like refined marula cooking oil, are regarded as healthier as they are cholesterol-free and unsaturated. Similarly, Elijah et al. (2012) indicate that marula oil is 10 times more stable in lipid oxidation than olive oil. Concurring, Mashau et al. (2022) add that marula oil possesses a high amount of mono-unsaturated oleic acid, which can be beneficial in substituting sunflower oil in biodiesel production. Moreover, marula oil is also used in manufacturing various medicines and cosmetic and skin care products due to its chemical stability and slow oxidising effect. Building upon these insights, the integration of Indigenous technology in marula oil extraction holds significant relevance. Traditional extraction methods, deeply rooted in IK systems, provide an opportunity to harness the oil's benefits in a manner that is both efficient and culturally sustainable. By aligning modern processing techniques with indigenous practices, this study bridges scientific advancements with centuries-old wisdom, ensuring that marula oil production not only meets commercial and industrial needs but also preserves ecological balance and community livelihoods. Ultimately, this exploration enhances the discourse on the value of IK in technological development, showcasing marula oil as a prime example of how local expertise can shape global industries. Emphasising the fusion of tradition and innovation is essential in supporting the broader integration of Indigenous technologies in sustainable development frameworks.

The Indigenous Technological Practice of traditional marula oil extraction has the potential to be used in science teaching and learning of concepts such as oil production, refinery, chemical reactions, and experimental techniques in organic chemistry. Hence, this study recognises that the marula oil extraction process involves Indigenous technological practices and experimental techniques that involve scientific concepts and skills such as using appropriate apparatus to separate mixtures and purify substances, measuring the rate of chemical reactions, identifying chemical and physical changes, and applying collision theory.

2.3 Chemical Reactions

Ensuring the extraction of marula oil's quality includes consistent observing of physical and chemical properties including fatty acid profiles and antioxidant levels (Shoko et al., 2018). There are chemical reactions involved in marula oil extraction. A chemical reaction in the context of traditional marula oil extraction refers to the process where the chemical composition of the marula kernels is altered to release the oil through application of heat and mechanical pressure (Gandure & Ketlogetswe, 2011). This can be useful as some learners seem to face challenges in understanding chemical reactions.

Owusu et al. (2024) observed that some learners face significant challenges in understanding the concept of chemical reactions in science subjects and struggle to understand the abstract nature of chemical reactions. Perhaps the lack of relatable teaching methods can be a contributing factor because traditional teaching methods may not always connect chemical reactions to real-life contexts. This may make it harder for students to relate to and understand the material. Incorporating interactive demonstrations and relatable examples can enhance comprehension (Timilsena et al., 2022). It seems like traditional teaching methods that rely heavily on rote memorisation rather than conceptual understanding (Mavhunga & Rollnick, 2013) can further hinder learners' ability to grasp these concepts.

Tilahun and Tirfu (2016) pointed out that the main factors that are attributed to the learning difficulties faced by learners in chemistry include: the absence of equipped laboratories and practical workstations that support theoretical lessons; the absence of teaching and learning resources; poor teaching and learning strategies, and so on. One could say that perhaps teachers should use visual aids like models, locally available materials (Asheela et al., 2021; Shinana et al., 2021), and PowerPoint presentations. The education offices at the district level and other stakeholders should try their best to provide laboratories with appropriate chemicals, apparatuses, and human resources.

There is also a need to capacitate chemistry teachers using additional on-the-job and long-term training. Although learning difficulties can be influenced by the lack of modern resources, this study critically argues for the integration of Indigenous technologies as tools for curriculum and pedagogical transformation brought about by colonial influences. Indigenous teaching approaches should therefore not always be confined to physical laboratories. Instead, IK custodians can flexibly contribute to teaching either within their residential area, where teachers and the learners can visit them or be invited to places, such as schools, during functions like educational conferences, or to support and enable teachers to relate IK to scientific concepts.

Evidence of the challenges faced by learners in their understanding of the concepts within chemical reactions was revealed in the Namibia Senior Secondary Certificate Ordinary grade 11 chemistry examiners' reports. For instance, the Namibia Senior Secondary Certificate Ordinary National Examiners' Report (Ministry of Education, 2020, p. 96) revealed that many learners were merely "describing factors that affect the rates of reactions in general form theory without contextualising this to the given chemicals, apparatus and additional guidance".

In addition, the Namibia Senior Secondary Certificate Ordinary national examiner's report (Ministry of Education, 2021, p. 88) noted that many candidates demonstrated "a lack of exposure to practical activities and that there is a need for greater emphasis on assessment objectives and making experiments part of teaching and learning to expose learners to practical activities and reinforce practical skills and abilities". To address this problem, the Namibia Senior Secondary Certificate Ordinary (Ministry of Education, 2021) recommended that teachers be encouraged to use easily accessible and locally available materials to conduct practical activities in the classrooms (Asheela et al., 2021; Shinana et al., 2021).

Against this backdrop, this study regards the indigenous technological practice of marula oil extraction as a cultural mediational tool that can be used to capacitate teachers to enhance teaching using experimental techniques. Moreover, it can be used as easily accessible and locally available material to conduct hands-on practical activities in their teaching. This can be done through professional development grounded in community cultural heritage. Experimental techniques provide a simple and engaging framework for familiarising learners with agriculture, production, pottery, medicine, metalwork, arts, painting, and many other topics (Kamba, 2016). For instance, before the African colonial era, Indigenous technological practices were well-practised in local epistemology (Akpomuvie, 2011).

However, with the influx of modern technology, Indigenous technological practices seem to have been relegated to the ancient past. As a result, Ezenagu (2014) and Hodson (2009) were concerned and recommended that traditional knowledge that constitutes technology should be taught as science. It seems there is a domination of and preference for modern technology and modern technological practices over indigenous technological practices, which seem to have been downgraded due to globalisation and modernisation in developed countries.

Admittedly, modern industries and technologies have eroded Indigenous technological practices. Yet, by critically analysing the facts regarding industrialisation, one can argue that modern technologies are an offshoot of traditional technologies. As a result, some discoveries of Indigenous technological practices, for instance, iron smelting (Kudumo & Ngcoza, 2023) and others, have been abandoned in some societies because of an overreliance on modern technology. Moreover, the exclusion of IK in curricula has excluded art, history, economics, religion and many other domains of knowledge (Cobern & Loving, 2001).

In this study, technology is being described as science, and there is an acknowledgement that there are ongoing debates among scholars based on the difference between science and technology. Due to the practical nature of IK, this study claims that some Indigenous cultural practices have technological components as well. For instance, Gumbo's (2020) work entertains this debate so much that he coins the term 'Teknowledge'. Perhaps this is because of different perspectives and views on IK and technologies.

2.4 Perspectives on Educational Technologies

Based on cultural perspectives, there is a sociocultural role of technology in education. Gumbo (2023) examines the integration of IK systems into technology education curricula; he thus critiques the dominance of Western paradigms in educational frameworks and advocates for the mobilisation of Indigenous technologies to create a more inclusive and representative curriculum. Moreover, Gumbo emphasises that integrating Indigenous perspectives not only enriches the learning experience for Indigenous learners but also broadens the understanding of technology for all learners. He proposes a reconceptualisation of technology education that values and integrates diverse cultural insights, thereby fostering a more holistic and equitable educational environment. It is acknowledged, however, that to achieve this, one should be able to understand the concept of Indigenous technologies.

Humphrey (2006) defined Indigenous technological practices as the inventions of humans that have allowed us to survive and enabled our culture to advance. Similarly, Munabete and Umar (2014) viewed Indigenous technological practices as anything designed, fabricated, adopted, and used in an environment to advance the people of that environment. Thus, these scholars defined technology as the scientific application of knowledge, skills, and resources to meet the needs and aspirations of the people. In this study, technology is regarded as any human effort that improves the standard of living to make people's lives easier.

In contrast, however, the educational perspective of modern technologies seems to look at achieving quality education using aspects such as computer information, electronic telecommunication and data storage and thereby providing a good platform for integrating other teaching methods (Lei, 2017). This relates to providing quality education using devices like computers, Information and communication technology, and other digital devices that can be used to enhance teaching and learning. In a similar vein, the educational perspective of Indigenous technological practices is all-inclusive. The Indigenous technology knowledge system covers technologies and their associated practices that have been and are still being used by Indigenous people for existence, survival, and adaptation in and to a variety of environments (Ankiewicz, 2016). Hamilton-Ekeke and Dorgu (2015) explain that Indigenous technological practices evolve from a people's traditions and cultural milieu. It simply means sciences that are locally developed in harmony with culture to meet the needs of people.

These debates triggered Gumbo (2018) to explore the imminent confusion between technology education and other fields like science. His findings revealed that there is a lack of a clear definition of technology education, which leads to misunderstandings among teachers, learners, and policymakers. Gumbo further highlighted that technology education often overlaps with other subjects such as Science, Mathematics, and Engineering, confusing its unique identity. Additionally, this is exacerbated by the fact that the design of the curriculum for technology education is often not well-aligned, leading to a mismatch between what is taught and what is intended to be taught.

There is inadequate professional development for teachers in Indigenous technology integration, and this may contribute to the misunderstanding and misrepresentation of IK, science and technology. There is a need, therefore, for a more precise definition of technology to have a better curriculum design for Indigenous technology in education, improved teacher professional development, and a shift in perception to address the misunderstanding of technology in education.

This study adapts the concept of Indigenous technologies and refers to them as Indigenous technological practices, while modern technologies will be referred to as modern technological practices. The Indigenous technological practices use technological skills and knowledge transmitted from one generation to the next within specific cultural contexts so that people can satisfy their needs and wants. According to Native American Silver Buffalo (2013), Indigenous technological practices emerge from the implicit to reflect the art of pragmatic, skilful living, which attracts a continuous learning spirit. Parents or elders are key foundations of Indigenous technological practices, as they are skilled and educate or transfer knowledge to their children through what Klein (2011) refers to as traditional life skills.

The primary goal for parents is to educate their children and equip them with the basic knowledge of how the essential tasks of life are carried out (Akpomuvie, 2011).

2.5 Indigenous Technological Practices and Indigenous Knowledge

Indigenous technological practices and IK are closely linked, and there is no way one can comprehend one without the other (Munabete & Umar, 2014). In addition, Indigenous technological practices cannot be separated from IK, as it is the umbrella under which all Indigenous technological practices are situated. In this thesis, IK and Indigenous technological practices are used interchangeably.

Shapi et al. (2012) researched IK in the Namibian context and found that Indigenous technological practices contribute significantly to household security, being the main sources of daily income and livelihoods (Thompson & Scoones, 2009). Furthermore, the findings of their study revealed that Indigenous technological practices, such as pottery (Mateus & Ngcoza, 2019), leather products, medicinal plants, making blankets, and the making of [3]*oshikundu*, [4]*ombike* and fermented milk are valued and have the potential to be carried out at an industrial level. In other words, Indigenous technological practices should be considered for integration into curricula, industrial processes, and the development of locally value-added products. Moreover, Hamilton-Ekeke and Dorgu (2015) suggested that it is imperative to integrate IK in the school curricula to ensure that local Indigenous technologies are improved to enhance the modernisation of society.

[3] *Oshikundu* is non-alcoholic beverage made from mahangu and ongudo.

[4] *Ombike*, also known as 'wambo liquor', 'kashipembe', or 'owalende', is a home-made, traditional gin extracted from different Indigenous fruits, such as palm fruits, eenyandi, wild berries, and dried bird plums, through the process of distillation. Ombike is popularly made in the northern parts of Namibia.

Furthermore, some studies of in-service teacher education that are linked to the integration of IK are engaged (Ajani & Gamede, 2021; Yip & Chakma, 2024). For instance, Jautse et al. (2016) reported on how the North-West University researched material IK resources from the Mphebatho Museum to address the need to enhance teacher knowledge about the IK system. The rationale for this study was to enable learners to use IK in society and the environment. However, the successful enactment of this policy was hindered by inadequate teacher education, among other things, and this has implications for teacher education programmes at universities (De Beer, 2016; Jautse et al., 2016). Findings revealed a sharp interest among teachers to learn about diverse cultures, and an increasing awareness among them about the need to integrate IK into the science education curriculum. Extending on Aikenhead and Jegede's (1999) seminal work, Jautse et al. (2016) referred to epistemological border crossing. In relation to this, the Namibian National Curriculum for Basic Education (Ministry of Education, Arts and Culture, 2016) oversees the transformation of education into a knowledge-based society and states that Namibian education considers locally embedded knowledge and innovation fundamental in the curriculum.

2.6 Indigenous Technological Practices Integration and Curriculum

Integrating Indigenous technological practices can advance teachers' content knowledge. Gumbo (2016) recognised that such integration provides a wider understanding of technology and access to technological resources, enriches the curriculum and indigenous technological practice applications, and identifies local technologists. Gumbo (2016) further understands that knowledge is co-created and community-owned rather than individualised, with elders being the custodians of such knowledge they possess the richness of Indigenous. This study recognised that integrating Indigenous technological practices into the curriculum is a good pedagogical approach that recognises culture, whereby community participatory teaching can be adapted. This is referred to by Mhakure and Otulaja (2017) and other scholars as culturally responsive pedagogy in teaching and learning (Haimene, 2023).

To achieve this, professional learning communities can be leveraged to embrace culturally responsive pedagogy, where a potential space of learning and interaction is created (Ngcoza & Southwood, 2019). It is believed to bring about benefits such as promoting knowledge application from everyday life and may help learners make sense of concepts and enhance learners' active participation. This study acknowledges that integrating IK into teaching is not an easy task and will have its challenges. As Seehawer (2018) indicated, one should consider asking questions like, how can teachers be expected to integrate IK if teacher education does not prepare them to do so; if there are no teaching resources available; if IK is hardly specified in the curriculum; and if teachers do not necessarily have IK themselves?

Seehawer (2018) discovered that what hinders teachers from integrating IK is a curriculum structure that lacks clear guidelines on IK integration, a lack of access to a variety of IK and cultural practices, and a clash between Christianity and the spiritual aspects of IK. To overcome the challenges associated with integrating IK, Seehawer (2018) further recommended that teachers reflect on what kind of IK to integrate into a chosen topic, identify the purpose of integrating IK, and determine the possible benefits that learners could gain from the lesson. Likewise, Mpofu (2016) argued that integrating IK encompasses complexities arising from two different knowledge systems, in the sense that the integration process of IK into schools has been very slow because of a lack of curriculum frameworks to guide teachers on what to teach. In addition, Mpofu (2016) felt that to teach this knowledge in the Western syllabi, knowing how to access this knowledge from the community is a challenge, and, hence, it is argued that science teachers are in dire need of guidelines and training.

2.7 Challenges in Integrating Indigenous Technological Practices

Some challenges to indigenous technological practice integration are based on teachers' attitudes and pedagogical knowledge (Shizha, 2007). Some teachers and parents seem to underrate IK as it is not documented, but instead, they rely on documented information as legitimate knowledge and prescribed scientific knowledge. Teachers' opposition to integration of IK in South Africa can be attributed to the fact that teachers have been trained in Western science and henceforth are more acquainted with that worldview than that of indigenous knowledge systems, while the new curriculum requires new instructional approaches in terms of contextualisation and indigenisation (Mutanho, 2021; Ogunniyi, 2007a).

Notwithstanding this, Gumbo (2016) recommended that teachers should show interest in Indigenous technological practices to accommodate learners' funds of knowledge, build relationships and interact with the community and elders to exchange funds of knowledge and wisdom (Lee et al., 2012; Shinana et al., 2021). Furthermore, Kazhila (2015) noted the shortcomings as the lack of documentation, the non-scientific nature of IK, and the diverse sociocultural backgrounds (Mavuru & Ramnarain, 2020) of learners and teachers. To overcome this, a paradigm shift is needed so that Namibian higher education institutions can indigenise the existing curricula or implement new IK degree programmes and courses (Mutanho, 2021).

However, Gumbo (2020) raised a concern about ‘poorly resourced’ schools in terms of tools, equipment, consumable materials, and curriculum materials. This is a transformative approach that can help teachers to be technology-oriented and stakeholders in education, and scholars to think differently about teaching Technology in ‘poorly resourced’ contexts. In this study, the notion of ‘resource sensitive teaching’ or ‘culturally responsive teaching’ approach is advocated. It is important to advance this line of thought to make Technology teachable in such contexts. A teaching framework, some teaching ideas, content, and an example of a lesson are offered ultimately in this thesis. These contexts may be erroneously perceived as poor, but it is a matter of thinking about how to tap into locally available resources in such contexts to make the teaching of Technology possible, vibrant, and relevant.

2.8 Approaches to Indigenous Technological Practices Integration

Shizha (2012) mentioned that teachers like to teach empirical scientific knowledge to learners and that this knowledge is usually predetermined. In contrast, integrating IK is not predetermined, nor are teachers given proper guidance; therefore, they find it difficult to teach. The epigraph at the beginning of this chapter states that “teachers who serve diverse students must navigate two ‘worlds’”; this study acknowledges the integration of indigenous technological practice through an inclusive and overlapping perspective of integration into the science curriculum. Steenkamp et al. (2019) understood that the inclusive perspective regards IK as part of science, whereby certain tenets are shared by both the Indigenous and the science domains, which eases the epistemological border crossing in the science curriculum. Overlapping perspectives is the view that understands that there is an overlap between the IK and the science domain to bridge the gap between science and IK (Zinyeka et al., 2016). Taylor and Cameron (2016) considered that the difference between the two types of knowledge domains is important in understanding the uniqueness of each knowledge domain. In a practical sense, this approach would mean that the focus in the classroom would be on the shared tenets of the two domains, shown in Figure 2.1 below:

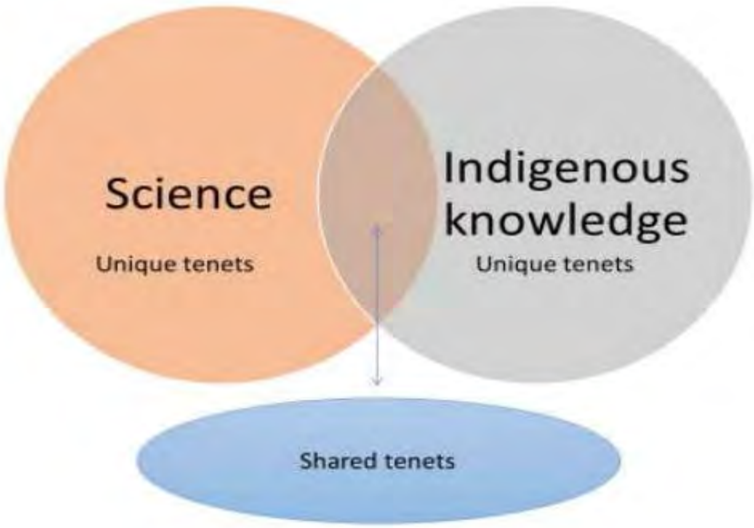

Figure 2.1: Overlapping perspectives (from Cameron & Taylor, 2016, p. 36; Zinyeka et al., 2016, p. 20)

Cronje et al. (2015) explained that sometimes IK is seen as unscientific and irrelevant to modern life, and this needs to be addressed with further research. In this study, Modern technological practices and Indigenous technological practices are interrelated and complementary in the sense that modern technological practices can facilitate indigenous technological practices in science teaching. Integrating the indigenous technological practice of marula oil extraction in science is a historical cultural integration in Western science. This recognised other way of knowing in teaching and learning.

Scholars such as Michie et al. (2023) and Hatcher et al. (2009) support the two-ways-thinking and two-eyes-seeing approaches, respectively, during teaching and learning repertoires. That is, these scholars believe that IK and Western science are complementary. For effective integration of IK in the classroom science teaching environment, it is suggested that approaches such as Indigenous perspectives and the two-eyes-seeing and two-ways-knowing approaches, with or without epistemological insight, should be considered (Bartlett et al., 2012; Coleman et al., 2021, 2012, 2015; Iwama et al., 2009; Michie et al., 2023). A two-eyed-seeing approach is the process of co-learning for integrating elements of IK into school science teaching (Gilbert et al., 2020). There are different epistemologies, and thus, Michie (2018) suggested that there is a relationship between Western science and Indigenous science in the sense that they should no longer be considered contradictory but should be complementary and respected.

Diwu and Ogunniyi (2012) observed that some scholars are of the view that IK should not be integrated into the science classroom. This is based on the exclusive perspective that sees IK and science as separate domains of knowledge. It seems like the exclusive perspective is grounded on ontological differences regarding IK. In contrast, the Africanist perspective is grounded on the notion of illustrating how IK reveals itself as a science (Gwekwerere, 2016). This resonates with De Beer (2016), who sees IK as a powerful vehicle to achieve the decolonisation of the curriculum. Yet, Le Grange (2019) argues that the voice of Indigenous people is silenced. Therefore, opportunities need to be provided for in-service teachers to integrate science and IK in the classroom (De Beer & Kriek, 2021). This can be done using teacher professional learning communities to strengthen teachers' professional development.

This study recognises Western science and Indigenous technological practices as complementary bodies of knowledge that are essential in science teaching and learning. The two-eyed-seeing approach promotes contextual learning, which enables Indigenous learners to create bridges between their cultural knowledge and Western science. In conclusion, Michie et al. (2023) advocated strategies such as the both-ways approach with epistemological insight as a functional way of bridging Indigenous and Western cultures for policymakers, curriculum developers, educators, and teachers to include IK in the Australian school curriculum. It could be argued that science, technology, engineering, and Mathematics education seems to support the 'two-ways' approach to teaching and learning.

2.9 Science, Technology, Engineering and Mathematics Education

Science, Technology, Engineering and Mathematics education means educating learners in four specific disciplines – science, technology, engineering, and Mathematics. It offers a wide range of skills needed in the Fourth Industrial Revolution. In this regard, Siekmann and Korbel (2016) see Science, Technology, Engineering, and Mathematics education as a 21st-century set of knowledge, skills, work habits, characters, and traits that are critically important to success in today's and tomorrow's world, particularly in secondary schools and workplaces. Teachers are the key players in imparting Science, Technology, Engineering, and Mathematics skills to their learners. Duarte et al. (2018) feel that if teachers are better equipped in a formal manner, they can address the problem of curriculum relevance and the underperformance of their students.

The United Nations Educational, Scientific and Cultural Organization, the Namibian Ministry of Education, Arts and Culture and the Namibian University of Science and Technology worked together to assess Namibian Science, Technology, Engineering and Mathematics Education, focusing on the primary level. The Science, Technology, Engineering and Mathematics (2009) found that science education is not well established in Namibian classrooms, and their findings revealed that science could be more interesting if students' existing knowledge and skills are acknowledged and connected to their classroom experiences. In addition, the Namibian curriculum implementation is faced with a lack of funding to purchase necessary teaching and learning support materials; hence, professional development is encouraged for educators to find creative solutions from easily accessible materials in the local communities. Tikly et al. (2018) also acknowledged the importance of connecting the Indigenous knowledge system and informal knowledge to secondary school science. However, there is a need to strategise teachers' training, and this study responded to this need by strengthening teachers' professional learning communities that tap local cultural heritage (Liveve, 2022; Mayana, 2024; Simasiku, 2022).

2.10 Nature of Professional Development in Namibia

Felix (2020) defined professional development as a wide variety of specialised training, formal education or advanced professional learning intended to help administrators, teachers, and other educators improve their professional knowledge, competence, skill and effectiveness. According to Funder et al. (2018), the decentralised model for continuing professional development for educators in Namibia (2012), continuing professional development can be regarded as a tool for pursuing Vision 2030 and the Namibian National Professional Standards for Teachers by improving teaching and learning. In the Namibian context, the Ministry of Education, Arts and Culture facilitates intervention in professional development activities through the National Institute for Educational Development, the Programmes for Quality Assurance division within the Directorate of Education, and the University of Namibia through its Faculty of Education.

The Educational Quality Improvement Programme is a teacher self-assessment activity that provides tools for teachers to reflect on their classroom practices, after which they can participate in professional development activities within local and national reform frameworks (LeCzel & Gillies, 2004). Continuing professional development is the key to ensuring that teachers can keep up with any new information and curricula introduced (Duarte et al., 2018; Killen, 2016). This can be done through in-service training and other opportunities promoting lifelong learning. However, many teachers lack the pedagogical skills required to deliver curricula efficiently; rather, they rely on teacher-centred or traditional methodologies due to teaching material shortages (Tikly et al., 2018). This study used the cultural heritage of marula oil extraction as a form of professional development and community initiative to capacitate teachers to strengthen their PCK of Chemistry concepts.

The objectives for interventions are to update individuals' knowledge of a subject considering recent advances in the area, to update individuals' skills, attitudes, and approaches considering the development of new teaching techniques, to exchange information and expertise among teachers, and to help teachers become more effective (Funder et al., 2018). The literature showed that there is a relationship between professional development embedded in the activity system of education and teachers' instructional practices.

2.11 Professional Learning Communities

A professional learning community is a platform where teachers work together and share their teaching experiences to improve the effectiveness of their teaching, which in turn leads to raising learners' achievements. Within professional learning communities, teachers have access to professional networks (Jusinski, 2021). Ngcoza and Southwood (2019) view professional learning communities as spaces for building constructive relationships within, between, and beyond educators. Professional learning communities are essential platforms for teachers to improve their teaching practices. Chauraya and Brodie (2018) advocated that the power of professional learning communities is to influence teacher learning through conversations and participation in a professional environment that creates learning opportunities for significant aspects of their teaching knowledge. In South Africa, the Integrated Strategic Planning Framework for Teacher Education and Development (Department of Basic Education, 2011–2025) defines professional learning communities as the communities that provide the setting and necessary support for groups of classroom teachers, school managers and subject advisors to participate collectively in determining their own developmental trajectories and to set up activities that will drive their development.

According to the Integrated Strategic Planning Framework for Teacher Education and Development, professional learning communities can enhance quality by bridging the gap between education theory, policy and practice, creating spaces for addressing practical issues and connecting pedagogical practice with subject content knowledge. These professional learning communities can also provide spaces where teachers share innovative ideas with experienced teachers and, thereby, experienced teachers mentor young teachers. This has the potential to stimulate teachers to interrogate and rejuvenate their practice rather than recycle old ideas. Hence, the objective of professional learning communities is to improve teacher practice, which might lead to improved student performance. Teachers should have opportunities to talk more with one another and reflect more deliberately and systematically in their practice to enable their work to become more intellectually engaging and to facilitate collective and sustainable shifts in practice for the intellectual benefit of learners (Brodie & Borko, 2016; Sung et al., 2016).

Roberts and Pruitt (2009) cited five elements of a professional community: (1) reflective dialogue; (2) focus on student learning; (3) interaction among teacher colleagues; (4) collaboration; and (5) shared values and norms. Each element is briefly defined here. Reflective dialogue is described as those conversations that focus on teaching behaviours and learning outcomes to encourage teachers to discuss their teaching practices and collaborate on how they can be improved. In explaining the element of focusing on student learning, Kruse et al. (2015) emphasised that the purpose of all actions in a professional community should be the growth and development of all students. The third element is characterised by ongoing conversations and decision-making about curriculum, teaching, and learning that concentrate on student outcomes. It is through teacher interactions that professional relationships are developed, which encourage teachers to share ideas, learn from one another, and help their colleagues.

The fourth element, collaboration, also described as the deprivatisation of practice, includes behaviours that lead teachers to open their classrooms for observation by other teachers. Traditionally, teachers work alone in their classrooms, creating a learning environment for up to thirty or more students at a time. Kruse et al. (2015) indicated that collaboration occurs when teachers share instructional strategies and techniques, make decisions about instructional issues, and come up with ideas that enhance learning for all members of the school community. The final characteristic, shared values and norms, expresses the idea that the professional community members agree about the mission of their school and the values and norms that shape their behaviours as professionals.

2.12 The Knowledge Gap and New Knowledge

Although several studies on indigenous knowledge systems were conducted in the Namibian context (Hooli & Jauhiainen, 2018; Shapi et al., 2012), there still exists a knowledge gap in the concept of technology within IK, and the aspect of tapping into the cultural heritage of community members for the teaching and learning of grade 11 chemistry was not addressed. My study sought to close this gap.

In a South African context, for instance, a study conducted by Maluleka et al. (2006) looked at the relevance and recognition of IK in the curriculum. The study raised questions or concerns about how Indigenous technological practices can be integrated into the curriculum. Considering this, Gumbo (2016) proposed that there is a need for a technology education course to integrate Indigenous technological perspectives. In contrast, Michie et al. (2023) noted that in the Australian science curriculum, there has been substantial discussion regarding the nexus between 'real' Western science and Indigenous ways of knowing and learning. Michie and his colleagues suggested using the two-ways-thinking or two-eyed-seeing approaches with epistemological insight to develop teaching materials and attend to Indigenous ways of learning and knowing. In the Namibian context, a knowledge gap still exists on the concept of two-eyed-seeing in IK integration into science teaching. My study sought to close this gap. My study, therefore, advocates a paradigm shift and closes the gaps in the body of knowledge by integrating Indigenous technological practices in science teaching and learning. Based on the Namibian context, the study provided me with advancement as a professional developer of Indigenous technological practices in teaching grounded in Indigenous manufacturing and food technologies. The study contributed to the new knowledge through expansive learning opportunities in terms of:

- *New concepts* – namely, Indigenous technological practices, modern technological practices;
- *Perspectives of technology* – that is, technology is not solely about information and communication technology;

- *Methodological* – participation of Indigenous knowledge custodians in professional learning communities; and
- *Pedagogical insight* – new ways and strategies of teaching science through the integration of Indigenous technological practices.

2.13 Chapter Summary

In this chapter, I presented the literature relevant to the study that discussed integrating Indigenous technologies into teaching. The chapter explored the importance of Indigenous technologies, perspectives on educational technologies, Indigenous technologies and curriculum, approaches to integrating Indigenous technologies, professional development in Namibian education and challenges in integrating Indigenous technologies into teaching. Since the study focused on Indigenous technologies, issues regarding the perspectives on educational technologies and science education were also discussed. In summary, the processing of marula oil constitutes Indigenous technological innovations that are relevant to the teaching and the learning of science concepts.

CHAPTER THREE: THEORETICAL FRAMEWORKS

> Cultural-Historical Activity Theory provides a lens to critically look at the complex epistemological border crossing between the natural sciences and indigenous knowledge systems. This could assist curriculum developers to consider aspects such as guidelines ('rules') that should govern the inclusion of Indigenous knowledge in the curriculum as well as most appropriate 'tools' (pedagogies) to facilitate such border crossing. (De Beer & Kriek, 2021, p. 51)

3.1 Introduction

Educational theoretical ideas have to do with questions such as: "How do people learn? Do students know any science before they are taught it? How can teachers find out what students have learnt? How does mental maturity influence thinking? Can mental maturity be accelerated? Do students know what they are doing in science lessons? Is there more than one kind of learning? Do students learn from practical lessons? From the discussion? From teachers' questions? Can we learn how to learn?" (Wellington & Ireson, 2002, p. 63).

In this chapter, I discuss the theories used to analyse data generated throughout the research process. Engeström's (2001) CHAT was used as a theoretical and analytical framework. I augmented this theory with Mavhunga and Rollnick's (2013) TSPCK as an analytical framework. I will now discuss these below.

3.2 Cultural-Historical Activity Theory

In this section, I discuss the historical development and tenets of CHAT. Additionally, I discuss the motivation and justification for the CHAT framework.

3.2.1 Historical development and tenets of CHAT

The study is informed by Engeström's (1987) CHAT, grounded in the work of Russian scholars such as Vygotsky, Leont'ev, Davydov, and others. Essentially, CHAT has been introduced in the West over a lengthy period by scholars including Bronfenbrenner, Bruner, Cole, Rückriem, Scribner, and many others.

CHAT provides a lens for understanding human activity as a socially, culturally, and historically situated phenomenon. It emphasises the interconnected nature of individuals, tools, rules, and community structures in shaping learning and development. As an evolving framework, CHAT has been particularly influential in educational research, workplace studies, and technology-mediated learning, offering insights into how systems adapt, transform, and evolve.

Furthermore, its emphasis on contradictions within activity systems makes it valuable for analysing tensions in integrating IK into formal educational settings. By highlighting the dynamic interactions among agents, tools, and societal influences, CHAT allows a deeper exploration of how IK and Western pedagogical frameworks can coexist and be harmonised within educational institutions. This theoretical foundation enhances the study's ability to critically examine how IK systems contribute to meaningful teaching and learning experiences.

It was expanded by Engeström through expansive learning. It can be used to analyse complexities in and surrounding academic activities (Behrend, 2014; McNeil, 2013). As a theoretical framework, CHAT helps us to understand human beings and their social environment. It acknowledges the significance of the social dimension of mediating learning and that individual or group interactions and actions are rooted in an activity social system. This study used CHAT as a framework because it has components that align well with examining cultural human activities, such as the indigenous technological practice of marula oil extraction, uncovering tensions and contradictions that may arise from the activity system, and how they can influence learning spaces. Moreover, CHAT was used to explore the extent to which teachers can acknowledge and integrate community expertise to enhance the learning of chemistry concepts.

In CHAT, learning is viewed as a socially and culturally mediated and historically connected process (Engeström, 2000, 2001) of interacting factors within an activity system. This suggests that teaching and learning are human activities. Hence, to explore and understand them better, CHAT was used to unpack how they are influenced by many factors such as subjects, objects, rules, tools, community and division of labour. In my study, the *subjects* were grade 11 chemistry teachers; the *object* was the integration of the indigenous technological practice of marula oil extraction in chemistry teaching; the *tools* were teaching and learning support materials in marula extraction, language, symbols, and teaching strategies; the *rules* were the curriculum, policies, cultural norms and values; the *community* was composed of chemistry teachers, IK custodians and

Education Officer, while the division of labour referred to different roles played by the community members. Each primary or secondary tool employed in an activity system reveals something about the relationship between actors and their conception of the object at the point in time in which the tool was appropriated or created (Foot, 2014).

It should be noted that CHAT has progressed through three generations that build upon each other (Nussbaumer, 2012). For instance, Engeström's first-generation CHAT is grounded on the notion of individual subjects and actions within a certain context. It highlights the importance of individual action within complex, dynamic, and contradictory relationships with collective action and subjects concerning its community, the rules that govern the activity, and the division of labour among the various actors intersecting with the subject (Isaacs, 2019). Second-generation CHAT is a collective activity which Engeström (2001) viewed as a human activity system of complex interacting factors such as subjects, objects, mediating tools, rules, community, and division of labour. Engeström (1999) termed the second generation as a socially organised collective human activity in the broad historical cultural-historical context.

However, this second generation is not open to outside factors that influence the activity system. The third generation encompasses numerous activity systems that look at how people, communities, historical contexts and interactions develop a social activity network system with common objects and contradictions (Engeström, 1987, 2001). The group of science teachers in the professional earning community was an activity system that involved objects transformed into a context-based outcome. The second generation was developed into the third generation that examined networks of interaction systems to address the contradictions that promote expansive learning (Engeström, 2001). The third generation acknowledges that human activities are influenced by multiple interacting activities with a common goal or object, in this case, of teaching science.

Engeström (2001) explains that CHAT has five principles: the first three being the *object-oriented activity system*, the *multi-voicedness* of activity, and the *historicity*. The fourth principle highlights the internal contradictions that drive change within interacting activity systems, while the fifth proclaims the expansive qualitative transformation of the activity system over time (Engeström, 2015). Drawing on these principles, the research involved interaction between three activity systems, comprising the teaching activity system, the world of modern professional learning communities with the modern technological practice activity system, and the community of IK custodians' activity system. Engeström further argues that a person's actions are rooted within an activity system in which there is a division of labour among community members who share activities to attain an objective governed by the rules that regulate the actions. This study drew on Engeström's (1987, 2001) second and third generations of CHAT to look at how different activity systems interacted as the teachers co-developed exemplar lessons that integrate Indigenous technological practices and how they mediated learning of these in their classrooms. The study also explored the interactions, historicity and contradictions inherent in the activity system. This was intended to establish a collective design effort that could be seen as a part of an expansive learning process (Sannino et al., 2016). Engeström (1987) modelled the second-generation CHAT as follows:

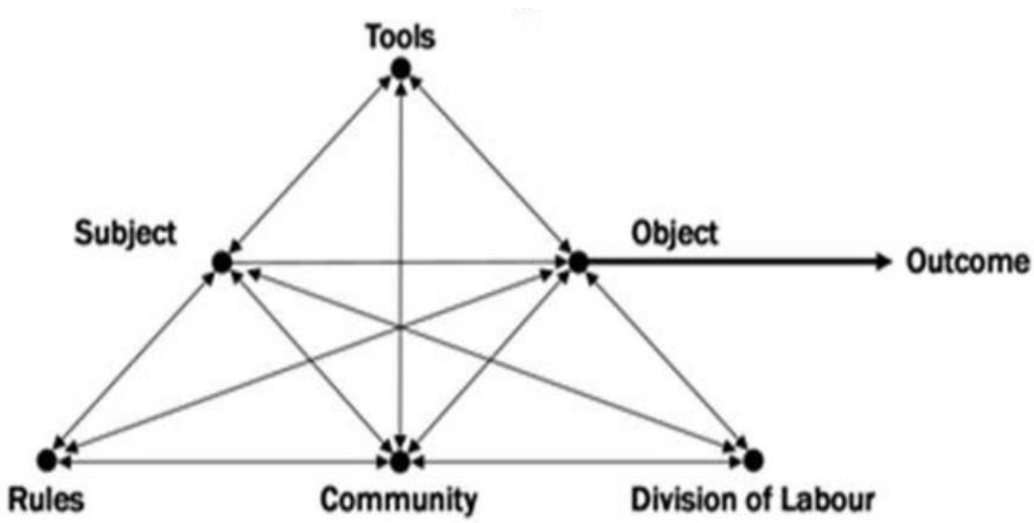

Figure 3.1: Structure of second-generation activity theory (Engeström, 1987, p. 78)

Concerning my study, Figure 3.1 presents the intervention as an activity system made up of different actors who collaboratively engage in an object-oriented activity to advance the teaching and learning of science (Engeström, 2011; Nussbaumer, 2012). In this regard, Daniels (2008) postulates that CHAT enables the researcher to scrutinise practical social activities concerning the psychological impacts produced by such activity. Likewise, Behrend (2014) asserts that CHAT provides a framework to analyse the sociocultural influences of rules, norms, community and division of labour and examine their interrelationships to identify affordances and contradictions within the system. Thus, the above model provided me with the lens to analyse how different factors of this intervention interacted to transform the teachers' pedagogical views on integrating Indigenous technological practices into science lessons.

3.2.2 Motivation and justification for the CHAT framework

In this study, CHAT provided the theoretical and analytical tools that enabled me to see how the collective agency of the science teachers, IK custodians, and senior education officers may transform the teachers' understanding of integrating Indigenous technological practices into their science lessons. At a micro level, Engeström's second-generation model was used to analyse how the different factors of this intervention interacted during the practical demonstration workshops. The CHAT helped me analyse the contradictions embedded in the activity system, enabling me to understand the contradictions and multi-layered, multi-voiced interactions of diverse participants. The CHAT is regarded as a contradiction-based (Bonneau, 2013) analytical tool; I used it to understand sociohistorical constructs undergoing tensions coming from different levels, such as educational policies, professional conduct and others. The model also enabled me to see how the participants' behaviour was regulated by rules, available resources, more knowledgeable others (Vygotsky, 1978) and historicity concerning science teaching in Namibia.

I was aware that I would be working with participants from diverse sociocultural backgrounds (Mavuru & Ramnarain, 2020); therefore, I needed a tool that would enable me to understand the learning prospects of different participants. The CHAT acknowledges that human behaviours are complex, mediated by learning through cultural tools, artefacts, and symbols embedded in activity social systems. The third-generation CHAT diagram below (see Figure 3.2) was adopted to analyse the contradictions among the different activity systems and how they shared the common object of science teaching.

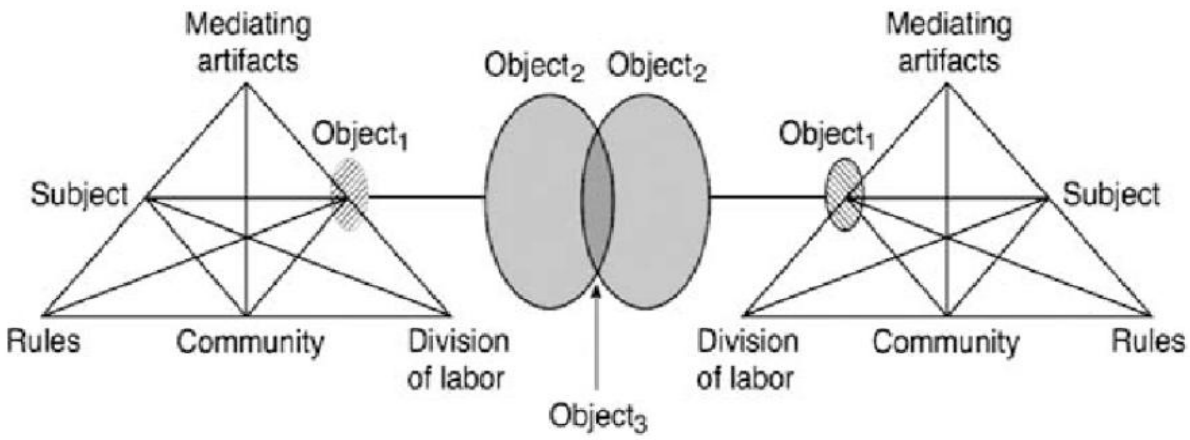

Figure 3.2: Human activity as a series of interacting activities (adapted from Engeström, 2001, p. 136)

The model shows the interaction of different activity systems among people with different experiences, skills and perceptions as they strive to achieve a common objective. In my study, this model enabled me to see how the activity system of different individual role players, such as community members' Indigenous technologies, shifted the teachers' pedagogical insights into integrating Indigenous technological practices into science lessons. This model was used to analyse the presentation of cultural heritage, and the change laboratory workshops (change laboratory workshops) to understand how they enabled the participants to gain new knowledge grounded on Indigenous technological practices. This model also served as a theoretical lens for looking at whether and the contradictions within the activity system could bring about the development of new knowledge.

During the IK custodians' presentation during the Change Laboratory Workshop on Indigenous technological practices, tensions arose in the division of labour between the science teachers and me. Moreover, between the teachers (*as the learners*) and the IK custodians (*Indigenous technological practices experts and facilitators*). CHAT enabled me to identify the tensions or dilemmas as manifestations of contradictions and see how the participants collectively and individually may expand their knowledge.

3.3 Contradictions and Tensions

Engeström (1987) defines contradiction refers to the dynamic tensions or conflicts that arise within an activity system as different elements interact. These contradictions are not merely problems or obstacles; rather, they are essential forces that drive change, adaptation, and transformation within a system. Engeström's work provides foundational insights into contradictions as drivers of change within activity systems. Tensions refer to the subtle pressures, contradictions, and conflicts that arise within an activity system as different elements interact. Unlike contradictions, which drive systemic change, tensions are ongoing struggles or disparities that emerge due to misalignments between components such as tools, rules, community, and objectives (Engeström, 2001; Engeström, 1987; Miles, 2020).

Engeström (1987, pp. 102-104) classified contradictions into several levels:

1. Primary contradictions, which happen *within* a single component of the activity system.
2. Secondary contradictions, which manifest *between* components of the activity system. For instance, the conflict between new technological tools in education and old cultural practices (rules).
3. Tertiary contradictions occur when a *new activity model* conflicts with an existing one.
4. Quaternary contradictions emerge between the *central activity* system and *neighbouring* system, for instance, misalignments between a school's curriculum implementations and Indigenous knowledge custodians' expectations.

Tensions are the observable manifestations of contradictions, such as frustrations, delays, or incongruities, that signal underlying system issues. Unlike structural contradictions, tensions are more *surface-level symptoms* (Engeström, 2022). Contradictions and tensions are important because they serve as catalysts for change in a special way that drives expansive learning, where individuals and groups reconceptualise their work. Tensions create developmental opportunities that lead to innovations in practice. Tensions precipitate development.

For instance, McNeil (2013) traces the poor quality of high school instruction to the tensions between the social control purposes of schooling and the schools' educational goals. McNeil argues that the poor quality of the high school instruction system stems from the conflicting purposes of schooling: social control, which conflicts with educational goals. According to McNeil, social control purposes are focusing on maintaining order, managing large groups of learners, and preparing them for societal roles. This often emphasises obedience and routine over critical thinking, while educational goals aim to foster deep understanding, intellectual curiosity, and meaningful learning experiences.

In relation to this study, the tensions lead schools to prioritise relevant stakeholders within the community and their contributions towards genuine learning. This is a holistic approach and compliant rather than true educational development. Schools often prioritise and focus on aspects such as year planning, administration of curriculum implementation, and classroom management in order to handle large numbers of learners. These are regarded as social control factors in this study. While busy focusing on social control factors, challenges arise, for instance, a teacher may rush to cover the curriculum content rather than coming up with culturally innovative ways that can enable their learners to master a deep understanding of science concepts.

Engeström and Sannino (2021) believe that learning is a collective process of creating and acquiring something that is not yet there. Through the notion of expansive learning, I had hoped to be able to see how my participants' understanding of Indigenous technological practices expanded and how new ideas could emerge, or existing ideas could be refined. Avis (2007) argues that it is through contradictions that activity systems develop new learning and transformative agency, resulting in expansive learning. Miles (2020) suggests that once contradictions have been identified, the subjects of an activity system can attempt to resolve them through the process of expansive learning, a bottom-up process that takes the ideas from the abstract to concrete implementation. This suggests that the initiation of expansive learning requires transformation in a way that the community can understand (Salloum & BouJaoude, 2021). Hence, in this study, teachers reviewed new objects and better understood the need for new instruments that could resolve contradictions and lead to improved conceptual science teaching. Herein lies the importance of expansive learning espoused by Sannino et al. (2016).

3.4 Expansive Learning

Expansive learning is a creative type of learning in which learners join forces to create something novel, learning something that does not yet exist, which can lead to transformation (Sannino et al., 2016). It requires initiative for transformation that can lead to new concepts and practices. Expansive learning is developed through a series of actions starting with questioning the existing practices, analysing them, and then modelling, examining and implementing a new solution (Figure 3.3 below):

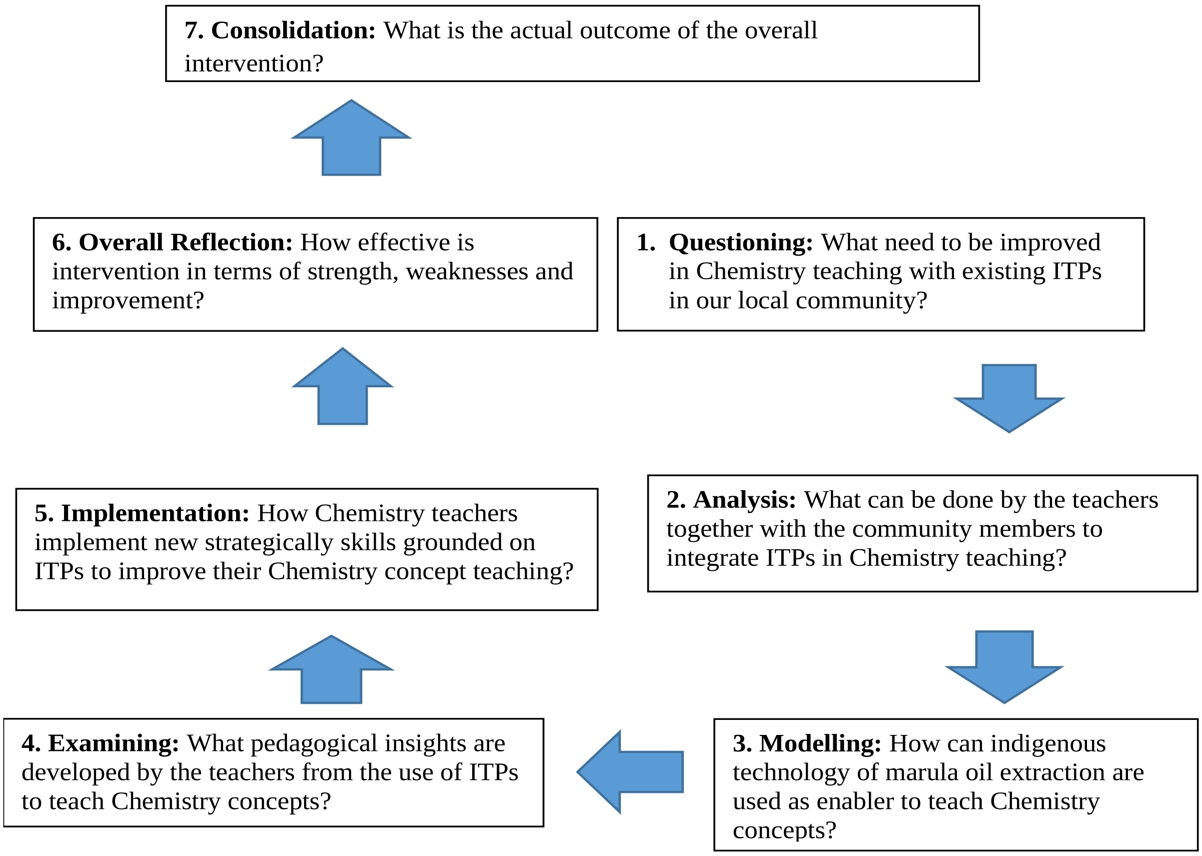

Figure 3.3: The expansive learning cycle or process (adapted from Engeström, 2000, p. 970)

Based on my study, modelling the first epistemological action entailed questioning some aspects of existing practice and existing wisdom and the standard Indigenous technological practices in science teaching. The second action was about analysing activity, system explaining the situation by tracing its origin, evolution and contradictions and constructing a picture of expansive activity. The third action was that of modelling, examining and testing whether participants learnt from the IK custodians from the community to develop new sets of ideas and practices that could contribute to scientific knowledge. In addition, the development and examination of the model identified its dynamics, potential and challenges. The fourth action was implementing the model through actual practical applications and classroom enactment. The fifth and final action was that of consolidating its outcome into new pedagogical practices. As an improvement in Engeström's (2000) expansive learning cycle, I adapted Haimene's (2023) approach in that reflections and evaluation processes were made at every stage throughout all the actions. The expansive learning cycle guided this formative interventionist study.

This study intended to expand the object of activity – teaching science with Indigenous technological practices – to bring about expansive learning in terms of improvement, new skills, and ways of integrating technologies into science teaching. In this way, expansive learning may create what Lotz-Sisitka et al. (2015) refer to as *transformative, transgressive social learning*, which is based on rethinking higher education in terms of pedagogical development in the stream of sociocultural and CHAT. An expansive learning cycle may shift the participants to a level where they can develop their own learning towards the transformative agency that Sannino et al. (2016, p. 4) describe as “breaking away from the given frame of action and taking initiative to transform it”.

Learning in CHAT is driven by cultural-historical human activity, which means that learning takes place through dynamic interactions among individuals in society (Engeström, 1987; Leont’ev, 1978). Learning can only be understood by investigating the relationship between the subject and objects through interactional mediation (Kim & Kwon, 2011). Learning is regarded as a complex occurrence in sociocultural contexts in everyday life. This points to a shortcoming of CHAT, in that it does not recognise that learning can be understood by examining an individual’s cognitive changes and development. This warrants the use of change laboratories (Engeström, 2001).

3.5 Change Laboratory

Based on Engeström's theory of expansive learning (1987), the generic change laboratory method was developed and applied successfully in health care services as well as the integration of information communication technology in schools in Finland (Engeström et al., 1996; Sannino et al., 2016). The change laboratory is a new method for developing work practices by practitioners, facilitating both intensive, deep transformations and continuous incremental improvement (Engeström et al., 1996). In change laboratory work, the researcher establishes a working team interested in developing potential strategic solutions to problems in their working practices.

It is a form of interventionist research, in which both the facilitator and participants are contributors, aimed at changing or improving organisations through framing new possibilities (Virkkunen & Newnham, 2013). The change laboratory is a structure which enables expansive learning. The change laboratory can be spread over 4–8 workshop sessions, with participants raising issues in their working practices.

A change laboratory research intervention has several potential benefits. It can promote the development of future possibilities for courses, curricula, and designs; develop concepts for researching student experience and academic work; undertake historical analyses of the changing mission of institutions; and develop the transformative agency of marginalised voices in higher education (Bligh & Flood, 2015). To achieve this, the change laboratory would focus on an intervention that Virkkunen and Newnham (2013) describe as a collaborative analysis and design, shown in Figure 3.4 below:

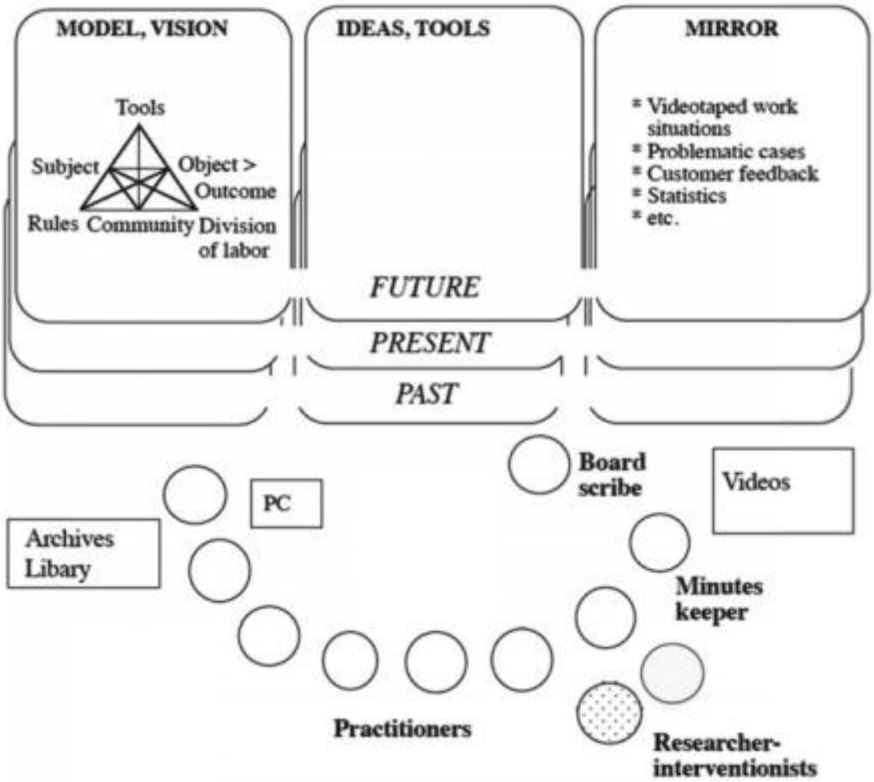

Figure 3.4: Change laboratory model (adapted from Virkkunen & Newnham, 2013, p. 16)

The main tool is a set of three writing surfaces to display the participants' work as they meet, interact and make notes. The three levels account for different levels of abstraction and generalisation (Engeström et al., 1996), ranging through 'model and vision', 'ideas and tools' and 'mirror'.

The mirror surfaces represent the experiences, views and insights that came from the work practice; these are regarded as baseline or first-hand data. Mirror data is useful for reflection and can be challenging situations, contradictions or innovative solutions. They can be in the form of audio, video, documents of the work activity or interviews of participants. The triangular model of activity (Engeström, 2015) and the cycle of expansive learning (Engeström, 1999) can be used to study the relationships of the components within the activity system being analysed. This helps the participants to systematically discover the roots of specific contradictions and how these affect the activity system. In this study, the mirror data (semi-structured interviews) provided an analysis of the challenges and contradictions inherent in integrating Indigenous technological practices into grade 11 chemistry lessons.

The central panel is a surface for ideas and tools. This represents the move of participants from concrete examples to theoretical models and visions; this allows them to view themselves as able to produce solutions and ideas to be tested. The vertical dimension of the writing surface emphasises the historical perspective, important in enabling an understanding of the potential and limitations of an activity system. The three writing surfaces represent the past, the present and the future.

Following the different steps of expansive learning illustrated in Figures 3.3 and 3.4, the first step in a change laboratory is questioning participants on current issues by showing mirror data from the past. The second step of analysing the problems was to trace their root causes and effects. In the third step, participants model the present activity and its internal contradiction, which helps to focus on the main sources of problems within the activity systems. The participants may create a new structure for the future activity that resolves the contradiction with tools and possible solutions. The fourth is finding concrete ways to implement solutions. In the fifth step, the new model or a new practice is tested. Experiments are audio-taped, videotaped and demonstrated during the follow-up change laboratory workshops to provide a mirror of the future and an overall reflection of the process. In the sixth step, consolidation takes place, and finally, the new model and practices are implemented and monitored. This warrants the consideration of Mavhunga and Rollnick's (2013) TSPCK as an analytical framework.

3.6 TSPCK Analytical Frameworks

The analytical framework used in this study was TSPCK. I deemed it appropriate for my study because it has components that promote the analysis of a teacher's professional competencies (subject content, pedagogy and planning, and classroom enactment).

3.5.1 Pedagogical content knowledge

Shulman (1986), a psychologist and scholar of teacher education, developed the notion of PCK as a response to what he saw as a discrepancy between teachers' knowledge of the subject and knowledge of teaching and education. Shulman (1987) maintained that effective teacher education should comprise teaching strategies. He created the third domain of knowledge that has to do with how to teach a particular subject based on how learners view the subject, why some topics are easy or difficult, and how to structure the topics in a way that students can make sense of what is taught. He stressed that when subject content knowledge and PCK are joined, they create a knowledge space referred to as PCK. Du Plessis and Muzaffar (2010) refer to this as *teaching within a pedagogical milieu.*

Drawing on PCK, the teacher will be able to interpret the subject matter and find different strategies to make the content understandable to learners. In the context of my study, it was hoped that the teachers might be able to understand the integration of Indigenous technological practices into their science teaching. However, PCK cannot be used as an analytical tool on its own; Widodo (2017) suggests that PCK is more focused on how subject knowledge can be taught to ensure better understanding for the learners. In other words, PCK does not address the learners' learning, focusing more on the teachers' perspective. One of the criticisms of PCK is that it is not a learning theory (Kind, 2009) but rather a teaching theory.

Scholars such as Park and Chen (2012) and Geddis and Wood (1997) developed a notion of PCK as subject specific. This includes components such as learners' prior knowledge, curricular saliency, what makes a topic easy or difficult to understand, representations, and conceptual teaching strategies. Mavhunga and Rollnick (2013) and Mavhunga et al. (2016) acknowledged, extended, and adapted the seminal work of Park and Chen (2012) and Geddis and Wood (1997), arguing that PCK should be topic-specific since teachers cannot use the same teaching strategies for different lessons in their teaching. Hence, they came up with the concept of TSPCK.

3.5.2 Topic-specific pedagogical content knowledge

Topic-specific pedagogical content knowledge (TSPCK) is the transformation of PCK into specific themes that learners can master. Mavhunga and Rollnick (2013) adapted the five content-specific components of the TSPCK as shown in Figure 3.5.

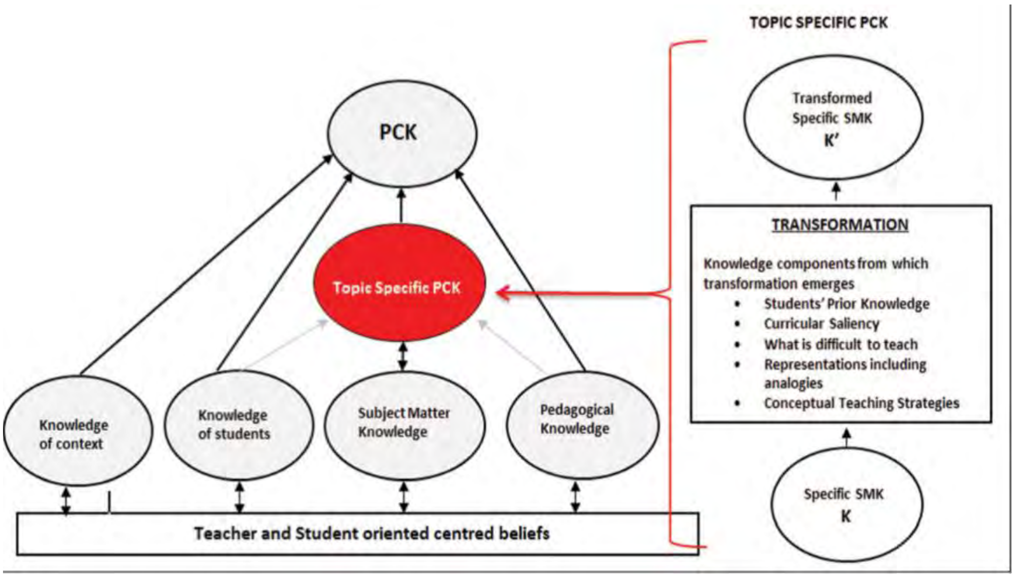

Figure 3.5: Components of TSPCK (Adapted from Mavhunga & Rollnick, 2013, p. 115)

This diagram shows the five TSPCK components teachers use to transform subject matter into comprehensible knowledge, accessible to learners and acknowledging learners' prior knowledge, curriculum saliency, what makes a topic easy or difficult to understand, representations, and conceptual teaching strategies (Mavhunga & Rollnick, 2013). It is understood that teachers need TSPCK to transform the content of a specific topic into a form that is more easily understandable to the learners. The TSPCK was used in this study because it was considered appropriate and enabled me to analyse aspects of teachers' professional competencies (subject content, pedagogy, planning and classroom enactment) and elaborated on in Appendix K.

Even though Shulman's theory of PCK and Mavhunga and Rollnick's TSPCK have been embraced as a way to examine teachers' and learners' understanding of subject matter, several criticisms have been levelled at them. It is criticised for lacking a theoretical foundation to support it (Kind, 2009). In response, a common understanding of PCK has been developed, the teacher professional knowledge model, also referred to as the consensus PCK model (Gess-Newsome, 2015, p. 31). This is shown in Figure 3.6 below.

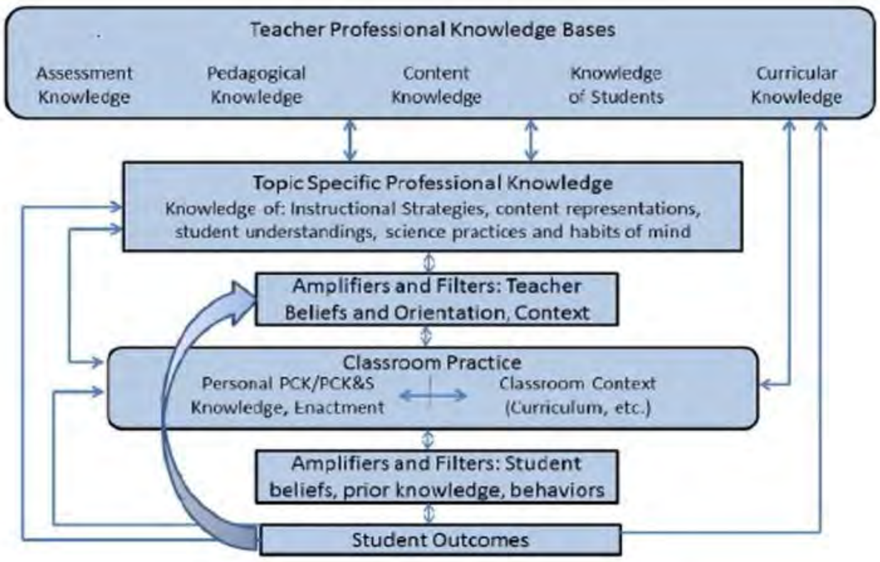

Figure 3.6: The consensus model of PCK from PCK Summit 2012 (Gess-Newsome, 2015, p. 31)

This model defined PCK as essential knowledge used in the planning and delivery of topics in a classroom (Gess-Newsome, 2015). The model was significant as a knowledge base for planning and teaching lessons (Shinana, 2019). However, the use of this model exposed some limitations; it had limited information about PCK. It did not emphasise teaching strategies (Mutanho, 2021). Subsequently, the model was further refined into a multi-dimensional PCK (Carlson & Daehler, 2019). This is shown in Figure 3.7 below.

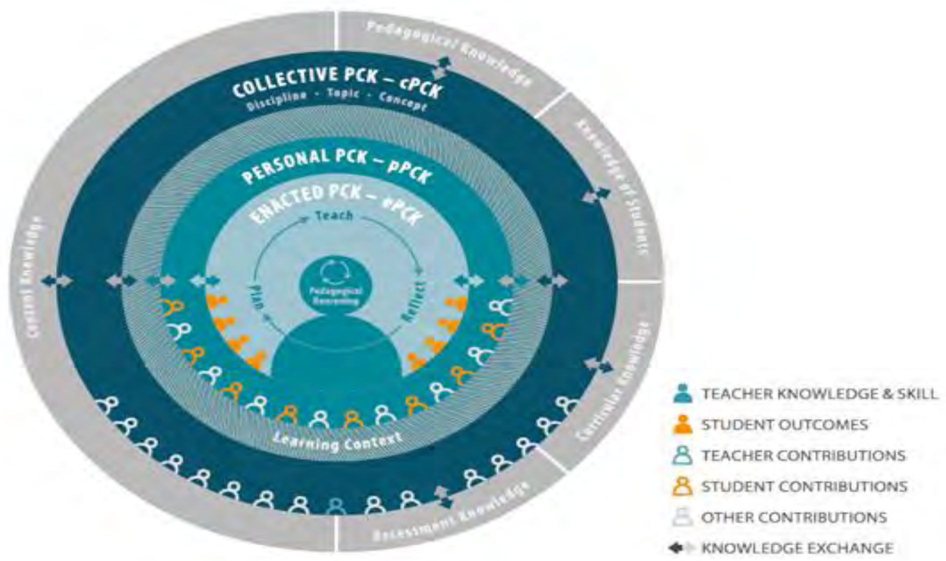

Figure 3.7: The refined consensus model of PCK (Carlson & Daehler, 2019, p. 83)

The new refined consensus model of PCK was built on the three categories of PCK – collective PCK, personal PCK and enacted PCK. The first category is collective PCK, which Carlson and Daehler (2019) explain as knowledge about a particular field, usually known by the teacher within that field. The teacher has acquired this knowledge while training, for example, at university. Such knowledge is regarded as collective because it is public and not offered to one person but rather commonly administered by all trained teachers (Mutanho, 2021).

Although the teachers acquired PCK collectively, they tend to show it in their own exceptional way – this makes up their personal PCK, which is the second category. Personal PCK is unique because teachers can practise different forms of creativity and have different teaching experiences and classroom contexts.

The third category is enactment PCK, which is the knowledge that a teacher applies to teach in the classroom. Enacted PCK is influenced by the teachers' planning, teaching and lesson reflection. According to Carlson and Daehler (2019), a teacher's personal PCK is developed, shaped and refined over time through formal education, teaching experience and professional engagements.

In this study, all three categories of PCK were considered essential as it was hoped that the participants would be afforded an opportunity to improve their personal PCK through social interactions with the IK custodians that occurred during the intervention workshops. The teachers improved their personal PCK by explaining their enacted PCK in teaching the topic of scientific processes and chemical reactions, in this way, making their PCK explicit (Carlson & Daehler, 2019).

3.6 The Relevance of the Two Theoretical Frameworks in This Study

According to Kay (2024), CHAT is a useful analytical and methodological framework to explore tensions, conflict and dilemmas that emerge between IK, teachers' professional knowledge and curriculum implementation. Engeström (2001) emphasises that tensions, conflicts, and dilemmas within an activity system are observable manifestations of deeper contradictions, which drive systemic transformation. These contradictions arise when traditional practices, tools, or structures within an activity system no longer align with emerging needs, creating friction between different components. Rather than being simple obstacles, contradictions serve as catalysts for expansive learning, encouraging individuals and communities to critically reflect, adapt, and innovate new solutions. By analysing and addressing these contradictions, activity systems evolve, shifting from rigid structures to more flexible and dynamic configurations that accommodate both historical influences and contemporary demands.

However, Engeström has acknowledged critiques of CHAT, particularly regarding its complexity and applicability in diverse contexts. Some scholars argue that CHAT’s structural approach to contradictions may not always lead to expansive learning, as tensions within activity systems can persist without resolution. Others critique its ability to fully account for power dynamics and agency within social structures. In response, Engeström (2001) refined CHAT by emphasising expansive learning, which allows for systemic transformation through contradictions and tensions. He also explored how activity systems interact with neighbouring systems, addressing concerns about external influences and broader societal structures. His work continues to evolve, integrating interdisciplinary insights to strengthen CHAT’s relevance in contemporary research.

That was the reason CHAT was complemented with TSPCK, which has components that were suitable and enabled me to analyse aspects of the teachers’ professional competencies (subject content, pedagogy and planning and classroom enactment). CHAT was used as a research lens, and TSPCK was used as an intermediate theory that observed the cognitive development of the teachers. Each of these frameworks had its own specific role; hence, collectively and complementarily, they provided me with analytical lenses to analyse my data.

3.7 Chapter Summary

This chapter looked at the theoretical frameworks that informed the study and were used to analyse the data generated in all four phases. Their unique contribution to new knowledge lay in the fact that it combined the Indigenous paradigm of Ubuntu with the transformative paradigm. Instead of viewing IK and Western science as polarised knowledges opposed to each other, this study viewed them as complementary bodies of knowledge from which insights can be drawn to benefit research. While CHAT and TSPCK provided the theoretical, methodological and analytical tools, Ubuntu provided the relational philosophy that informed our conduct in this study. The CHAT also enabled me to observe and understand the historical tensions and contradictions embedded in science education in Namibia and the expansive learning spaces that influenced learning in professional learning communities during the transformative intervention. The next chapter presents the research methodologies used in this research.

CHAPTER FOUR: RESEARCH METHODOLOGY

> Relational Indigenous methodologies advance collaborative research that is inclusive of communities' voices as it revitalises, restores lost identities, value system, legitimises Indigenous knowledge as content and as a body of thinking. This can be viewed along a continuum scale that ranges from the least indigenised to the geocentric methodologies. (Chilisa et al., 2017, p. 329)

4.1 Introduction

Research methodology is about how researchers go about obtaining knowledge about how they collect data based on the ontology and epistemology adopted for the study and how they describe and explain phenomena (Bertram & Christiansen, 2020). Taking my cue from the above epigraph, in this study, I drew insights from both the so-called Eurocentric or Western research paradigms and methodologies and the Indigenous African philosophy of Ubuntu. This chapter briefly explains the two research paradigms. It further explains the research design, which is a qualitative, transformative, participatory and expansive case study. The data generation techniques are also discussed in this chapter. Finally, the chapter looks at the research site, sampling, research process, data analysis, as well as validity and trustworthiness.

4.2 Research Paradigms

Research paradigms are the abstract beliefs and principles that shape how a researcher sees the world and how they interpret and act in that world (Kivunja & Kuyini, 2017). In essence, a paradigm can be regarded as the lens through which a researcher looks at the world and understands it. It helps the researcher to examine the methodological aspects of their research project to determine the research methods that will be used and how the data will be analysed.

Because this study explored ways of decolonising the curriculum through the integration of Indigenous technological practices, working with the Indigenous Namibian teachers and IK custodians, it drew insights from both the *transformative* and *Indigenous research paradigms* (Chilisa, 2012; Chilisa et al., 2017). The section below discusses each of these in detail.

4.2.1 The transformative paradigm

The transformative paradigm provides a philosophical framework for designing research that has the potential to bring about change at the individual and societal level; research which engages research participants, focusing on supporting changes that challenge an oppressive status quo (Mertens, 2017). The transformative paradigm is built upon the early work of Guba and Lincoln (2005) and offers opportunities to develop responsive strategies that identify differences and inequality in cultural understandings and lead to richer understandings of the meaning of experiences and changes.

The critical agenda for this study was transformative pedagogy in teaching and learning for both the individual and society. The transformative paradigm was regarded as suitable to provide *epistemologica*l, *ontological*, *axiological* and *methodological* lenses that link Indigenous technologies to science teaching and determine the kind of science knowledge and Indigenous technological knowledge that we need to build new knowledge (Chilisa, 2012).

Mertens (2012) defined a transformative paradigm in terms of its epistemology, ontology and axiology. *Epistemology* refers to the nature of knowledge and the relationship between the knower and that which would be known. An awareness of epistemology promotes establishing relationships that determine ways that the study can be more culturally responsive. *Ontology* refers to beliefs about the nature of reality; that there are different opinions about what is real, based on different lenses that people bring to the situation. Awareness of ontology calls upon the researcher to develop strategies to determine different versions of reality, the factors that are related to those versions in terms of power and privilege and make visible the potential for social change associated with those different versions of reality.

However, if the purpose of research is to challenge the status quo and bring about social change, the researcher needs to be aware that all versions of reality do not have equal legitimacy. *Axiology* refers to beliefs about the meaning of ethics and moral behaviour, including the importance of respecting cultural histories and norms of interactions to conduct research that has the potential to increase social justice. *Methodology* refers to beliefs about the process of systematic inquiry. The transformative methodological assumption is logically derived from the above three assumptions. Seehawer (2018) suggests that researchers start with qualitative data collection to learn about the community and begin to establish trusting relationships. What was transformative about this study was that it explored innovative ways of integrating Indigenous technological practices embedded within Indigenous and cultural practices to improve the teaching and learning of science.

Transformative strategies can complement and enhance collaborative approaches to generate new knowledge of teaching and learning. They can guide researchers and participants to ethically examine their own roles within the community in which they are working. A transformative paradigm offers an integral perspective that helps educators embrace and understand the aspect of integration in the sense that all ways of knowing are equally legitimate and important (Taylor et al., 2012). During the research process, I had to guide the process towards a variety of epistemologies to maximise teachers' participation in transformative teaching and expansive learning.

Although a transformative research paradigm can enable researchers to resolve social issues, particularly in the education system, it also has some limitations. While the transformative research paradigm provides a perspective on empowering people and achieving equality in society, sometimes it is not easy to observe these changes as the results of actions may take time to emerge (Pham, 2018). I believe that transformative researchers should be humble and patient, employing postcolonial Indigenous paradigms to build a broader understanding of social issues that can lead to better teaching and learning. Therefore, I used an Indigenous research paradigm to complement the transformative paradigm.

4.2.2 The Indigenous research paradigm

The Indigenous research paradigm uses Indigenous methodologies that acknowledge the participants' culture (Chilisa, 2012; Chilisa et al., 2017). Indigenous methodologies approach community and cultural protocols, values and needs as an integral part of the research, and they emphasise common principles of respect, reciprocity, relevance and responsibility (Williams & Shipley, 2023). The Indigenous paradigm was used to understand the knowledge within the community and explore how it can be shared through storytelling and practical demonstrations. For instance, the indigenous technological practice of marula oil extraction is cultural knowledge respected in the community. This introduces several contradictions in science education since IK was for many years regarded as inferior, unscientific and not worth learning (Mutanho, 2021). Ubuntu was used as a philosophical, ethical and relational principle acknowledging the interdependence of the participants and myself. Ubuntu is an isiXhosa term that describes the

African philosophy of togetherness in southern Africa. It embraces a strong sense of social ethics grounded on principles of humanity, interdependence, interconnectedness and sharing (Okeke et al., 2014; Seehawer, 2018; Seehawer & Breidlid, 2021). Chilisa (2012) postulates that Ubuntu comprises philosophical assumptions about the nature of social reality (*ontology*), ways of knowing (*epistemology*) and ethics and value system (*axiology*). It is summarised in the African expressions: "I am because you are" and "You are because I am."

Critical educational researchers assume that reality is shaped by cultural, political, ethnic, gender and religious factors through interaction within the social system (Rehman & Alharthi, 2016). Ubuntu research agendas contribute to strengthening methodologies that are community based, relational and participatory, including local ethics protocol and Indigenous epistemologies (Seehawer, 2018; Smith, 2012). This resonates with Marovah and Mutanga (2023), who posit that Ubuntu's focus on equality and human dignity aligns with the goals of transformative research, which seeks to address inclusivity, social injustices, and empower marginalised communities. In this research, integration of Indigenous technology of marula oil extraction is regarded as a critical tool for empowerment, valuing the voices and experiences of all community members, individual teachers to actively participate in the research process and contribute to meaningful change.

In this research, the principles of Ubuntu are regarded as supportive of the movement to decolonise educational research (Mutanho, 2021). This has to do with efforts that contextualise research methodologies in terms of the culture, values and history of Indigenous people, promoting involvement, eagerness, generosity and togetherness. These qualities characterise community members' participation in formal education, facilitating workshops and ethical issues considered during the research processes. Ubuntu principles such as interdependence, mutual trust, values and respect enable collaboration. Ubuntu was the lens through which the transformative collaborative effort and the interdependence, based on mutual trust and respect, were understood by the research participants.

This study adopted an inclusive social and ethical perspective where both the researcher and participants demonstrated good relationships with IK custodians from the Indigenous community. In this study, the reality concerning Ubuntu was that the Indigenous community was used as a tool to educate science teachers and guide and maintain positive human interactions. This was achieved in line with Islam et al.'s (2021) advice on how important it is for the researcher to have good communication skills and virtuous attitudes to maintain the research community based on complementary relationships and trust. I used reflexive practices as described by Holmes (2020) in relation to Ubuntu, from which it emerged that the Indigenous research paradigm had the potential for restoring Indigenous values, heritage and cultures through research. In other words, Ubuntu can serve as an instrument to decolonise and indigenise research, which Mutanho (2021) regards as a call to many Indigenous scholars.

4.2.3 The complementarity and relevance of the two research paradigms in this study

Transformative, emancipatory research was used to examine the nature of reality and the transformative changes that took place in this study (Mertens, 2017). The transformative lens also helped me to understand the expansive learning opportunities and qualitative changes that took place as liberator moments in which the participants' ways of thinking and doing things were liberated from old ways to innovative ways of teaching science. However, although the transformative research paradigm gave me insights into how knowledge was co-generated as teachers worked in groups, learning from each other's funds of knowledge, it could not give me access to the qualitative nuances related to relational matters as people work together in a community. It is for this reason that I supplemented the transformative research paradigm with the Indigenous research paradigm of Ubuntu.

According to Chilisa et al. (2017), postcolonial Indigenous research emphasises reality as being socially constructed, comprising multiple realities, based on the relationships humans have with each other and the world around them, both living and non-living. In this regard, this study used the approaches of both-ways thinking and two-eyed seeing (Michie, 2018, 2023; Hatcher et al., 2009) to establish that reality can be constructed from many ways of knowing. Values of reciprocity, respect and representation are emphasised (Chilisa, 2012; Chilisa et al., 2017). Knowledge is derived from relationships and the transformative framework that examines assumptions related to ethics, the nature of reality, and epistemology that can guide researchers who choose to address both the personal and societal levels of transformation within the IK system. Typical research designs include participatory, transformative and Indigenous approaches.

4.3 Research Design

This study is a qualitative, transformative, expansive case study. It worked with qualitative data and followed expansive learning processes driven by historicity (Engeström, 2001), where participants were engaged in designing their learning. I opted for this research design because it focuses on bringing about change and actively engaging people within a community of practice to work towards change. It encouraged me to work collaboratively with the participants on a transformative intervention programme where we explored expansive ways of improving our teaching. It helped to create awareness among us about professional learning communities grounded in cultural heritage and the need to take action to create change and improve teaching strategies. Furthermore, it enabled us to engage with participants and cause a paradigm shift in understanding discovery learning, using radically Indigenous technologies and developing transformative strategies. For instance, video clips that were captured during the IK custodians' presentations on the indigenous technological practice of marula oil extraction were used in the classrooms to teach chemistry.

Steneck (2007) argues that researchers can collaborate with colleagues and other people who have expertise or resources to carry out a particular project. An intervention is a deliberate attempt to change the world in some way to assess the impact of the intervention and create solutions (Coe et al., 2017; Sannino et al., 2016). Hodson (2009) identifies three important characteristics of case study research: *naturalistic inquiry*, which focuses on studying real work situations and how they unfold naturally, *unique case orientation*, which means that each case is special and unique, and *design flexibility* has to do with being open to adapting inquiry as the situation changes. Bryman et al. (2017) hold that qualitative studies emphasise words rather than quantification in the collection and analysis of data. Effective case study research requires the researcher to probe beyond the surface of phenomena (Cohen et al., 2018).

4.4 Research Site and Sampling

The research was conducted in an urban area of the Okahandja circuit in the Otjozondjupa Directorate of Education, Arts and Culture in Namibia. Okahandja is a city of about 24,100 inhabitants in the Otjozondjupa region, central Namibia, and is known as the Garden Town of Namibia. It is located 70 km north of Windhoek on the B1 road. It was founded around 1800, by two local groups, the Hereros and the Namas. Otjozondjupa is one of the fourteen regions of

Namibia. Its capital is Otjiwarongo, 188 km south of Okahandja, where I am based which has about 97,945 inhabitants. The Five Rand informal settlement of Okahandja is a poor community with poorly resourced primary schools. It is also where Indigenous technological practices, for instance marula oil extraction, are conducted. All members of this community are Africans of the Herero, Oshiwambo, Damara, Nama and Kavango tribes.

The Namibian regions and towns in the Otjozondjupa region are shown below:

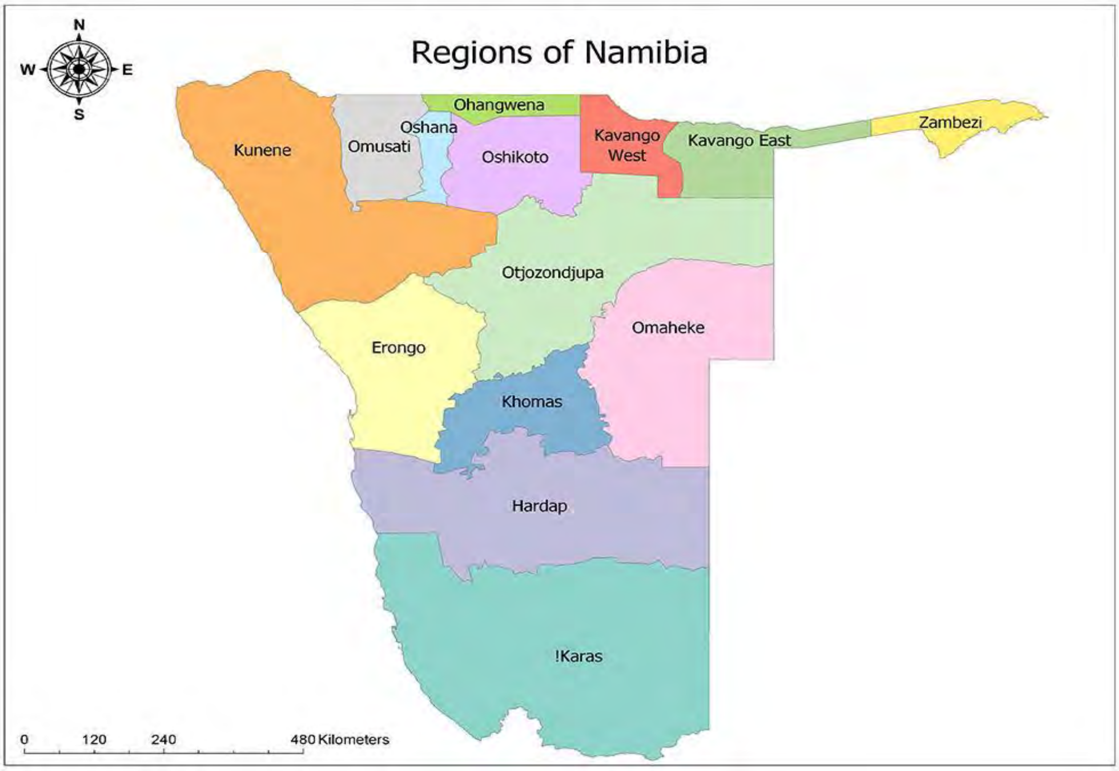

Figure 4.1: Regions of Namibia (https://www.mappr.co/wp-content/uploads/2021/01/image-739.jpeg)

Figure 4.2: Towns of Otjozondjupa region (https://creativecommons.org/licenses/by-sa/3.0/de/legalcode)

Initially, six[5] chemistry teachers from two schools in Okahandja and three community members from Okahandja were participants in this study. Four of these teachers had done their master's in science education. Two other teachers had done their Honours in Science Education. I worked with them as a professional learning community to see how best we could expand our knowledge of science teaching with Indigenous technological practices. Herein lies the importance of expansive learning, emphasised in the CHAT (Engeström, 1987). All these teachers were black Namibians, three females and three males. Four of them were experienced in teaching chemistry, and two were inexperienced.

Purposive sampling was considered appropriate. Pandey and Pandey (2015) explain that purposive sampling means selecting a sample based on criteria which are considered important to the study. Cohen et al. (2018) point out that purposive sampling does not mean exclusive sampling; rather, the researcher is choosing the participants based on their judgement of participants' characteristics.

[5]Happiness could not continue due to her critically ill mother who had to be transferred from the North (about 700 km) to be hospitalised in Windhoek. Despite this dilemma, she had indicated that she was willing to continue to be involved in the study as she saw the benefits of professional development.

4.5 Research Participants

Each of the six teachers was given a code from TA to TG. However, some of the participants were not happy with the codes (see Section 1.14). I thus asked them to choose pseudonyms of their choice and explain what those meant (see Table 4.1 below). Notably, none of these had participated in research that involved IK custodians demonstrating Indigenous technologies before.

Table 4.1: Participants' self-chosen pseudonyms and personal details

Names	Gender	Meaning and Reasons for Choosing a Pseudonym	Qualification	Experience
Theoretical	Male	Intellectual and critical thinking based on certain theories	Bachelor of Education, Honours in Science Education, Master of Educational Leadership and Welfare Policies	7 years of teaching experience; majored in chemistry and biology
Scientist	Female	The love of science that drove me to participate in this study	Bachelor of Education, Honours in Science Education and Master of Science Education	14 years of teaching experience; majored in chemistry and physics
Nelago	Female	My Indigenous name means lucky one and I consider myself lucky to have been part of this educational research	Bachelor of Education, Honours in Science Education and Master of Science Education	11 years of teaching experience, teaching chemistry and physical sciences
Panduleni	Female	I am thankful to be part of this research	11 years of teaching experience, teaching biology, chemistry and physical sciences	Bachelor of Education, Honours and Master of Science Education
Brave	Male	I regard myself as a brave man who is competent and knowledgeable in teaching chemistry	4 years of teaching chemistry	Honours in Mathematics and Physical Sciences Education

4.6 Research Focus and Processes

The study is an interventionist, participatory, expansive and formative case study. Following pupils' attitudes towards technology similar to the change laboratory, this study explored the integration of Indigenous technological practices – in this case, marula oil extraction – into grade

11 organic chemistry lessons. It looked at drawing on the community's cultural heritage of Indigenous technologies through collaboration and community participation to form professional learning communities. Indigenous technological expertise (cultural heritage) was used to support teaching and learning, and professional learning communities to broaden training and workshops. Six (except for Happiness, who could not continue) grade 11 chemistry teachers in Okahandja learnt to improve their teaching strategies through community members' presentations on Indigenous techniques of marula oil extraction. Unlike Engeström and Sannino's change laboratory cycle shown in Figures 3.3 and 3.4, this formative interventionist study was conducted in three phases.

4.6.1 Phase one: Mirror data generation

This was baseline data that Engeström (2001) refers to as *mirror data,* aimed at finding out pedagogical experiences and insights into grade 11 chemistry concerning the integration of Indigenous technological practices. However, I was mindful that from a scientific perspective, in particular, physics, the left-hand side in a mirror becomes the right-hand side. Also, although mirrors do not lie, there are blind spots or contradictions. To surface contradictions, I used semi-structured interviews (Cohen et al., 2018). This phase thus aimed at answering the first research question:

> What were grade 11 chemistry teachers' pedagogical insights regarding integrating Indigenous technological practices into science teaching and what contradictions emerged?

Following Klein et al. (2018), I opted to interview all six participants as it is a more accurate way of obtaining information, as participants can openly air their views. Phase One was conducted during the COVID-19[6] pandemic lockdown state of emergency, and I could not travel from Otjiwarongo to Okahandja, where my participants were based. I telephonically interviewed six teachers to explore their pedagogical insights into integrating Indigenous technological practices in science teaching. I administered interview schedules adapted from Cetin-Dindar and Geban (2017) (see Appendix G). Semi-structured interviews were piloted with PhD scholars. However,

[6] During the COVID-19 outbreak in Namibia, the lockdown state of emergency was declared and travelling from one place to another was not allowed. I could not travel from my duty station to Okahandja, where my participants were situated. Therefore, I had to interview my participants via the phone.

interviews alone were not considered sufficient to collect data; moreover, Klein et al. (2018) indicate that interview data might be subject to bias. Hence, workshop discussions were also used.

4.6.2 Phase two: Capacity building and expansive learning

In this phase, I was engaged in facilitating and directing workshop discussions and reflections. The intervention for capacity building and expansive learning phase responded to the second, third and fourth research questions:

- What contradictions regarding integrating Indigenous practices surfaced when grade 11 chemistry teachers co-analysed the curriculum documents and textbooks?
- What expansive learning opportunities were created (or not) when the grade 11 chemistry co-developed exemplar lessons that integrated traditional marula oil extraction and other Indigenous technological practices?
- How did grade 11 chemistry teachers enact and reflect on the exemplar lessons that integrated traditional marula oil extraction and other Indigenous technological practices into their classrooms?

Ahmed and Asraf (2018) noted that workshops serve well as an avenue for the meeting of participants who have volunteered to be a part of the study. Through workshops, researchers may be able to elicit rich information from the participants. In this study, workshops were conceptualised as change laboratories (Engeström et al., 1996). Ørngreen and Levinsen (2017) identify three perspectives on workshops, namely, *workshop by means* which views the workshop as the means of achieving the goal, *workshop as a practice* which focuses on investigating the relationships between the workshop and its form and outcomes, and *workshop as a research methodology* which concentrates on the study of domain-related cases using the workshop format as a research methodology. A change laboratory is a direct intervention that promotes expansive learning by giving direct transformative collaborative agency to the participants through questioning and analysis (Englund, 2018). A change laboratory is typically conducted in an activity system facing a major transformation (Engeström & Sannino, 2017). In this study, workshops were regarded as the different stages of the change laboratory and the discussions were viewed as a practice to achieve the research goal. In this phase, we conducted an orientation workshop and a document analysis workshop, all audio recorded for data analysis purposes with the participants' permission (see Appendix J).

During these change laboratory workshops and cycles, we discussed and reflected on the contradictions and factors that constrained the integration of Indigenous technological practices into chemistry lessons. Teachers engaged in expansive learning in the change laboratory workshops and learnt to expand their pedagogical reasoning. I now look at the change laboratory workshops in more detail.

4.6.2.1 Change laboratory workshop one: Orientation

The first Change Laboratory Workshop was conducted on 24 March 2022 and lasted about one hour and 45 minutes. The purpose was for the participants to familiarise themselves with the research goal, objectives, questions and processes involved. Data generated from the workshop discussions was augmented with data from document analysis. Although I expected all six teachers to attend the workshop, two of them were absent: on the day of the first workshop, I could not get hold of Happiness as and her phone was unreachable. I assumed that perhaps she changed her mind and withdrew from the research, while the other one (Brave) sent an apology. I decided to proceed with four teachers, and the whole orientation workshop session went very well. I observed active participation. Reflections were made on this session, and this Change Laboratory Workshop allowed participants to interact and familiarise themselves with the research processes concerning the integration of Indigenous technological practices; this helped them to move from a limited understanding to an expanded view of technology.

4.6.2.2 Change laboratory workshop two: Document analysis

The second Change Laboratory Workshop was conducted on 11 April 2022 and lasted about two hours. Before the document analysis session, participants reflected on the previous workshop. Document analysis is a data collection method whereby documents are used as a source of data to answer research questions. Marchant (2018) acknowledges that document analysis is an affordable technique, and quicker than collecting data from scratch, as the information already exists. Documents can provide useful background data on the research topic. The significance of document analysis is that documents provide supplementary research data and insights that can be valuable additions to a knowledge base (Bowen, 2009). In this study, document analysis helped me to answer the following research question:

> What expansive learning opportunities were created (or not) when the grade 11 chemistry co-developed exemplar lessons that integrated traditional marula oil extraction and other Indigenous technological practices?

To achieve this, documents such as the National Curriculum for Basic Education, the grade 11 chemistry syllabus, policy documents and textbooks were analysed using Mavhunga and Rollnick's (2013) TSPCK as an analytical tool (see Appendix J). The tool of TSPCK was used to find out the main ideas on each topic, namely: learners' prior knowledge, what is difficult to understand for each topic, how the topics can be broken down into teachable units and presented in a manner that enables the learner to understand and lastly, how teachers think through the different teaching strategies that they can use to teach each topic concerning Indigenous technological practices and how to integrate technology into science teaching. We looked at the concept of technology, which in this research was regarded as a key learning area and a critical aspect of teaching and learning. Teachers identified numerous examples of Indigenous technologies and related these to grade 11 chemistry topics, themes and concepts.

We also analysed in depth the extraction of marula oil, which was the core aspect of my research. Many questions regarding the experimental techniques of marula oil extraction emerged – some were reserved for the IK custodians (who were regarded as more knowledgeable than others in this research) in the next planned session. Grade 11 chemistry textbooks were also analysed to see if our local examples of Indigenous technological practices were cited or not, and to what extent they were cited. It was very interesting and seemed like teachers were empowered and, most importantly, emancipated – herein lies the importance of the transformative paradigm in my study.

This study admits that document analysis may not provide more insight into participants' personal thinking or behaviour, as it may produce data restricted to what already exists. Similarly, the types of documents we read may differ in terms of information and accuracy, and some may be very opinionated or subjective, while others may be highly factual and descriptive (Cohen et al., 2018). In addition, secondary data from books, websites, reports and newspapers was regarded as lacking sufficient data, and therefore observation was also used as a data collection method.

4.6.2.3 Change laboratory workshop three: Indigenous knowledge custodians' presentations

The third Change Laboratory Workshop was conducted on 29 April 2022 and lasted two hours and 30 minutes. As in previous workshops, a reflection on the previous workshop was made. This was an intervention where presentations were made by three expert community members who were regarded as IK custodians. Five teachers and I visited the IK custodians and attended the workshop. The experts presented and demonstrated the indigenous technological practice of marula oil extraction. The purpose of this phase was to answer the following research question:

> How did the practical demonstrations on traditional marula oil extraction by the Indigenous knowledge custodians enable and/or constrain the grade 11 chemistry teachers from becoming cultural knowledge brokers?

The initial idea was to have only one community member, and I was surprised to find on the day of the presentation that there were three community members to facilitate the workshop. This shows the spirit of Ubuntu in the form of togetherness and eagerness. I could not turn away the other *uninvited* IK custodians because, in Ubuntu, when such a thing happens, we welcome everybody. After all, Ubuntu is about sharing and mutual benefit. There were also more than ten other community members, and some learners were present. Surprisingly, one of the three community member facilitators was a male. In Oshiwambo culture, marula oil extraction is believed to be a cultural activity for women. He contributed by facilitating and explaining the procedures involved in marula oil extraction. This male facilitator was bold enough to break this cultural belief and said, "*It is just a belief; everyone can do it".* Thus, the issue of gender emerged (Haimene, 2023), which I was not expecting. The whole group of community members was so happy and excited to be part of this presentation, and no objection was raised.

4.6.3 Participatory observations

Fraenkel and Wallen (2008) indicated that certain kinds of research questions can best be answered by observing how people act or how things look. It is through participatory observation that the professional learning community members carefully watched how teachers learnt (or did not) during the practical participatory demonstration. Participatory observations were made, and I used the CHAT components – contradictions, rules, division of labour and other components – to illuminate the expansive learning spaces that were created. Reflections were also made at this phase. I noticed during participatory observation that some of the teachers, especially those not sure about integrating Indigenous technological practices, reflected and related their observations of certain scientific concepts.

4.6.4 Change laboratory workshop four: Co-development of lessons

The fourth and final Change Laboratory Workshop was conducted on 16 May 2022 and lasted about two hours and 20 minutes. This is where we carried out co-development and teaching of exemplar lessons, classroom observation, stimulated recall interviews and reflections. Participants came together, and we had a session that enabled us to co-develop the exemplar lessons that integrated Indigenous technological practices. Concept mind maps were formulated, which guided our selection of the topics that were taught. Two teachers were given the responsibility to teach two lessons each, while other participants were observed as critical friends. After the lessons, participants came together to conclude the intervention by reflecting on the entire research process and anticipating Indigenous technological practices. Change laboratory workshop four aimed at answering the fourth research question:

> How did grade 11 chemistry teachers enact and reflect on the exemplar lessons that integrated traditional marula oil extraction and other Indigenous technological practices in their classrooms?

4.6.5 Phase three: Intervention

During this phase, co-developed lessons were taught, observed and analysed. Reflections were also made.

4.6.5.1 Participatory lesson observations

Co-developed lessons were taught, videotaped and observed with the participants' permission. I opted for participatory lesson observation, as Cohen et al. (2018) explain that it allows a researcher to directly observe real-life situations and use their senses to examine naturally occurring situations, integrated IK, and their students' engagement during the IK-mediated lessons. Klein et al. (2018) contend that observation may be subject to observer bias and limited to observer perception. The presence of an observer may also have a considerable impact on the behaviour of those being observed and the data collected (Fraenkel & Wallen, 2008). During the participatory lesson observation, I noted that teachers became cultural brokers as they used the cultural tools from IK custodians to mediate chemistry lessons. Thus, I had stimulated recall interviews and journal reflections to strengthen my observation data.

4.6.5.2 Journal reflections

Writing in a personal reflective journal may be valuable to student teachers for developing cognitive abilities for promoting their self-orientation and responsibility for the processes of their personal and collaborative learning (Bashan & Holsblat, 2017). In this study, learning was regarded as an argumentative process; thus, teachers were exposed to learning activities within research processes and encouraged to reflect on the learning events to make their judgements and contributions to the intervention. The reason for using reflective journals in this study was to inspire teachers to be more aware of their roles within the intervention concerning what they did and how they did it, and to identify impacts, strengths, weaknesses, problem-solving strategies and future plans.

Teachers reflected on the lesson deliveries and the entire intervention process following Otulaja and Ogunniyi's (2017) suggestion that reflection-on-action should occur after the lessons or learning activities. Participants reflected on the cultural heritage presentation by a community member, mediating lessons that integrated Indigenous technological practices and the general intervention process. Cohen et al. (2018) believe that highly reflexive researchers will be aware of how their selectivity, perception, background, values, inductive processes and paradigms shape their research. Through journal reflection, I discovered what works better (or not) and areas of improvement.

4.7 Data Analysis

Data were coded according to themes that emerged from the data (see Appendices H and I). Mavhunga and Rollnick's (2013) TSPCK components offered me the lens to investigate the expansion of the object activity through teachers' pedagogical insights, participation and learning in workshops, developing model lessons, reflections and classroom enactment. This was done to see how teachers transformed the subject matter and represented it using certain teaching strategies that would make it simpler for their learners to understand curriculum concepts. I also used CHAT to examine how the participants within the activity system interacted through the division of labour, for instance, how the teachers used their prior knowledge. Video-recorded lessons were transcribed and colour-coded to represent events in the lessons describing the enactment of specific TSPCK components (see Appendices H and I). Remarks during stimulated recall interviews where teachers explained their pedagogical reasoning were coded. Mavhunga and Rollnick's (2013) five TSPCK components are the following.

Curriculum saliency – unit analysis: teachers' ability to understand, re-arrange and sequence key ideas and concepts of grade 11 chemistry concepts within experimental techniques; traditional oil extraction (*odjove*) (Nyamakuti, 2021). *Representations* – using strategies and tools (oil extraction), conceptual teaching strategies, collective consideration of *curriculum saliency*, *learners' prior knowledge*, *what is difficult to understand* and how it can be made easier. Representations entail using cultural tools and determining if they lead to effective teaching and learning. This project was a formative intervention, an expansive learning study that sought to expand the object of science teaching activity with Indigenous technological practices, and therefore, TSPCK components were used with the third-generation CHAT across three activity systems: *teaching, cultural and community* and the *professional learning community.*

The triangular models of the units of analysis of the first three generations were *mediated action*, *collective activity* system, and *three interacting activity systems with a partially shared object*; they were regarded as effective instruments for participatory collective analysis and design. The CHAT expansive learning cycle components and principles were used to see how activity systems interacted and intersected at the point of the shared object to develop new technological science knowledge and to see possible tensions and contradictions. Analytical frameworks followed inductive and abductive approaches.

4.8 Validity and Trustworthiness

Validity and trustworthiness are the degree of confidence in the data, findings and instruments used. Validity, reliability and trustworthiness are important elements that provide quality in research. Pandey and Pandey (2015) define validity and reliability as the ability of an instrument to measure what is expected consistently throughout a series of measurements. If the research process and data are invalid, the research will be insignificant. Furthermore, Moon et al. (2016) advocate that quality in qualitative research can be achieved by looking at four aspects: dependability, credibility, confirmability and transferability.

- **Dependability -** ensured by clearly documenting the methods used to explore Indigenous technology, including how data was collected from teachers, communities, and experts in IK systems.
- **Credibility -** engaged with various stakeholders such as science teachers, IK custodians, and learners to ensure the findings accurately represent how marula oil extraction can be integrated into science education. Triangulating data from interviews, observations, and curriculum analysis strengthened validity.
- **Confirmability -** provided a transparent member checking, participatory observation, ensuring that interpretations are based on evidence rather than personal bias. Using direct quotes from participants, field notes, and supporting literature reinforces the objectivity of the findings.
- **Transferability -** insights gained from integrating Indigenous technology into grade 11 chemistry teaching and learning were presented in a way that allows other educational contexts, especially those with similar cultural and technological needs, to adopt or adapt the approach. Comparisons with Indigenous and modern education models from other regions could enhance the relevance of your findings globally.

By applying these criteria, my study strengthened the reliability and applicability of IK in formal science education, bridging traditional practices with modern curricula meaningfully.

To ensure validity and trustworthiness in my study, piloting of data gathering tools or instruments, triangulation of methods, transcription of interviews, reflections, member checking and stimulated recall interviews were used. I thus presented my work and piloted my instruments within our community of master's and PhD scholars to validate my research project. I also co-presented my study together with four of my research participants, namely, Panduleni, Theoretical, Scientist, Nelago and Brave, at the South African Association for Research in Mathematics, Science and Technology Education Namibian chapter colloquium on 6 October 2022. So, my research informants were known by the Science, Technology and Mathematics Education community. For instance, this ethical dilemma or tension begs other questions. Is anonymity possible in interventionist studies? Is it ethical not to use research participants' real names and also blur their faces? Could this be a perpetuation of colonialism?

In this regard, Smith (1999, p. 1) argues that

> …the term 'research' is inextricably linked to European imperialism and colonialism. The word itself, 'research', is probably one of the dirtiest words in the Indigenous world's vocabulary. When mentioned in many Indigenous contexts, it stirs up silence, it conjures up bad memories, it raises a smile that is knowing and distrustful. It is so powerful that Indigenous people even write poetry about research. The ways in which scientific research is implicated in the worst excesses of colonialism remains a powerful remembered history for many of the world's colonised people. It is that still offends the deepest sense of humanity.

Interestingly, Scientist raised the issue of initially being referred to as TB (which stands for tuberculosis) at the colloquium. In hindsight, that turned out to be a learning experience for other students. For example, the danger of giving pseudonyms to participants, especially in interventionist which they have contributed construction of knowledge. It could be argued that this is tantamount to separating the knowledge from the knower.

Moreover, similarly to Simasiku (2022), Liveve (2022), and Mayana (2024), I had a sharing circle with my participants and IK custodians to acknowledge and appreciate their knowledge, wisdom and skills they shared with us. The IK custodians felt a deep sense of pride and responsibility in participating in the study on integrating marula oil extraction into Namibian science secondary education. Their involvement allowed them to share generations of knowledge while ensuring that Indigenous practices were recognised and valued within formal education. They expressed appreciation for the opportunity to bridge traditional wisdom with modern science, viewing it as a means of preserving cultural heritage while contributing to sustainable education. However, some custodians also voiced concerns about ensuring that their expertise was accurately represented and respected, emphasising the need for collaboration and fair acknowledgement of Indigenous contributions. Overall, their engagement fostered a renewed commitment to promoting IK as an essential component of scientific inquiry and technological advancement

4.9 Ethical Considerations

During this research, I reviewed my actions to ensure that my participants' rights and welfare were protected. The first thing that I did was to present my proposal to Rhodes University's

Ethical Department, where I received an ethical clearance certificate (see Appendix A). From there, I asked permission in writing from the regional education director to carry out the research in the schools in the region (see Appendix B1). I also asked permission from the circuit inspector and school principals to allow me to work with their teachers (see Appendix E1). Informed consent letters were sent to the teachers who participated in this research and to the parents of the learners involved in the lessons observed (see Appendix E2). Informed consent is the practical application of the principle of autonomy and respect for persons where the researcher demonstrates respect for each participant as a person capable of decision-making (Kruger et al., 2014). In the context of my study, participants were subjected to the ethical obligation that they were allowed the opportunity to choose whether they were willing to participate or not.

I analysed my research context to see if there were any jeopardy or potential risks and benefits to the participants. I explained the goals and objectives of the study to them. In my role as primary investigator, I was mindful of my positionality as I served a dual role as both a senior teacher at the regional level and a researcher. As a senior education officer for the Teachers' Resource Centre in the Otjozondjupa region where the research was conducted, I had to remain cognisant of interactions with participants with whom I had prior professional connections within the region as an advisor in teaching and learning resources. Power relations between the researcher and participants were acknowledged as a potential factor influencing the quality of data collected (Greene, 2014). I did not misuse my position as a senior education officer but rather conducted my research in agreement with research principles.

As an insider researcher, I was also aware of the insider knowledge I possessed regarding the professional practices of the participants within the context of my study that might have influenced the objectivity of my conception. To diminish subjectivity during the data collection process, I was vigilant to remind the participants that their honest perspectives were significant to the study and that they should not allow my position to influence their responses. My role was to collect, record and interpret the data in a non-judgemental manner. To strengthen credibility, I transcribed interviews, workshop discussions and journal reflections accurately. In addition, I applied my insider knowledge of the situational context and professional relationship with the participants in framing the interpretation of data. I conducted my research following the code of ethics of professional development within the education sector. I paid special attention to critical circumstances that included vulnerable participants, such as teachers from marginalised groups in the community. The research was conducted based on the principles of respect, integrity, dignity, transparency, honesty, accountability, responsibility and academic professionalism.

There were critical, challenging ethical dilemmas that were encountered in this study. Firstly, the issue of confidentiality and anonymity arose when participants were not comfortable with the codes. According to the Eurocentric research protocols, participants' identities should be treated with confidentiality and anonymity and will not be revealed. Although they ended up choosing their preferred nicknames as pseudonyms, it appeared that they wanted to use their real names because, according to them, they could not see the point of being hidden. They indicated that they were proud to be part of this study, and they gave me consent for their faces not to be covered but rather to be seen with uncovered faces (see Appendix Q). Why should you cover our faces while we have contributed knowledge to this study (Scientist, Panduleni)?

Mutanho (2021) argues and questions where we draw the line between academic theft and the concern to protect people from potential harm, and why we should use one perspective to interpret everything that happens in human experiences. Based on what emerged in this study, ethics should be controlled by the local understanding of local people, local protocols, and experiences of Indigenous people (Smith, 1999), whose contributions will be published. It dawned on me that this experience signalled the importance of decolonising research methodologies and the role of researchers in Indigenous contexts, as reiterated by Seehawer (2018) and other scholars. In this regard, Datta (2018) argues that traditional Western research approaches often oppress Indigenous communities and fail to respect their cultural knowledge and practices. This suggests that researchers cannot dictate to the participants regarding their decision about confidentiality and anonymity. This rather emphasises the importance of building collaborative, culturally appropriate, and respectful research frameworks that honour Indigenous sovereignty and ways of thinking. Datta (2018) further shares personal experiences and case studies to illustrate the challenges and benefits of decolonising research, ultimately advocating for more empathetic and responsible research practices.

Secondly, the matter concerning Happiness, who was absent from the first workshop, unfolded in a challenging way. As I alluded to earlier, I could not get hold of Happiness as her phone was unreachable. I assumed that she had changed her mind and withdrawn from the research. Yet, that was not the case, and I came to know what was happening with her at a later stage when I was done with the data collection. According to Happiness, on the day of the first workshop, something beyond her control came up and she could not attend, although she wanted to. After some time, when the data gathering process was completed, she voluntarily communicated with me that she had a challenge with her mother, who fell critically ill. However, she was still interested in the study. As a result, one of the participants briefed her on how the research process went. Based on the integrity of the research data, I acknowledged that Happiness did not withdraw; she was just absent and gave consent for her data to be used (see Appendix R). On reflection, the dilemma was that I found it difficult to find a proper term that could describe the absence of a participant who could not continue due to circumstances that came up, but still wanted to be part of the study. That was the reason I used her interview data for phase one. This ethical issue was complex, and I applied the principles of Marovah and Mutanga (2023), that Ubuntu provides a moral framework that guides researchers in conducting ethical and respectful research, ensuring that the rights and well-being of participants are prioritised.

4.10 Chapter Summary

In this chapter, I explored various research methodologies pertinent to our study, outlining their theoretical underpinnings, practical applications, and the rationale for their selection. I discussed the qualitative and quantitative paradigms, elucidating their distinct characteristics and relevance to our research objectives. I then delved into specific data collection techniques, including surveys, interviews, and observational methods, emphasising their appropriateness in capturing the study's nuances. I highlighted the importance of research ethical considerations, ensuring that the processes adhered to the highest standards of integrity and respect for participants. Furthermore, I examined the data analysis procedures, outlining the steps involved in qualitative analysis. The triangulation of data was discussed as a means to enhance the validity and reliability of the research findings.

CHAPTER FIVE: CHEMISTRY TEACHERS' PEDAGOGICAL INSIGHTS: DO PARTICIPANTS' VOICES MATTER?

> Mirror data are useful for researcher-interventionists themselves to become acquainted with the actual work practice and the tensions involved but are primarily shown to the practitioners to prompt discussion amongst participants. (Meijer et al., 2023, p. 31)

5.1 Introduction

This study contends that it is important to understand teachers' perspectives and pedagogical insights into integrating Indigenous technological practices into science teaching. This helped to strengthen the first step in the change laboratory process, which was gathering mirror data (Engeström, 2011). As highlighted in the above epigraph, mirror data are useful for researcher-interventionists to become acquainted with the actual work practice. This chapter thus presents data gathered during the pre-intervention phase aimed at addressing the following research question:

> What were grade 11 chemistry teachers' perspectives and pedagogical insights regarding the integration of Indigenous technological practices into science teaching and what contradictions emerged?

The data presented in this chapter were gathered through telephonic interviews. The interviews were done telephonically because, during that time, there were strict COVID-19 regulations and lockdowns were imposed. Hence, I was unable to travel and meet my informants face-to-face as I had planned initially. The informants and I thus agreed to conduct interviews telephonically.

In this chapter, I present the manifestation of contradictions that emerged in the mirror data gathered through semi-structured interviews (see Section 4.6.1). Firstly, data sets were recorded and transcribed. I then colour-coded them (see Appendices G1 and G2) and categorised them into sub-themes and themes. I intended to triangulate the data sets from different analytical lenses in addition to the main (CHAT) analysis (Engeström, 2011).

5.2 Data from Semi-Structured Interviews

The themes and sub-themes were then linked to the theory/literature as shown in Table 5.1 below.

Table 5.1: Themes emerged from semi-structured interviews

Theme	Sub-theme	Literature	Theory
Teachers' understanding of and insights into the integration of Indigenous technological practices	• Understanding of indigenous technological practice concepts • Insight and views on Indigenous technological practices integration	Cobern and Loving (2001) Munabete and Umar (2014) Ankiewicz (2016) Aikenhead and Jegede (1999) Gumbo (2016) Seehawer (2018)	CHAT TSPCK
Significance of integration of Indigenous technological practices	• Link between cultural practices and school science • Enabler of teaching and learning of science concepts	Mukwambo (2016) Mavuru and Ramnarain (2020) Gwekwerere (2016) Shinana et al. (2021) Tikly et al. (2018) Asheela et al. (2021) Hashondili (2020) Ndevahoma (2019) Nikodemus (2017) Seehawer (2018)	CHAT TSPCK TPACK
Tensions, conflicts and dilemmas surfaced in indigenous technological practice integration	• Indigenous technological practices integration is neglected and undocumented • Ignorance, lack of training and exposure, human resources, time and financial constraints	Farrar (2016) Engeström (2001, 1987) Mawere (2014) Semali and Kincheloe (1999) Odora-Hoppers (2002) Breidlid (2013) Emeagwali and Shizha (2016) Shizha (2016) Maluleka (2006) Shizha and Emeagwali (2016) Ngcoza and Southwood (2015) Gumbo (2016) Ogunniyi (2007a, 2018)	CHAT
Possible examples of Indigenous technological practices	• Drinks and food production • Food preservation and purification • Herbs and soap	Kamba (2016) Simasiku (2022) Liveve (2022) Nyamakuti (2021) Shinana et al. (2021) Shizha (2016) Breidlid and Botha (2015) Cheikhyoussef (2018)	CHAT

As can be seen in Table 5.1, four themes emerged from the semi-structured interviews and are discussed below.

5.2.1 Teachers' understanding and insights regarding integrating Indigenous technological practices

The teachers identified some common and novel understandings and pedagogical insights. For instance, when teachers were asked about their understanding of Indigenous technological practices, they seemed to have some understanding of this. For example, they understood it as the kind of local technology, experiences that involve cultural practices in our everyday lives, and the use of natural resources to produce cultural products that can make life easier. In this regard, Theoretical defined Indigenous technological practices as:

> *Local experience, local methods or methods that are used by the Indigenous people who are occupying a certain geographical area for quite long time. What I do understand is that these are the symbols and technological skills that have been used by our forefathers or some of the Indigenous people and these are not documented.*

On the other hand, Nelago understood Indigenous technological practices as:

> *These are our everyday life practices and I think in most instances we misunderstand this can make our lives easier and used to teach our learners to learn better. There is always a link between Indigenous knowledge and technology.*

The excerpt above highlights an important perspective on the interplay between IK and technology. It suggests that our everyday practices, often rooted in Indigenous wisdom, can serve as tools for simplifying life while enriching learning experiences for students. However, the excerpt also notes a common misunderstanding concerning the tendency to overlook or undervalue the potential of IK in the context of modern technology.

Indigenous knowledge (IK), which is derived from generations of experience and interaction with the environment, offers invaluable insights. When properly understood and integrated, it can harmonise seamlessly with technological advancements. This synergy can not only improve practical applications but also enhance teaching methodologies, making learning more accessible and relevant to students' lived experiences. The excerpt serves as a reminder that fostering this connection between Indigenous knowledge and technology requires effort and intentionality. Teachers and learners alike can benefit from embracing this relationship as a means of innovation and cultural appreciation. By doing so, we can pave the way for more inclusive and effective educational practices and contribute to the broader understanding of how tradition and modernity can coexist and thrive together.

Panduleni's understanding of Indigenous technological practices also had to do with practices that people do at home to make their lives easier. Likewise, Brave seemed to understand them as important activities that take place in different cultural practices across the country, using the natural resources around them to make certain cultural products. According to Panduleni, Indigenous technological practices have to do with IK and are mostly what is done at home. Like Nelago, he added that this could be brought into the classroom to make the learners understand better.

These teachers' responses revealed that they displayed various understandings of the concept of Indigenous technological practices. Their definitions seem to resonate with Munabete and Umar (2014), who view Indigenous technological practices as anything designed, fabricated, adopted, and used in an environment for the advancement of the people of that environment. Similarly, these definitions seem to be congruent with Ankiewicz (2016), who understands that Indigenous technologies are all about associated practices that have been and are still being used by Indigenous and local people for existence, survival, and adaptation in different environments.

Teachers were also asked to share their opinions on the integration of Indigenous technological practices into science lessons, and these were some of their responses:

> *But in my view, I feel that, if we happen to incorporate the Indigenous technological practices in science teaching, this of course will close the gap between home science and school science (Theoretical).*

> *I think this will make the work easier for both teachers and the learners in the teaching of the chemistry concepts so it is something will make the work easier for the learners to understand concepts better or to understand certain contexts better or also maybe to make it easier for the teaches to be able to explain concepts or certain context to the learners and make them understand (Scientist).*

> *People in the community are using materials that can be scientifically used in our chemistry syllabus. So, the integration at the school is appropriate (Brave).*

From the excerpts above, it seems that these teachers thought that the integration of Indigenous technological practices could link the learners' home cultural background to school science teaching, which Aikenhead and Jegede (1999) refer to as border crossing. Considering her immediate context, Godlo (2024) refers to this as a river crossing. In her metaphor, Godlo (2024) explained that in her area, schools and homes are separated by rivers. In addition, Brave noted that community members were using scientific materials relevant to the science curriculum and that such integration was regarded as an appropriate strategy in teaching.

These comments seem to indicate an awareness of PCK, which Mutanho (2024, pers. com) referred to as personal PCK. Judging by this semi-structured interview, it seems like integrating Indigenous technological practices into science lessons has the potential to connect home background situations to school science. This is situated learning that Lave and Wenger's (1991) stress that situated learning theory revolutionised the way we understand learning, which emphasises that knowledge is best acquired through active participation in authentic settings, rather than in abstract or decontextualised environments. Situated learning perspectives understand that learning occurs through the act of interacting and socialising in real contexts with others who possess varying degrees of expertise and knowledge (Jusinski, 2021). Applying a situated learning approach enhances understanding of how certain teachers contribute to their learning, which subsequently improves their professional development.

Extending on Aikenhead and Jegede’s (1999) seminal work on border crossing, Gumbo (2016) believes that the integration of Indigenous technologies in education has the potential to be a practice of hope, bridging the gap between home and school by addressing authentic problems in learners’ environments. Concurring, Mhakure and Otulaja (2017) refer to such pedagogies as being culturally responsive or sensitive because learners’ sociocultural contexts are considered (Mavuru & Ramnarain, 2020).

However, these teachers had different views on integrating Indigenous technological practices. For instance, Theoretical revealed: “*During my year of teaching, I have never heard about Indigenous technological practices mentioned in our curriculum”.* This comment suggests that Theoretical might have little understanding of integrating Indigenous technological practices into science lessons. It seemed it was the first time he had heard about Indigenous technological practices. Besides, it could be deduced, therefore, that there was a knowledge gap in his PCK, which is critical in making subject content knowledge comprehensible and relatable to learners. On the same note, Nelago commented that although the syllabus encourages IK to be integrated into daily lessons, the tensions or conflicts, or dilemmas are that it is not explicit on how it can be done. This suggests that the silencing of IK in the Namibian curriculum is not silent, as this might have a negative influence on teachers’ PCK (Mavhunga & Rollnick, 2013).

Understandably and not surprisingly, therefore, these teachers were at different zones of proximal development regarding integrating Indigenous technological practices into the curriculum. For instance, both Theoretical and Nelago faced a dilemma within their teaching practice and curriculum content, as they lacked guidelines for the integration of Indigenous technological practices. From their perspectives, curriculum documents have no clear guidelines on how to integrate Indigenous technological practices into science teaching. This observation resonates with Seehawer (2018), who found that what hindered teachers from integrating IK, was the lack of clear guidelines in the curriculum. Lack of access to various IK and cultural practices can also be a constraint.

In this regard, Brave felt that integrating Indigenous technological practices would be a new approach for the learners and he recommended that integration be done across the curriculum. This means that it should start from lower grades, resulting in what Bruner (1996) referred to as a 'spiral curriculum'. Bruner's idea of a 'spiral curriculum' complements scaffolding by emphasising the revisiting of key concepts across different grade levels, with increasing complexity each time. In terms of Indigenous technological practices, this could mean introducing basic ideas in lower grades, such as traditional methods of farming or crafting, and then exploring their scientific principles and technological applications in higher grades.

Arguably, this approach ensures that learners deepen their understanding over time while building on their prior everyday knowledge (Kuhlane, 2011). In practice, scaffolding might involve breaking down tasks into manageable steps, providing hints or prompts, using visual aids, or encouraging collaborative learning. For example, when introducing Indigenous technological practices, teachers could start by connecting these practices to learners' everyday experiences (Gwekwerere, 2016), gradually introducing more complex applications and theories as learners become familiar with the concepts.

5.2.2 Significance of the integration of Indigenous technological practices

When these teachers were asked to share their views on the benefits of integrating Indigenous technological practices into science lessons, their responses showed that they viewed the integration of Indigenous technological practices as a learning enabler. They argued that it provided learning and teaching support materials, improved teaching and learning of science concepts, provided local opportunities for educational excursions, and enhanced hands-on practical activities.

For instance, Theoretical explained: "*integration of Indigenous technological practices into science lessons can help learners to bridge from what they know to what they do not know*". In support, Scientist commented: "*When the home practices are brought to the classroom context learners will not forget because they are familiar with the practices from their home*". What is evident in these responses is that these teachers viewed the integration of Indigenous technological practices as a good platform from which to link home practices to the classroom context, as noted earlier. Mukwambo (2016) refers to this as contextualised teaching and learning. Similarly, Mavuru and Ramnarain (2020) also contended that effective teaching should consider learners' diverse sociocultural backgrounds. However, these scholars do not provide suggestions on how to do this.

The teachers who participated in this study viewed the integration of Indigenous technological practices into chemistry positively. They argued that the use of Indigenous technological practices enabled them to resolve the problem of a shortage of teaching and learning support materials in many rural schools in Namibia. They argued that the integration of Indigenous technological practices tended to go hand in hand with chemistry and physics because there were scientific skills and processes connected to Indigenous technological practices. This can benefit them as they are enriched with a wide range of teaching and learning support materials.

For instance, Theoretical said that the integration of Indigenous technological practices such as oil extraction from marula nuts into science teaching enables the teachers to make use of available teaching and learning materials in their communities, rather than relying on modern technological teaching and learning support materials and which are expensive and lacking in some of their schools. Similarly, Scientist shared her experience that not all schools are well equipped with science laboratory equipment. Some schools do not even have science laboratories. Integrating Indigenous technological practices is an approach that can help teachers overcome the challenge by using local examples relating to the everyday life of the learners (Gwekwerere, 2016; Shinana et al., 2021).

Furthermore, the findings revealed that if Indigenous technological practices were to be integrated into science lessons, many varied teaching and learning support materials could be created. These Indigenous technological practices could be used in practical demonstrations and experiments in science classrooms. Brave said:

> *If we integrate some of those things in schools, it will open eyes wider that there is a connection between these two because finally, we will end up having learning and teaching support materials that are already in place wherever there is the need.*

This comment resonates with Tikly et al. (2018), who indicate that many teachers lack the pedagogical skills required to deliver curricula efficiently since they rely on teacher-centred or traditional methodologies. This study used the cultural practice of marula oil extraction as a form of professional development to capacitate teachers in terms of PCK. I contend that for effective curriculum implementation, teachers must be equipped with the necessary teaching aids, technology, and other relevant materials to support quality teaching and learning in their science classrooms. In this regard, using easily accessible materials in science teaching and learning is recommended (Asheela et al., 2021; Shinana et al., 2021).

When asked about the benefits of integrating Indigenous technological practices into science teaching and learning, the teachers in this study pointed out that it could improve learners' interest in science, which would make it easier for them to understand. In this regard, Scientist reflected: "*This will be a wow moment for the learners and it will be a learning curve already because it will sound interesting to the learners".* On the same note, Brave commented:

> *The integration of Indigenous technological practices may provide an opportunity for the learners to learn science concepts from different perspectives and relate them to Indigenous technological practices as well as to other subjects.*

These excerpts seem to suggest that the integration of Indigenous technological practices has the potential to be an enabler of teaching and learning. These teachers also revealed that integrating Indigenous technological practices into chemistry would promote interest among their learners in science subjects. Moreover, Panduleni added that in some chemistry textbooks, the learners are expected to contextualise and should not just learn to memorise facts and concepts. Instead, learners need to be able to link science concepts to local technologies that they practise in their homes. Furthermore, the findings revealed that integration of this kind of knowledge can arouse the learners' curiosity and active participation. In this regard, Theoretical commented that there is a need for Indigenous technological practices to be used as illustrations and examples in their Namibian textbooks to help learners understand better.

Theoretical further lamented that integrating Indigenous technological practices can involve Indigenous or local people with expertise assisting teachers in the content and pedagogical knowledge for grade 11 chemistry. Having community members assisting and sharing their expertise with teachers promotes collaboration in teaching and learning. This is linked to the Ubuntu research agendas that contribute to strengthening methodologies that are community based, relational, and participatory and underpinned by Indigenous epistemologies (Seehawer, 2018).

The study further revealed that if Indigenous technological practices were integrated into science lessons, it may improve local knowledge and technology. For instance, Theoretical said:

> *Even when the learners are being taken on a tour, they are just taken to modern industries that are sometimes not located in their school environment. For me to integrate Indigenous technological practices into chemistry teaching, it could bring about opportunities of local educational tours.*

Theoretical further suggested that integrating Indigenous technological practices promoted local knowledge, technology, and advancement. The study also revealed the potential of community involvement that might create good relationships and bridges between schools and communities. Theoretical gave an example of teaching a lesson presenting the brewing or fermentation of alcohol, where some community members are called to demonstrate how to brew and distil alcohol or even make '*odjove*'[7]. Community members may get excited about demonstrating these processes to the teachers and the learners.

In this way, good relationships are created through a participatory approach. Integration of this kind can also create an opportunity for the teachers and the learners to do practical activities in the classroom. The Namibia Senior Secondary Certificate Ordinary national examiner's report (2021)

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[7]In the Namibian context, odjove refers to a traditional oil extracted from the kernels of the marula fruit. This oil is produced using traditional methods, often involving hand-cracking the marula nuts and pressing the kernels to extract the oil. Odjove is highly valued for its culinary uses, particularly as a delicacy served during festivals, weddings, or when hosting important guests. It is also appreciated for its rich, nutty flavor and is sometimes used in traditional dishes.

noted that many candidates lacked experience in practical activities. There is a need to emphasise assessment objectives and make experimentation part of teaching and learning to expose learners to practical activities to reinforce practical skills and abilities. It then recommends that teachers be encouraged to use easily accessible and locally available materials to conduct hands-on practical activities in the classrooms (Asheela et al., 2021; Shinana et al., 2021).

5.2.3 Manifestations of primary contradictions that surfaced from the integration of Indigenous technological practices

An analysis of the teachers' responses to the pre-intervention interviews revealed some manifestations of contradictions embedded in science teaching with regard to the integration of Indigenous technological practices. Haapasaari et al. (2016) argue that contradictions manifest as tensions, conflicts, and dilemmas in the activity system. In this study, the tensions, conflicts, and dilemmas emerged as hindrances to integrating Indigenous technological practices in science teaching and learning. Contradictions are based on aspects such as failing to integrate Indigenous technological practices, undocumented Indigenous technological practices, the dilemma of integrating Indigenous technological practices in multicultural classrooms, teachers' dispositions towards the integration of Indigenous technological practices, lack of training and exposure, and human resource constraints. These emerged when the teachers were asked to share their views on the challenges of integrating Indigenous technological practices. Figure 5.1 shows the manifestation of primary contradictions that emerged in this study – manifestations or symptoms of contradictions that historically evolved as a tension between two opposing forces in an activity system.

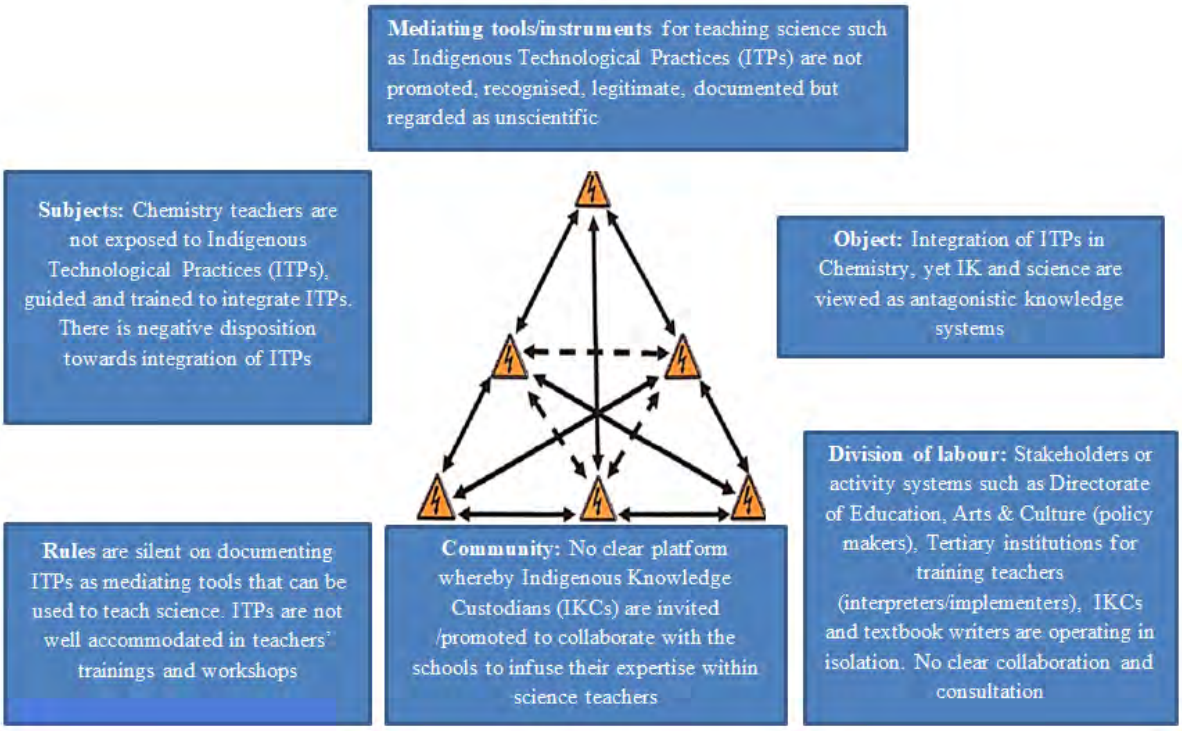

Figure 5.1: Manifestations of contradictions embedded in the science activity system (adapted from Mutanho, 2021, p. 127)

As shown in Figure 5.1, I used Engeström's (2001) second-generation model to show these tensions, conflicts and dilemmas. These are discussed below.

5.2.3.1 Object

In this study, the object[8] is regarded as the motive for teaching science through the integration of Indigenous technological practices. The extraction of marula oil was used as an example of how Indigenous technological practices could be integrated into the teaching of grade 11 chemistry on the topic of experimental techniques and chemical reactions. The first manifestation of a contradiction within this object was that although the Namibian curriculum supports the integration of Indigenous technological practices, it does not provide guidelines on how this should be done, as reiterated by Nelago above. As a result, this leaves teachers with the dilemma of not knowing how it should be done. Furthermore, the second manifestation of a contradiction was in the form of a dilemma that Westernised science and IK are generally viewed as antagonistic

[8] It is so intriguing that the CHAT scholars (even Vygotsky) do not refer to this as an OBJECTIVE and yet OBJECT is used synonymously with MOTIVE.

bodies of knowledge (Mutanho, 2021). This implies that teachers are required to reconcile two contradictory knowledge systems whose ontological and epistemological roots are completely different (Smith, 2020).

This supports what Seehawer (2018) discovered – that a curriculum that lacks clear guidelines on IK integration hinders teachers from integrating it. That is, there seems to be no alignment between what the teachers are expected to do in the class to implement and the curriculum documents that guide teaching and learning. In other words, curriculum documents and policies are not explicit, thereby creating the challenge of interpreting the curriculum into appropriate pedagogical strategies that enhance effective teaching and learning. It seems this dilemma within an object has resulted in teachers neglecting Indigenous technological practices in their teaching.

The third manifestation of a contradiction through conflict within the object was that Indigenous technological practices and modern technological practices ar also referred to as information communication technology – are two knowledge systems that are ontologically and epistemologically different and perceived as contradictory to each other. In the Namibian context, for instance, this tension emanated because of the historicity of information communication technology suppressing Indigenous technological practices. The mirror data from semi-structured interviews revealed this through Nelago's response:

> *This is one thing that I believe that it has been neglected in our day-to-day teaching methods. We do not really get to integrate Indigenous technological methods in our teaching when teaching science concepts. Yes, very much neglected and maybe what I can add is that when you see teachers coming from the workshops, when the specific things are presented for example when we attended our revised curriculum trainings and workshops, only few methods of local technologies were presented, but these things are not even documented or used regularly.*

Looking at the above excerpt through the lens of the CHAT, one can surmise that Indigenous technological practices seem not to be promoted in science teaching. During the teachers' workshops and training sessions, examples of Indigenous technological practices are neglected. Perhaps this is because Indigenous technological practices are not documented. This resonates with literature in which some African scholars are of the view that the science that is taught in African schools seems not to carry an African identity, and Indigenous technological ways of knowing seem not to be recognised by teachers (Mawere, 2014; Seehawer, 2018; Semali & Kincheloe, 1999). In addition, Kazhila (2015) argue that there are challenges such as the lack of documentation, the non-scientific nature of IK and the different cultural backgrounds of students and lecturers.

Furthermore, some scholars have criticised the dominance of Western epistemologies in African science education and advocated the integration of IK (Breidlid, 2013; Emeagwali & Shizha, 2016; Odora-Hoppers, 2002; Shizha, 2016). Moreover, the information communication technology used in science teaching is modern. Maluleka et al. (2006) posit that Indigenous technological practices, with their long history, cannot be ignored. Instead, they should be assigned a more prominent place in the curriculum. Nelago's responses revealed the manifestation of contradictions within science education, traceable to the historicity of science education. This is not only in Namibia but perhaps in many parts of Africa, as can be seen in Theoretical's comment: *"This study can keep us close to our roots rather than just depending and focusing on Western ideas"*.

The above excerpt has affinity with Freire's (1970) perspective on humanising pedagogies that enable one to reflect deeply on the essence of education. Most importantly, its power to honour cultural identity and collective roots challenges us to rethink the dominance of Western paradigms in educational frameworks. According to Freire's (1970) notion of humanising pedagogy, there should be an envisioning, centring on dialogue, critical thinking and the recognition of diverse ways of knowing in a way that advocates for us to embrace the unique histories, experiences, and epistemologies of communities which is overshadowed by contemporary globalisation. In doing so, this study acknowledged that there is a danger of overlooking IK systems and local practices in favour of Western-centric models. In essence, integrating Indigenous technologies in science education becomes an act of liberating cultural assimilation and empowering individuals to see value in their traditions. Smith (1999) discusses the importance of IK systems in education, particularly in relation to science. The work highlights how Eurocentric models often overshadow Indigenous perspectives, leading to the marginalisation of local knowledge and practices. Smith emphasises that integrating Indigenous technologies into science education is not just about integration but rather an act of empowerment and cultural liberation, allowing individuals to recognise the value of their traditions.To summarise, Freire's insights are relevant to this study as they seem to challenge teachers, educators, policymakers, and learners alike to decolonise education. By doing this, they can champion a pedagogy that celebrates diversity, nurtures inclusion, rooted in ensuring that the richness of human cultures is preserved and valued in every learning space.

5.2.3.2 Subject

The mirror data revealed some manifestations of primary contradictions within the subject. Engeström (1987) defined the subject as an individual or a group of activity-oriented people who can transform the object. When teachers were asked about their pedagogical insights, views and experiences concerning the integration of Indigenous technological practices, it emerged that they seemed to be lacking 'training' and exposure to Indigenous technological practices, yet they are expected to integrate them into their science lessons. Two teachers revealed a lack of guidance on how teachers could integrate Indigenous technological practices into their lessons. For instance, Panduleni said that the challenge of integrating Indigenous technological practices in teaching, teachers need to be exposed to them and be guided professionally. This can be done by means of scaffolding and professional development. Research underscores the role of scaffolding in teacher training to integrate IK into classrooms, which involves continuous professional development programmes that equip educators with the skills to incorporate Indigenous practices effectively (Rahman et al., 2015).

It came out strongly that one of the factors that might hinder the effective integration of Indigenous technological practices into chemistry lessons was teachers' faulty perspectives. In this study, faulty perspectives refer to the teachers' viewpoints, opinions, or interpretations that are based on inaccurate or incomplete information that can arise as a result of misunderstandings, misinformation or an inability to see an issue from multiple angles. In this regard, Theoretical said:

> *It will be quite hectic to convince the people to be involved in local technological knowledge in science teaching because at the moment most of the teachers that we have went through the teaching of Western science.*

It emerged that some teachers may feel that integrating indigenous technological practices was a sign of going back to old things, with simple indigenous technological practices rather than the modern technological practices that speak to the Western or developed countries' curricula. Moreover, there might be some difficulties among teachers in understanding this new concept of indigenous technological practices.

Brave concurred with Theoretical, saying: "*There will be a lack of participants due to the mentality of some people that modern technology is more important than Indigenous technological practices".* This excerpt suggests that tensions, conflicts and dilemmas exist between the rule and the subjects. The rule – the curriculum policy – expects teachers to integrate indigenous technological practices, yet the teachers seem to be ignorant of this or have a negative view of IK, as pointed out by Theoretical. Participants felt that some teachers may ignore local knowledge. However, as Shizha and Emeagwali (2016) point out, the more teachers are exposed to these practices, the more likely they are to understand their significance and be comfortable with them in teaching and learning. Herein lies the significance of this formative interventionist study.

Theoretical also reflected that the education officers could create different platforms to set up subject research groups to enlighten teachers on improving teaching strategies by drawing on Indigenous practices. The challenge with integrating Indigenous technological practices raised by Theoretical and Panduleni resonates with Seehawer (2018), who found that what prevents teachers from integrating IK is the curriculum structure, which lacks clear guidelines on IK integration. Ngcoza and Southwood (2015) also stress that the way teachers are 'trained' at times inhibits innovation in teaching and learning. Teachers are 'trained' to think that technology is all about information communication technology rather than indigenous technological practices. In this case, the lack of professional development support contributes to the tension between policy formulation and implementation. The findings revealed that there is a need to document Indigenous technological practices and provide more 'training' by community experts who are regarded as more knowledgeable others (Vygotsky, 1978). Scientist commented on this:

> *Something needs to be planned. Maybe teachers need to be workshopped, to be taught because even if you know something you might not know how to bring it in a different environment. You see just like our parents at home; they know how to do things culturally and when they know science … but you know you cannot go and take a parent home to come and teach science at school who is not a teacher. So, the teachers need to be inducted and assisted on how to go about it. The same applies to the usage of modern technologies in teaching and learning, for example, a teacher can be trained on how to use a projector and how it works. You know, as teachers, when we teach we use a curriculum that is developed and somehow that emphasises the use of local knowledge, integration of local knowledge not only technology but local knowledge.*

From the above recommendation, it could be concluded that for teachers to integrate indigenous technological practices effectively, they need proper guidance and capacity building.

5.2.3.3 Rules

In this research, the rule is the policy that recommends that Indigenous technological practices should be integrated into science education. There are tensions, conflicts and dilemmas within the curriculum documents in that they mention the integration of Indigenous technological practices but are not explicit on how this should happen. The findings of this study revealed that it was not easy to integrate Indigenous technological practices and that there were barriers in multicultural classrooms.

Scientist felt that since there were many tribes, like the Ndonga, Kwambi, Kwaluudhi, and Kwanyamas, it might be challenging for other tribes who do not have the same practices. Therefore, some learners may not benefit and understand better because they are unfamiliar with the practices. She further reiterated that teachers are not ‘trained’ on the issues of culturally responsive pedagogies. Culturally responsive pedagogies are teaching approaches that recognise and incorporate learners’ sociocultural backgrounds into the learning process to enhance engagement and achievement (Mavuru & Ramnarain, 2020). Culturally responsive pedagogies promote respect for diversity, inclusion, and the integration of cultural knowledge into educational practices. This creates tension and a dilemma since teachers do not know how to handle the cultural diversity within their classrooms when integrating Indigenous technological practices. This study addressed these tensions and dilemmas in a way that participants expanded their learning spheres.

In this study, the central mediating tool was indigenous technological practices. Instruments are technical tools directed toward the object in an activity system (Engeström, 1987). In CHAT, the function of the mediating tool serves as the conduit of human influence on the object of the activity, ultimately leading to change in the object (Vygotsky, 1978). According to Kay (2024), tools can be classified as tangible, which include physical objects, and symbolic, which include beliefs and language concepts. The intervention in this study used the indigenous technological practice of marula oil extraction as an example of a mediational cultural tool. This was used to shape the way teachers engaged in pedagogical practices and the way they thought about an activity system as its influence on teaching. This enabled the teacher to build on and develop more ideas on integrating other Indigenous technological practices into science lessons. It was pointed out earlier that documentation of these Indigenous technological practices was challenging because of the Namibian multicultural setup, and it might be difficult to come up with relevant integrations. This is linked to Shizha (2007), who pointed out that there were challenges based on teachers’ attitudes and pedagogical knowledge; some teachers and parents seemed to underrate IK as it was not documented (Semali & Kincheloe, 1999).

Instead, they relied on documented information as legitimate and prescribed scientific knowledge. Gumbo (2016) recommends that teachers show interest in Indigenous technological practices to accommodate learners' funds of knowledge. They also need to build relationships and interact with the community and elders to exchange knowledge and wisdom. In summary, indigenous technological practices as tools are not documented, and there is a manifestation of a contradiction in the conflict between the tools and the rules.

5.2.3.5 Division of labour

In this study, the division of labour refers to how participants played and shared different roles within the community activity system. Responsibilities, roles, and tasks were shared, surfacing some tensions, conflicts and dilemmas as discussed above. Traditionally, teachers are regarded as the sole primary providers and transmitters of knowledge to the members of the community who are assumed not to be knowledgeable (Lee & Tan, 2018). In modern classrooms, teachers are required to shift from traditional perspectives of being sole primary providers and transmitters of knowledge to using technology to reinforce knowledge acquisition. This study, thus, acknowledges the evolving roles of teachers by contrasting traditional views with emerging modern perspectives that emphasise facilitation and collaboration. In this study, however, the IK custodians were the more knowledgeable others (Vygotsky, 1978) because they were the custodians of the Indigenous technological practices.

5.2.3.6 Community

In this study, the community was made up of activity system such as the Directorate of Education, Arts and Culture, the rule-making employer of the subjects, tertiary institutions for 'training' teachers, teachers within the school context (interpreters and implementers), textbook writers (tool makers) and IK custodians (tool makers). Within this community, there seems to be tensions, dilemmas, and conflicts because there is no effective consultation and collaboration between the activity systems. After all, the IK custodians' activity system is not formally acknowledged by the school activity systems. This has resonance with the findings of Mutanho (2021) conducted a study in a South African context and noted that these educational stakeholders tended to operate in silos, yet they sought to achieve the same object or motive.

The Namibian educational history is characterised by the denigration of IK. As a result, the contribution of IK custodians, who are the custodians of Indigenous technological practices, is often neglected. Thus, the tensions, conflicts and dilemmas embedded in the division of labour in this study are traceable to Namibia’s educational history, where IK was treated as unscientific and not worth knowing. The tensions among the stakeholder activity system in the Namibian curriculum are discussed as manifestations of secondary contradictions below.

5.2.4 Manifestations of secondary and tertiary contradictions surfacing from the integration of Indigenous technological practices

In addition to the manifestation of contradictions discussed in Section 5.2.3, the findings from the semi-structured interviews also revealed tensions, conflicts and dilemmas between stakeholders concerning the role they play in science education. Engeström's third-generation CHAT model was used to analyse tensions, conflicts and dilemmas emerging between the teachers within the school context, the initial tertiary institution for training teachers, the Directorate of Education, textbook writers, and the community. I asked the teachers to share their challenges in integrating Indigenous technological practices into science lessons, which would reveal these tensions, conflicts and dilemmas. I did not expect teachers to give descriptive responses that unearthed manifestations of secondary and tertiary contradictions attached to the history of Namibian education. According to Engeström (1999), secondary contradictions are tensions that arise between different components of an activity system when new elements are introduced, which often occurs between the existing practices and the new tools, rules, or objects driving change and development within the system. They are seen as a source of innovation and transformation in activity theory.

On the other hand, tertiary contradictions are described as tensions that arise when a new, more advanced activity system is introduced and challenges the existing one, which occurs during efforts to innovate or transform practices, as the new system may conflict with established norms, tools, or objectives (Engeström, 1999). They play a critical role in driving systemic change and development.

The use of CHAT third generation made it possible to incorporate the historical continuity of an activity (Engeström, 1999). These tensions, conflicts and dilemmas were also the challenges that the teachers faced when integrating Indigenous technological practices into science lessons. Figure

5.2 below shows Engeström's (2001) third-generation CHAT model that I used to uncover the manifestation of secondary and tertiary contradictions in this study.

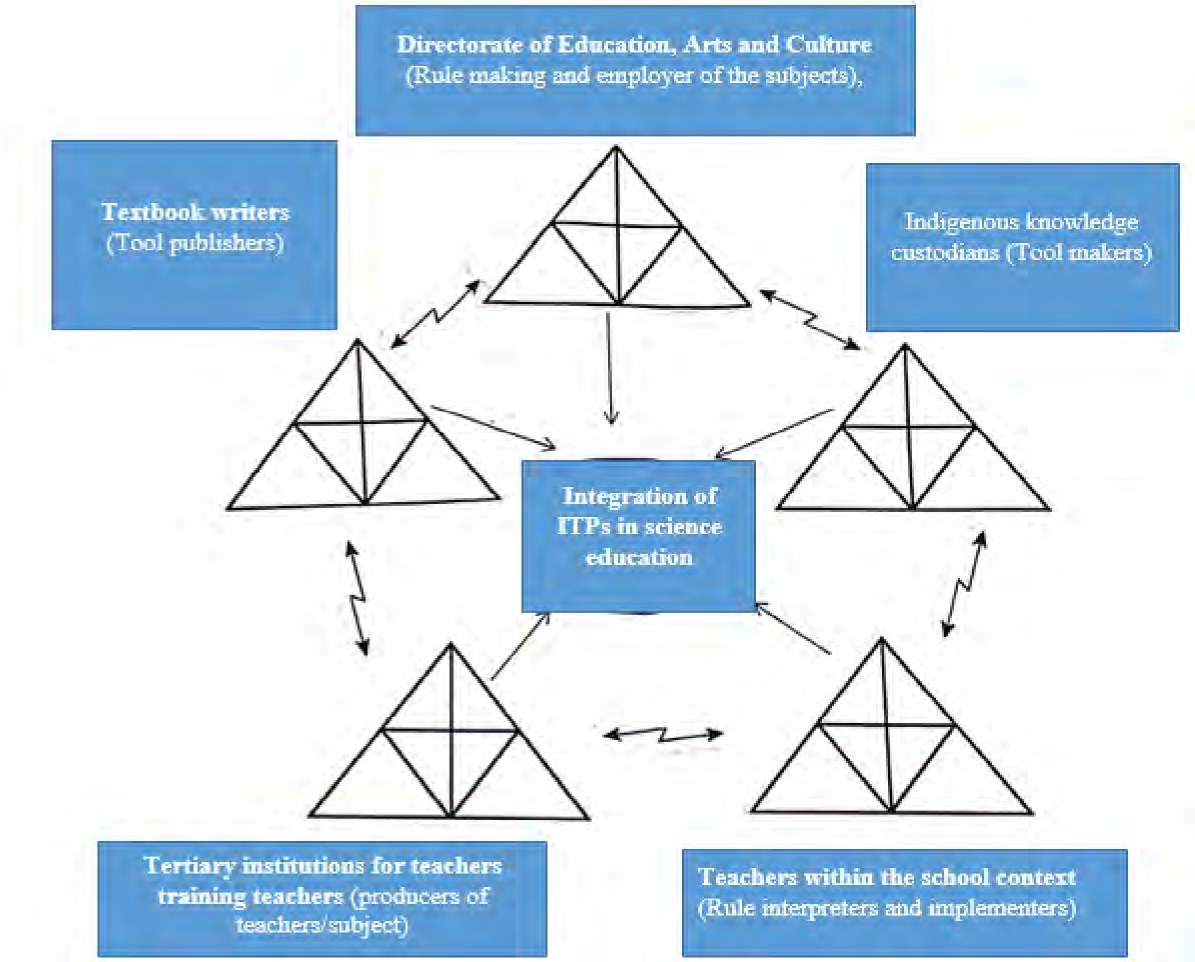

Figure 5.2: Manifestation of contradictions between different stakeholders in the science education activity system (adapted from Mutanho, 2021, p. 137)

Figure 5.2 above shows the tensions, dilemmas, and conflicts among the stakeholders' activity system concerning the integration of Indigenous technological practices into science education. The tensions, conflicts and dilemmas in Figure 5.2 emerged from the semi-structured interviews as the teachers pointed out the challenges of integrating Indigenous technological practices into science teaching. Engeström's (2001) fourth-generation theory focuses on interconnected activity systems, highlighting the importance of multi-voicedness, historicity, contradictions, and expansive cycles as drivers of change. This research further advocates that all other stakeholders, such as school governing bodies, subject heads, subject advisors, and teacher educators from higher learning institutions. Their interest in teachers' professional development is critical; they should be involved to avoid what Engeström refers to as a 'runaway object'. This is further depicted in Figure 5.3 below.

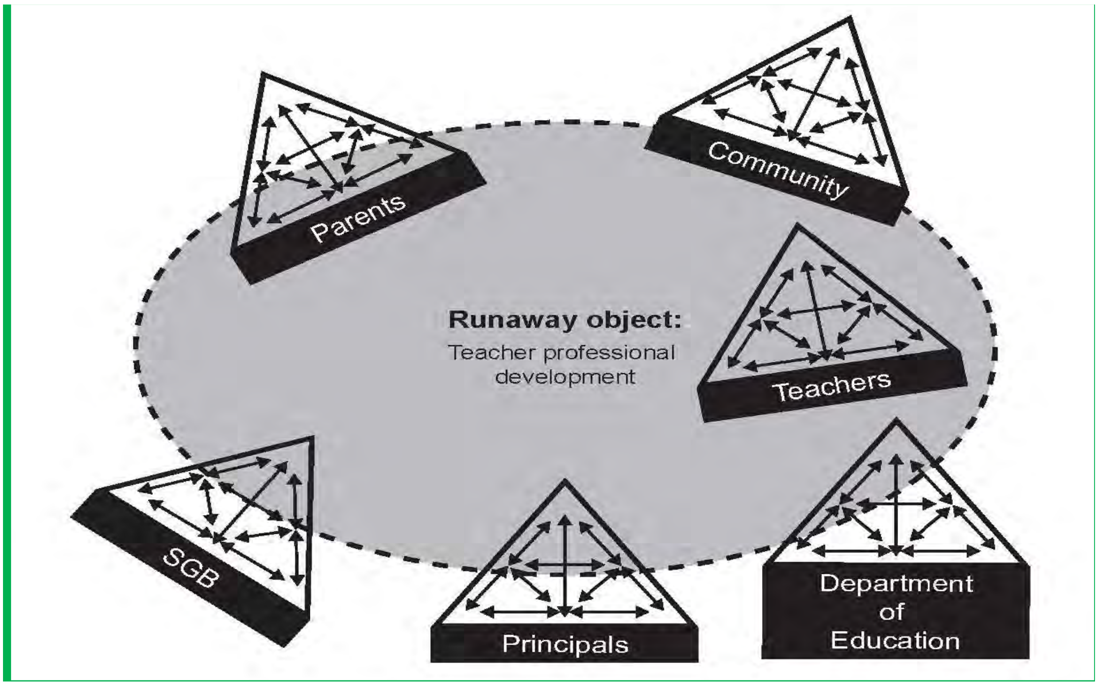

Figure 5.3: Fourth generation as conceptualised by Engeström (2008)

McNeil (2013) explored the tensions between the social control purposes of schooling and the educational goals of schools. He argues that the poor quality of high school instruction can be traced to these tensions, which manifest as contradictions within the school system. These tensions, conflicts and dilemmas arise from the conflicting demands of maintaining social order and providing meaningful education. This study supports the notion of tensions, conflicts and dilemmas that control in a way that impact classroom practices and student learning. It hence advocates a re-evaluation of educational structures to better align with educational goals. Tensions, conflicts and dilemmas manifested in the teachers' responses during the interviews. Table 5.2 shows some of their response.

Table 5.2: Teachers' views on the challenges of integrating Indigenous technological practices

Participants	Responses
Panduleni	*My pedagogy is all about how I was just trained to teach but not much on integration. We are much more on finishing the syllabus, prepare the learners for examination*
Nelago	*Our syllabus talks about IK integration, it is not explicit explained……..*
	Teachers need training to effectively integrate Indigenous technological practices in multicultural set up school environment
Scientist	*Something needs to be planned, maybe teachers need to be workshopped*
Brave	*Lack of participants due to the mentality of some people that modern technology is more important than Indigenous technological practices*

Figure 5.2 and Table 5.2 show the tensions between the tertiary institutions for training teachers and teachers within the school context. There is evidence of a manifestation of a secondary contradiction between the teacher education activity system and the teachers within the school context. Teachers are not trained in culturally responsive pedagogies (Haimene, 2023). Thus, there is tension and a dilemma when teachers do not know how to handle cultural diversity within their classrooms when integrating Indigenous technological practices. That is, science teachers are not pedagogically equipped to integrate and introduce elements that make science subjects more interesting. Gwekwerere (2016) argues that teachers need to make the subject matter comprehensible, relevant, and accessible to their learners.

In the Namibian context, one can attribute this tension to the Directorate of Education, Arts and Culture, which fails to monitor the integration of IK in teacher training institution programmes. This gap in their programmes leads to newly qualified teachers' ignorance, as far as integrating Indigenous technological practices into their teaching is concerned. Besides that, the Directorate of Education does not provide culturally responsive professional activities to capacitate teachers to improve their PCK concerning the integration of Indigenous technological practices. The rhetoric is that the directorate makes the rule that states that IK should be part of the curriculum but does not instruct teacher educators on how to integrate IK into their curriculum. This has left the teachers with a pedagogical dilemma. These tensions, dilemmas and conflicts are congruent with Ngcoza and Southwood's (2015) argument that how teachers are taught tends to inhibit innovation in teaching and learning.

The conflict also arises between the teachers within the school context, the IK Custodians and the Directorate of Education, Arts and Culture. This is attributable to curriculum documents such as the Namibian National Curriculum for Basic Education (Ministry of Education, Arts and Culture, 2016), syllabuses and policy documents that are silent about involving IK custodians in science teaching. There is a conflict in that knowledge is within the community and nothing is documented, inviting IK custodians to collaborate with teachers or schools. The community expertise is not acknowledged in education. Consequently, stakeholders like the Directorate of Education, teachers and IK custodians operate in isolation. A heightened sense of agency described by Haapasaari et al. (2016) also emerged.

The emergence of these tensions, dilemmas and conflicts resonates with Ogunniyi's (2007a, 2018) findings. His study raised a concern that IK and Indigenous technological practices were overshadowed by foreign technologies from developed countries, which sadly did not take cognisance of the Indigenous knowledge system of African people.

Teachers who are curriculum implementers are thus faced with the challenge of integrating Indigenous technological practices. This emerged from the contradictions manifested between the activity system, namely, the textbook publishers, the Directorate of Education, teachers, and IK custodians. The Directorate of Education does not provide proper guidelines for textbook writers to document Indigenous technological practices. There is tension between the textbook writers, tool makers, and the school activity system. For instance, textbook writers exclude and fail to acknowledge IK custodians, exposing teachers to a situational dilemma of not having significant tools to integrate Indigenous technological practices.

This is linked to the findings of the Otjozondjupa Regional External School Evaluation report (2012), physical sciences classroom observations concluded that most teachers they observed faced pedagogical challenges in integrating learners' sociocultural backgrounds. This caused ignorance among the teachers and a negative disposition towards indigenous technological practice integration. Therefore, the central activity system – the integration of Indigenous technological practices is compromised.

5.2.5 Examples of Indigenous technological practices

Participants were asked to share examples of Indigenous technological practices. They listed the brewing of traditional drinks, oil extraction, turning fresh milk into sour milk, natural herbs, soap making, water purification, types of materials, making traditional cakes, filtration using Indigenous plants, and the crushing of mahangu grains. The examples identified by the teachers are also suggested by scholars such as Shinana et al. (2021) and Shizha (2016), who state that there are traditional skills and techniques used in the production of arts, crafts, weaving, and brewing that represent Indigenous technologies in Africa (Shinana et al., 2021; Shizha, 2016).

These participants also mentioned the brewing of different traditional alcoholic and non-alcoholic drinks such as *oshikundu*, *otombo*, *okatokele*, and *ombike*. They indicated that all these examples of brewing traditional drinks involved fermentation, filtration, distillation, osmosis, and other processes. This is a technology that can be integrated into chemistry lessons. For instance, Theoretical responded:

> *Now if you have to go to the modern industries of producing liquor, there is a lot of machinery are involved and so on, but if you visit these local Indigenous people that have technological expertise and see how they brew "Ombike", you can tell that these people are well equipped and specialised in many Indigenous technological practices. They know which raw materials to use and how they can mix them up to get the end product(s), how they are boiling and measure the temperature. So they know everything but it is not documented.*

Scientist shared her views that every practical activity in the school curriculum is attached to a particular indigenous technological practice and that chemistry topics are environmentally based. This means that Indigenous or cultural practices done in the local community are also environmentally based. We have many resources locally, but the challenge is how to bring them into the classroom. It seems like every concept and topic in grades 10 –11 chemistry can be linked to a certain indigenous technological practice within our communities. This coheres with Breidlid and Botha (2015), who argue that IK offers interesting possibilities for including alternative cultural activities in our learning and teaching practices. Another example that was given was milk from a cow. The *omunghudi root* is cut and put into the milk to make it sour. Theoretical explained:

> *Of course, if you process fresh milk changing it to sour, there is also a process in Chemistry on how substances are treated by enzymes but reflecting on our cultural practices of turning fresh to sour milk, we use that root of a certain plant or all the things are not documented.*

Moreover, Nelago contributed that there is also a process of making *omagadhi goontanga*, the oil from watermelon seeds. This is done following procedures that are the same as marula oil extraction (Nyamakuti, 2021).

The extracts above show that the process of turning fresh milk into sour milk involves the concept of enzymes, like the indigenous technological practice of marula oil extraction (Nyamakuti, 2021). This resonates with Cheikyoussef (2018), who said that the method of marula oil extraction involves enzymatic hydrolysis. Other examples identified involved the use of herbs, which, according to Brave, are collected naturally from the environment to treat flu, coughing, and snakebites. The findings further revealed that certain Indigenous materials, such as wood ash and animal fats, can be used to manufacture bars of soap (Neporo, 2022). This process often involves combining rendered animal fat with lye and water, resulting in a chemical reaction called saponification. It was shared that in the local communities; people purify unclean water by boiling it and using wood ash. It emerged that the types of material that are taught in chemistry can be linked to ceramics that are produced culturally. Theoretical explained:

> *There clay pots that we culturally produce in our local communities that sometimes we use them as containers to cook food, storing liquid substance to cool down and others. We use them because of their properties as such as good conductors of heat, good insulators. But the fact will remain that we don't use these local examples in our science teaching when we teach the chapters of "Materials". Whereas we teach different types of materials such as ceramics, plastics, Nelago. and which ones are conductors and insulators. But we never linked this chapter of materials to the Indigenous technological practices of ceramics, particularly our clay pots that are locally made.*

The other example is making traditional cakes. Scientist stressed that when you bake cakes, practically and locally at home, you put them in a traditional oven, where expansion takes place and carbon dioxide is produced. Bringing this kind of example of Indigenous technological practices to class may benefit learners. Teachers also talked about the preparation of food products; for example, crushing mahangu grains to make mahangu porridge and others where you need to crush certain grains to produce products. This resonates with Simasiku (2022) and Liveve (2022), whose research findings included crushing mahangu and other grains as an example of IK.

5.3 Chapter Summary

This chapter explored mirror data for the grade 11 chemistry teachers' pedagogical insights into the integration of Indigenous technological practices into science teaching. The findings revealed that although these teachers seem to support the integration, there were tensions, dilemmas and conflicts that emerged. This manifested in some of the participants' responses, which suggest that the integration of Indigenous technological practices links the learners' cultural knowledge from home to school science. However, the findings revealed that teachers need proper training and guidance in order to integrate Indigenous technological practices into their teaching. The data gathered reveals the manifestation of primary, secondary and tertiary contradictions embedded in science education concerning Indigenous technological practices. These were in the form of tensions, dilemmas and conflicts, and were based on challenges, such as the integration of Indigenous technological practices has been neglected, the lack of indigenous technological practice documentation and training opportunities, ignorance, human resources, time and financial constraints and cultural diversity. Finally, the findings revealed that it is necessary to guide and train teachers, use integration to cover many different cultures, document Indigenous technological practices and integrate IK into all grades.

CHAPTER SIX: ORIENTATION WORKSHOP AND DOCUMENT ANALYSIS

> In a country where teachers play the most important role in its development and progress, a teacher should be qualified, well educated, and well trained to deliver the lessons to the students effectively in the classroom. Continuous teacher training should also be held and conducted so that the teachers can update their teaching skills, especially for those teachers who have been in service for many years. Teacher training is believed to help update the teaching strategies of the teachers. (Ulla & Winitkun, 2018, p. 1580)

6.1 Introduction

The previous chapter presented the findings from the semi-structured interviews. In this chapter, I present data gathered from the orientation workshop and document analysis sessions. The orientation workshop was done for the participants to familiarise themselves with the research goal, objectives, questions, and processes involved. The purpose of this workshop was to analyse curriculum documents such as the national curriculum, the syllabus, policy documents and textbooks. The orientation workshop and document analysis were both aimed at answering the second research question:

> What contradictions regarding the integration of Indigenous technological practices surfaced when grade 11 chemistry teachers co-analysed the curriculum documents and textbooks?

To address this, teachers were exposed to a series of five workshops to analyse curriculum documents and textbooks. These types of workshops helped to resolve the tensions, conflicts and dilemmas that emerged from phase one (mirror data).

6.2 Findings from the Orientation Workshop

Before the workshops, I wanted to understand how the participants felt about the study and what personal and professional growth opportunities they expected because they participated in the research study. Therefore, everyone had a chance to share their expectations. This is a ‘bottom-up cascade model’ in action, unlike what Sung et al. (2016) termed the bottom-down paradigm. It is also contrary to the ‘top-down cascade model’ that the Ministry of Education uses, where teachers’ needs are often not considered.

In contrast, what this study did differently was to start by exploring the teachers' needs before the change laboratory workshops – it could be argued that the workshops were tailored to the teachers' needs. In the Namibian context, this is the new knowledge and approach I used concerning change laboratory workshops. The participants had the following expectations:

- To be able to use local, readily available materials in their teaching.
- To be able to identify different types of Indigenous technological practices in their local communities.
- To enhance the development of new concepts.
- To unpack Indigenous technological practices and establish if they would inform their teaching concerning expansive learning.
- To get better ways of bringing in or involving more knowledgeable others and community members in education.
- To learn other Indigenous technological practices for different cultures.
- To explore more Indigenous ways of extracting oil.

The orientation workshop seemed to have successfully addressed all the stated expectations. For instance, the participants reflected that they learned the importance of using readily available local materials (Asheela et al., 2021; Shinana et al., 2201) effectively in their teaching practices and identified various Indigenous technological practices within their communities. It could also be argued that the orientation workshop appeared to enable the teachers to opt for better methods of involving knowledgeable community members and others in education. In addition, the participants reflected that they had gained insights into Indigenous technological practices from diverse cultures and explored new Indigenous techniques for oil extraction, fulfilling all outlined goals. The data gathering process from the orientation workshop and document analysis workshop is presented in the next sections.

6.3 Evidence of Expansive Learning: Shifts in the Knowledge of Indigenous Technological Practices Concept

The purpose of the orientation workshop was for the participants to become more familiar with the research study and to hear their expectations for participating in the research. Through engagement and discussions, I noted that teachers seem to be learning. The outcome of the orientation workshop shows an expansive shift in the teachers' understanding of Indigenous technological practices and Information Communication Technology. For instance, Panduleni reflected:

> *I have learnt the difference between Indigenous technological practices and Information Communication Technology, that Indigenous technological practices is Indigenous while information communication technology is modern and that information communication technology can be used to enhance Indigenous technological practices, like pictures of Indigenous technological practices, like taking pictures of Indigenous technological practices and use it in the classroom through video or presentations.*

The above excerpt from Panduleni shows a shift in the understanding of Indigenous technological practices. The participant related it to information communication technology. In phase one, however, Indigenous technological practices were only related to IK, and IK was never linked to modern technology. In the same vein, technology was never linked to Indigenous technological practices. Panduleni's shift in knowledge of the indigenous technological practice concept resonated with Scientist's reflections:

> *But for me, I also have learnt something completely new. I was just familiar with IK, pure IK which is Indigenous knowledge, so the concept of Indigenous technological practices was new to me and I have never heard about it before. Making odjove, ombike and others I have been aware about, but I did not think about them in the way of technology. My understanding of these cultural practices was that they are just Indigenous knowledge of making oil, ombike and oshikundu. But then to link these practices technologies was completely out of my mind. But when I attended this workshop, and it is something interesting that I have learnt today, understand, assimilate and accommodate it. It is a new knowledge for me and I am excited about it.*

Scientist's reflections clearly show a shift in understanding from the old perspective of pure IK to the new perspective of IK as technological knowledge. These teachers seemed to view IK as knowledge that does not include technology. Therefore, their understanding of technology in education as a concept shifted from a limited view of IK to an expanded view of Indigenous technological practices. In addition, Nelago articulated:

> *The use of technology limits us to think, because, imagine we were only use to talk of only Indigenous knowledge, we were only used to the concept of Indigenous knowledge, but we do not think of practices and technology. My old perspective of IK was just knowledge but today I have learnt that IK could be also technology.*

While in sociocultural theory, learning is viewed as a shift in understanding within a Zone of Proximal Development from a lower level to a higher level, the shift that occurred in this study was expansive because participants understood IK without knowing the technology aspect within it. So, their old perspective of IK was just knowledge, while the new perspective of IK was technological knowledge.

6.4 Document Analysis

Teachers are expected to understand, interpret, and implement the curriculum effectively (Ministry of Education, Arts and Culture, 2016). Initially, we explored the aims of the national curriculum, key learning areas and types of technologies. The national curriculum, syllabus, policy documents and textbooks were analysed to identify the Indigenous technological practices they recommend and the methods of integrating them stipulated in the curriculum (see Section 4.5). Although technologies and local knowledge are discussed in curriculum documents, the participants in this study had little knowledge of how to link them to science teaching. The findings that emerged from co-analysing the curriculum documents are as follows.

6.4.1 Co-analysing curriculum documents enabled Chemistry teachers to develop an expanded view of technology

The outcomes of this workshop show that through engagement and co-analysing the national broad curriculum, teachers gained new insights into the content and how to interpret the curriculum. There was a shift in their understanding of technology. For instance, they discovered that there are two types of educational technologies, namely information communication technology and technology material. This is evident in the following extracts:

> *As for me I think that we can relate and link our Indigenous technological practices to material technology that is indicated in our National curriculum. The term information communication technology comprises of all technology in media used for management of information which indicates finding, evaluating, processing and presenting information. So my point is that if I can extract marula oil, I am generating the information, that I can explain to the learners and share it with them again. Which means that I am passing information at the same time and using materials (Theoretical).*

> *I did not expect this, so material is also a technology. The way I am getting this is that we cannot teach without technology whether it's information communication technology, Indigenous technological practices or material technology we always find examples to make learners understand and those examples are done using materials from environment, right!! Now if we use those materials to teach our learners and I maintain my point that "we cannot teach without technology" it is just always part of teaching in terms of information, materials or Indigenous technological practices. When we teach concepts like distillation, filtration and others we always refer to material technology, things that we have in class like condenser Indigenous technological practices within our community or information communication technology (Panduleni).*

These excerpts show that these teachers' views of technology shifted from the conventional understanding of technology as modern Western technology to the new view of Indigenous technologies. Nelago added: "*Me too, I did not expect material to be referred as a technology".* This shift in the teachers' understanding of Indigenous technological practices has an affinity to what Haapasaari et al. (2016) termed 'transformative agency' (Sannino et al., 2016). This shows a heightened sense of responsibility. Transformative agency has to do with teachers taking it upon themselves to integrate IK. This shift in understanding is critical for their ability to embrace Indigenous technologies in their classrooms to mediate teaching and learning. At the end of the workshop, their understanding aligned with the Namibian National Curriculum for Basic Education (Ministry of Education, Arts and Culture, 2016, p. 12), which recognises two types of educational technologies:

> The term 'information and communication technology' comprises all the technology and media used for the management and communication of information. Studying information communication technology include finding, evaluating, processing and presenting information. Material technology starts with the idea for designing a product, is followed by the selection of raw or refined materials and the process of transforming them through the use of tools/utensils and processes, and then ends with the evaluation and improvement of the process and product.

Technology is also one of the eight key learning areas for the basic education curriculum (Ministry of Education, Arts and Culture, 2016). After co-analysing the broad national basic education curriculum, we also co-analysed the grade 11 chemistry syllabus.

6.4.2 Shift in attitude towards curriculum in a technological world

Another observable change noticed in teachers' attitudes was that in phase one, teachers viewed the curriculum as a constraint to the integration of Indigenous technological practices into chemistry lessons. This was because the curriculum is not explicit on how Indigenous technological practices can be integrated into teaching; this makes it difficult for the teachers to do so.

In phase two, however, these teachers began to view the curriculum in relation to its aims. The analysis shows the aim of the chemistry grade 11 syllabus (Ministry of Education, Arts, and Culture, 2018, p. 2) is to promote learners' understanding of the physical and biological world around them to solve problems in society; however, this requires advanced technology and efficient use of equipment and materials processes. This was noticed by Theoretical, who reflected:

> *Curriculum mainly focuses on modern technology to assist the learners to solve problems. But to us we can improvise and use Indigenous technological practices to assist the learners and solve problems.*

Looking at Theoretical's excerpt, it could be argued that his views and attitudes towards Indigenous technological practices concerning the curriculum shifted from a limited understanding to an expanded understanding. In phase one, tensions, dilemmas, and conflicts emerged about the curriculum and integration of Indigenous technological practices. In phase two, the teachers seemed to understand that even though the curriculum mainly focuses on modern technology to assist the learners, they had to learn to improvise by using Indigenous technological practices to help their learners.

The integration of Indigenous technological practices in terms of curriculum was then viewed as an opportunity to integrate Indigenous technological practices in teaching through improvisation. This is what Sannino et al. (2016) termed 'expansive learning'. The above shift was observed and linked to the history of Namibian education in that some of these teachers were trained in a way that inhibited innovation in teaching and learning. Perhaps this could be the reason why the curriculum was viewed as a constraint regarding the integration of Indigenous technological practices in phase one. In addition, the grade 11 chemistry syllabus (Ministry of Education, Arts and Culture, 2018) aimed to teach learners to become confident in a technological world. In this regard, Nelago commented:

> *You know when you bring a computer in classroom, not all the learners are very familiar with this modern technology. But if we bring in Indigenous technologies that they know and familiar with from their home, they may feel much more comfortable with it and become confident in technological world.*

What is your commentary on this excerpt? What does it tell us? This is what Mhakure and Otulaja (2017) refer to as culturally responsive pedagogy.

6.4.3 Possible examples of Indigenous technological practices that can be integrated into grade 11 Chemistry

Teachers were able to identify numerous examples of Indigenous technological practices that can be integrated into grade 11 chemistry lessons and link them to scientific themes and concepts. This is presented in Table 6.1 below.

Table 6.1: Identified examples of Indigenous technological practices that can be integrated into grade 11 Chemistry

Participant	Indigenous Technological Practices	Link to Grade 11 Syllabi Themes/Topics
Panduleni, Theoretical	Indigenous ceramics, bracelets (gold, silver & bronze), ornaments such as knifes, pots, hoes, spears, etc. Indigenous	Materials, innovation, metals, uses, properties of metals and suitability
Nelago	Indigenous practice for cooling drinks, construction of thatched rooms	Scientific skills/processes
Theoretical	Extraction of salt in the salt pan	Preparation of salts
Scientist	Extraction of traditional oil	Fractional distillation of oil, hydrocarbons, manufacturing of oil, refining oil particle nature of matters, physical and chemical changes
Panduleni	Indigenous ways of purifying water	Availability and purification of water
Scientist	Indigenous ways of separating substances and mixtures	Filtration, mixtures and methods of separation
Brave	Indigenous ways of preserving food	Food preservation

The table above shows what emerged from the group activity discussions when the participants were asked to come up with possible examples of Indigenous technological practices. Based on their responses, many examples of Indigenous technological practices can be integrated into chemistry lessons. Based on Mavhunga and Rollnick's (2013) TSPCK, certain topics were identified, and these were regarded as difficult topics to teach and understand.

6.4.4 Shift in teachers' transformative agency

From the teachers' reflections, one can see a shift in their agency regarding the integration of Indigenous technological practices from a state of fear, uncertainty, and tension to a state of confidence and action-oriented commitment. In phase one, for instance, they seemed to regard integrating Indigenous technological practices into science lessons as a complex exercise nearly impossible to achieve. However, after the orientation and document analysis workshops, they started to see indigenous technological practice integration as a new teaching practice/pedagogy that they could adapt to improve their teaching. This shows that the tension between Indigenous technological practices and Western science that initially existed in their minds had been resolved. The teachers no longer experienced the dilemma of not knowing how to integrate Indigenous technological practices. This shift in understanding was coupled by an emerging agency, as can be seen in Theoretical's response:

> *Technology is available in our local communities is just that we were not aware about them. It is now our task to integrate Indigenous technological practices in our lessons instead of modern or machinery and scientific apparatus that is lacking in some of our schools.*

What is evident in this extract is the willingness and commitment to integrate Indigenous technological practices into science teaching, as can be seen in the action-oriented phrases. This shows a heightened sense of responsibility where the teacher realises that they are responsible for integrating IK into their teaching practices. In phase two, teachers' pedagogical insights were transformed into discovery learning and two-eyed-seeing (Hatcher et al., 2017) or two-ways-thinking (Michie et al., 2023). Scientist and Nelago reflected respectively that "*scientific processes or skills are manifested in all the Indigenous technological practices, and this can be integrated into science lessons and can be taught throughout the chemistry lessons"* and "*Utensils that are used in our everyday activities at home are material technology and we can use these to drive and become innovative".*

The above extracts show that these teachers were able to apply the principle of two-eyed-seeing (Hatcher et al., 2017; Gilbert et al., 2020) or two-ways-thinking (Michie et al., 2023) to make sense of both cultural home science and school science. Furthermore, teachers came to a realisation and developed an understanding of this new approach to teaching science. For instance, Nelago reflected that this is based on three pillars, namely, consideration, innovation, and integration: "*Science is not taught just anyhow, so we need to teach it with consideration, innovation, and integration".* Panduleni and Scientist reflected:

> *I could not understand the concept of technology but today I have learnt that material could be also a form of technology and there is also aspect of media and information that bring about information communication technology. I came with the statement that says: 'we cannot teach without technology'. In fact, I have learnt and conceptualised a lot from this document analysis (Panduleni).*

> *I did my study for a master's degree in easily accessible materials to teach science but I did not know that we were doing technology through hands-on practical activities and experiments with my*

> *learners. When we looked through these documents I did not know that almost all the topics that we have in grade 11 chemistry are related to many Indigenous technological practices. I have learnt a lot around the concept of technology. Although we have all these documents I was unable on my own to know the types of technologies, so this was really an eye opener for me to know now that even things that we regard as simple could be technology (Scientist).*

From Scientist's and Panduleni's reflections above, technology is now regarded as an enabler in teaching and learning. In addition, technology is one of the key learning areas stipulated by the National Curriculum for Basic Education (Ministry of Education, Arts and Culture, 2016). Teachers also analysed grades 10–11 chemistry textbooks from different publishers such as Living Oxford, Solid Foundation, and Namibia College of Open Learning. They discovered that of the three publishers, only Solid Foundation cites a few examples of Indigenous technological practices. IK is not well documented, as stated by Shizha (2007, 2013).

6.4.5 Expanded view in the perspectives of Indigenous technological practices

In phase one, some of the teachers' responses were negative, but shifted to positive comments in phase two. This was manifested in the expressions that were analysed to track down the teachers' agency. This is shown as the shift in the perspective about the integration of Indigenous technological practices as shown in Tables 6.2 below.

Table 6.2: Initial and new perspectives of the integration of Indigenous technological practices

Initial Perspectives		
Type of Expression	**Description of Expression**	**Excerpt**
Resisting	Resisting the interventionist change of indigenous technological practice integration by confessing fear, questioning, opposition, or rejection	"*Indigenous technological practices are not documented*"
Criticising	Opposing the way that faults concerning indigenous technological practice integration are indicated	"*Indigenous technological practices are regarded less important and unscientific*"
Explicating	Opposing in a way the idea of indigenous technological practice integration needs some new possibilities to be considered	"*Workshops and trainings are needed*"
Resisting & Criticising	Opposing and resisting indigenous technological practice integration by confessing fear and concern	"*It will be difficult to get more knowledgeable others within the community*"
Resisting & Criticising	Opposing and resisting indigenous technological practice integration by confessing fear and concern	"*Integrating Indigenous technological practices in a multicultural classroom will be a challenge*"
New Perspectives		
Envisioning	Sense of positive reflection, imagination and realisation towards indigenous technological practice integration	"*I have learnt*" "*We were not aware*" "*This was an eye opener*"
Committing to actions	Act of committing concrete actions aimed at changing and integrating Indigenous technological practices	"*It is now our task to integrate Indigenous technological practices*" "*I am now able to*"

From the above table, it could be argued that the teachers seemed to have shifted from the initial perspectives of resistance to the new perspectives of being action oriented.

6.5 Chapter Summary

This chapter presented the data gathered during the capacity building and expansive learning phase. What emerged as new knowledge in this chapter is that a 'bottom-up model' was in action, where the teachers' needs were considered, unlike the 'top-down cascade model' used by the Ministry of Education. What this study did differently was to start by exploring the teachers' needs before the change laboratory workshops. The workshops were then tailor-made to meet their identified needs. This is the new knowledge and approach I used for the change laboratory workshops. It emerged that chemistry teachers gained new pedagogical insights into integrating Indigenous technological practices into chemistry lessons. Based on Mavhunga and Rollnick's (2013) TSPCK, teachers were able to identify possible examples of Indigenous technological practices and link them to specific chemistry concepts and topics. The shift in attitudes and knowledge of Indigenous technological practices was observed, and these led to an expanded view of Indigenous technological practices where transformative agency was developed. Shifts from tension, conflict and dilemma (negative attitudes) to commitment to action (positive attitudes) were also observed.

CHAPTER SEVEN: TAPPING INTO THE INDIGENOUS KNOWLEDGE CUSTODIANS' CULTURAL HERITAGE

> As Elders Cultural Knowledges and Storytellers, Elders pass knowledge from generation to generation through their teachings and carry the history and spiritual values of the community, bridging past, present, and future. Elders' cultural knowledges are seen as having a critical role to play in schools in closing the educational gap and making education and schooling more relevant to Indigenous, Black, Latinx, and other racialized students in their validation of Indigenous cultures within the school through an educational process that connects the learner with his/her culture, lived experience and environment. (Dei et al., 2022, pp. 127-1146)

7.1 Introduction

Different technologies that Indigenous people practice are relevant to the modern science classroom. However, these Indigenous technological practices are not documented and not regarded as a legitimate way of teaching science (Shizha, 2007). This study recognises that science and technology are present in local communities and that schools should include these. As the above epigraph notes, IK custodians should play a major role in schools to support teaching and learning. Drawing insights from the sociocultural theory and the CHAT, this study explored how to tap into IK custodians' funds of knowledge or cultural heritage.

In this chapter, I present, analyse, and discuss data gathered when three IK custodians demonstrated the process of traditional marula oil extraction for the teachers. The teachers and I were participatory observers and reflected on what was observed. As a researcher, I wanted to explore and understand the nature of social interactions as reiterated by Vygotsky (1978) and the learning opportunities created among the participants. The purpose of the practical demonstration sessions was to address my third research question, which reads as follows:

> What expansive learning opportunities were created (or not) for grade 11 chemistry teachers during the presentations by the Indigenous knowledge custodians on traditional marula oil extraction?

Data generated during this practical demonstration workshop session are presented in this chapter. With the use of the CHAT as a theoretical lens, three main activity systems interacted. These were the school system, the professional learning community (using modern technological practices), and the IK custodians within the community of cultural heritage. Engeström (1987) notes that the actions of a person(s) are rooted within an activity system.

In this study, this helped me to understand how the division of labour and learning opportunities were generated among the participants who shared the object of improving the teaching of science. It also enabled me to understand the rules that regulate their actions. Accordingly, data analysis of the presentations by the IK custodians was done using concepts from Engeström's (1987; 2001) CHAT second and third generation and looked at how different activity systems interacted during the practical demonstrations. This is illustrated in Figure 7.1, which shows the model of analysis that enabled me to understand the activity system.

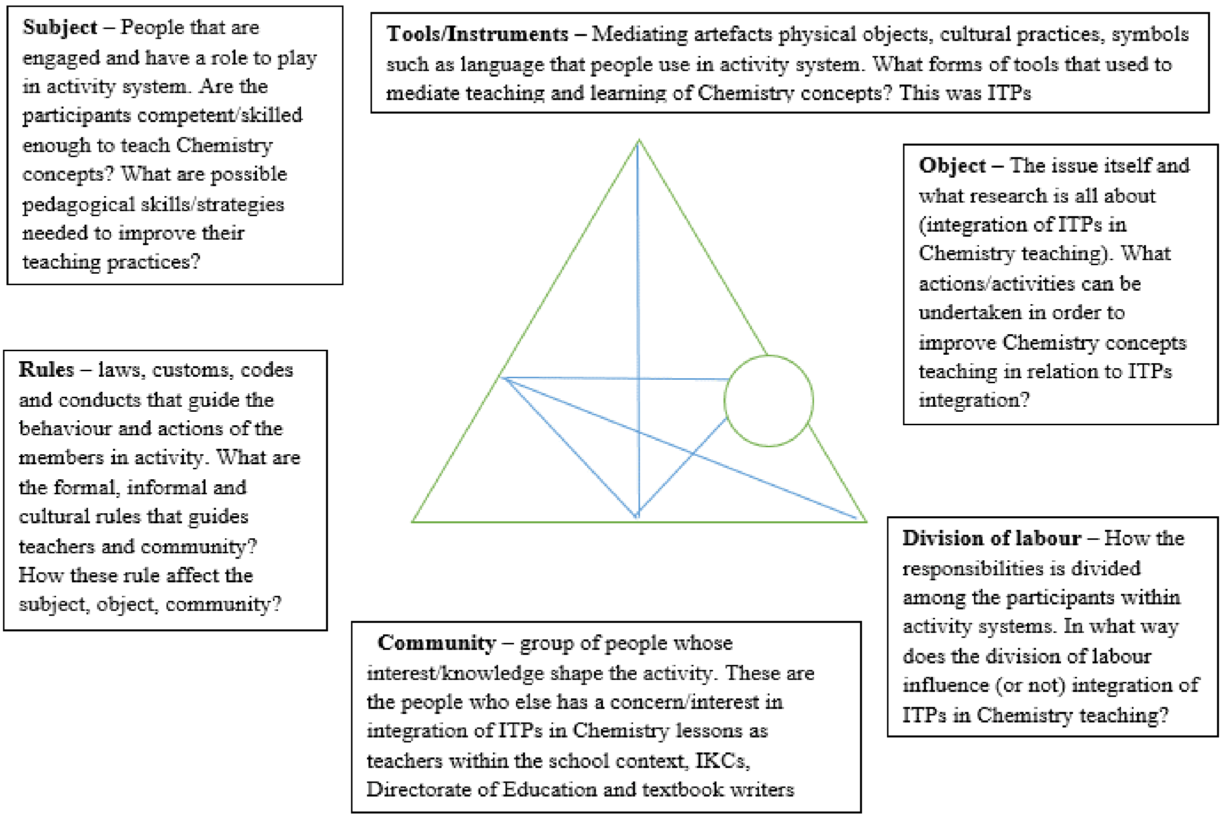

Figure 7.1: Components of the second-generation activity system and how they are related to answer the research question(s) (Engeström, 2001)

I used CHAT components and principles to study and discuss the social interactions of the teachers, IK custodians, and artefacts. This is linked to what Engeström (1987, 1999) emphasised, that the researcher must examine not only the kind of activity that the participants engage in but also the goal or object, and the rules or norms delimiting behaviour in the activity system. In this way, the researcher can capture the activity's multi-layered and multi-voiced nature. Learning has to do with the use of cultural tools or artefacts to transform teaching practices. Learning was encouraged in this study using the IK custodians' practical demonstrations so that the teachers could become cultural knowledge brokers (Simasiku, 2022; Wyatt et al., 2017). Moreover, learning took place through interactions and tensions, dilemmas and conflicts between the activity system and the elements within this activity system. I will now discuss the data generated from the practical demonstration sessions.

7.2 Welcome and Introduction

Consistent with the Indigenous research paradigm, as recommended by scholars such as Chilisa (2012), Seehawer (2018), and Mutanho (2021), we visited the IK custodians at the site where they extract marula oil to show respect. Upon arrival, the IK custodians had already gathered and were waiting to meet us. We were warmly welcomed. Since some of the IK custodians could not express themselves very well in English, we arranged for Scientist and a critical friend to translate into Oshiwambo and English.

I then greeted the gathering and made it clear that we had visited the IK custodians to be taught and learn about our indigenous technological practice of extracting marula oil. The initial idea was to have only one IK Custodian, and we were surprised to see three IK custodians and some community members. The three IK custodians were there to facilitate the workshop. This shows the spirit of Ubuntu in the form of togetherness and eagerness (Ogunniyi, 2018; Seehawer, 2018). I could not turn away the other uninvited IK custodians and community members. When such a thing happens, we welcome everybody as *Ubuntu* is about sharing and mutual benefit and is important to this study. There were also more than 10 community members, and some school-going kids present. Oil extraction is meant to be done by females in the Oshiwambo culture, but surprisingly, one of the three IK Custodian facilitators was male.

Figure 7.2: [9]Participants and IK custodians in a sharing circle

The floor was then given to the IK Custodian, and she started with the following remarks: "*Iyaloo tangi unene komhito ei mwetupa. Apa outnapo omahuku etu aa eli moshimbale omu. Otwahala nee okumulonga nghee omaadi eengongo haa ningwa ile okuetwapo*" (Thank you very much for the opportunity that is given to us. So, we are going to start: Here are our marula nuts *omahuku* in this basket. We are going to show you how marula oil is generated and extracted from the marula seeds).

7.3 Practical Demonstration and Participatory Observation

[10]Meme Fudheni demonstrated the cultural practice of adding coarse salt to the marula nuts. Participants were curious to know why coarse salt is used instead of refined salt and Meme Fudheni responded:

> *Ohatu longifa ashike omongwa womawe, shaashi owopamufyuululwakalo wadja kekango lomogwa ndele haye ou wa kweywa uli meefitola* (We use coarse salt because it is locally available in the villages from the saltpan, and we regard it as cultural and Oshiwambo salt but not refined in the shops).

Meme Fudheni proceeded with the presentation and added the burning charcoal to the marula nuts. She explained that the main reason is to bring out a nice smell and increase the warmth for the oil to come out.

[9] Both the research participants and the Indigenous knowledge custodians consented for their photographs to be used.
[10] In the Oshiwambo culture, Meme is used to show respect to an elderly woman and Mama is used in the Xhosa culture (Mutanho, 2021).

Figure 7.3: Burning charcoal added to marula nuts for flavour and to increase the temperature

Teachers were impressed and reflected on their learning. For instance, Nelago and Panduleni noted that the charcoal provided the "*activation energy"*, while Panduleni observed that the smell that was coming out showed that there was *diffusion*. Based on that, [11]Tate Sheehama and [12]Mee Ndatoolomba added that if there is no sunlight, one can expose marula nuts to direct sunlight for activation energy, but sunlight will not bring out the smell. This discussion resonates with Krishna et al. (2023), who noted that charcoal is carbon, which is an absorbent that is used to extract a wide range of hydrocarbons, including oil.

From this discussion, it is evident that the teachers' understanding shifted from everyday knowledge to a scientific understanding of the significance of charcoal in the process of extracting marula oil. Novel ideas were generated as they were observing, socially interacting, and learning from each other as they tried to link their observations to scientific concepts. This resonates with Engeström's (2000, 2001) view that learning is a socially, culturally, and historically connected process of interacting factors within an activity system.

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[11] In the Oshiwambo culture, Tate is used to show respect to elderly men.
[12] In the Oshiwambo culture, Mee is used to show respect to middle-aged women.

7.4 Mortar and Pestle – Crushing of Marula Nuts

Tate Sheehama demonstrated the mortar and pestle and explained that they are used to pound and crush the nuts. Meme Fhudeni added: "*Ohatutaeke nee okutwa omahuku"* (Now we are starting the process of crushing and pounding marula nuts).

Figure 7.4: IK custodians using a mortar and pestle to crush marula nuts

Mee Ndatoolomba explained: "*Paife omahuku otala tuwa nee opo anyanyauke, nokukala moupambu vashona lela, shaashi ngeenge inaa nyanyauka nawa omaadi itaeyamo*" (The reason for pounding and crushing is to reduce the size of particles so that when the warm water is added, the process will be easier and faster for oil extraction). Regarding crushing the marula nuts, Brave reflected: "*In other words is to reduce or decrease the surface area".* The tools that IK custodians were using stimulated the teachers' knowledge as they gave full descriptions of the scientific processes and linked them to the chemical reactions.

During the observation and learning process, teachers interacted with the IK custodians through reflections and asking questions. The questions enabled the IK custodians to elaborate on some of the scientific concepts, such as pressure and surface area. Tate Sheehama commented: "*The way it looks was as we are pounding it can be called a 'magma'".* Nelago was curious to know why Meme Fudheni was pounding while she was seated rather than standing. Mee Ndatoolomba explained that if she stood, she would apply more pressure, and the magma may spill out – the process did not need much pressure. Meme Fudheni further informed the participants:

"*Ohatutwikile okutwa fiyo shanyanyauka nawa tu dule kuwedako omeva mapyu"* (We will continue to pound until particles are reduced, become smaller for us to be able to add warm water).

The teachers also learned that crushing seeds until they are all uniformly small makes it easier to access the oil from them, as it increases the surface area by breaking them into smaller pieces. They also noted that, scientifically, it breaks down the cell walls to allow the oil to come out, thereby increasing the yield and efficiency of the extraction process. Meme Fudheni went on to explain that: "*Paife ohatu wedamo nee omeya mapyu"* (Now we are adding warm water and the pounding should be faster). After adding the warm water, the texture of the mixture (referred to as magma) started to change, becoming oilier and brownish. Meme Fudheni kept on adding small amounts of warm water. Tate Sheehama explained:

> *For you to extract more oil it will depend on many things like for how long marula nuts has been kept, if it is too old or kept for so long the amount of oil produced will be less. The magma is becoming juicy which means that more oil is about to come.*

Meme Fudheni added: "*Paife omaadi okweya nee Paife omaadi ohatuakufamo, she hatwaatile nee mokambiya"* (Now the oil is generated or extracted, and so now we are pouring the marula oil in the pot). The teachers were surprised to observe that the oil was indeed generated, and it had increased.

Theoretical asked: "*Why do we only see the oil generated and where is the water that was added?"* Mee Ndatoolomba responded: *"It mixed with solid nuts and it was just used to bring about oil".* Brave reflected that it involves both physical and chemical changes, depending on the stage of the process being described. The act of pouring marula oil into a pot and the separation of oil from water is a physical change. These processes do not alter the chemical structure of the substances involved; they simply involve a change in state or separation. The generation of marula oil itself, as described by Brave, reflects a chemical change, whereby the water mixed with solid nuts played a role in breaking them down and caused a reaction leading to the extraction of oil, and then chemical changes occurred. A chemical change is characterised by the formation of new substances that differ from the original components.

7.5 Cultural Beliefs About Marula Oil Extraction

Nelago stated that she heard that certain myths are associated with the extraction of marula oil, such as that *"extraction cannot be done by two people".* Tate Sheehama commented on this: "*We also hear about it, but I don't think it is true because it is a tiring process and there must be a division of labour, especially on the crushing and pounding".* Panduleni added that she heard that *"if marula oil poured on the ground or on the floor, all the people in the house will die".* Mee Ndatoolomba commented on this: "*I think since marula oil is regarded as a precious oil in our culture maybe this was just said to scare people to take good care of it and avoid wasting it".* Concurring, Meme Fudheni shared:

> *Omaadi eengongo oshinima shafimana unene momufyuululwakalo wetu woshiwambo, nongaashi paife omaadi meefitola a ninga ondilo, ohatu tende ashike eengongo ndee hatuli odjove. Oina noxo oukolelele noitungifi ihapu ei twa pumbwa momalutu etu* (marula oil is a very precious oil in our culture as Oshiwambo-speaking people. Like how the modern oil in shops became very expensive, and now we will just extract our marula oil instead of buying from the shops. Moreover, marula oil is a healthy oil, with vitamins and nutrients that our bodies need to be healthy).

From the excerpt above, it emerged that marula oil is an essential product. In this regard, Cheikhyoussef (2018) noted that seed oil production from Indigenous sources has economic importance for Namibia and is an asset in improving the livelihoods of local communities (Thompson & Scoones, 2009). The current situation in many developing countries is that vegetable oils are replacing animal fats because of health concerns and costs.

Nelago reflected: "*I heard that oil extraction is only done by females but not males*". Tate Sheehama, a male, commented that this is just a cultural belief, and the fact remains that anyone can do it. Regarding gender, one could say that IK custodians were accommodating because there was a male facilitator among them. This observation supports what Haimene (2023) proposed, that gender-responsive strategies in teaching should be embraced. Moreover, she recommended that teaching and learning should be inclusive, interactive, and gender responsive.

7.6 Division of Labour

Division of labour was shown as the IK custodians shared the responsibilities and tasks with the participants. As the practical demonstration proceeded, Meme Fudheni told the participants that the marula oil extracted in the first round was to practically demonstrate the process to the participants. The second round was for participants to extract the oil themselves under the IK custodians' guidance. She then asked: *"Opena ou a hala kuyengako kewi litivali?"* (Is there anyone who would like to try and do extraction for the second round?). Nelago responded: "*Let me do it*". Tate Sheehama observed what Nelago was doing and commented:

> *You are doing it very well. Like I said earlier that the quality and the quantity of oil that will be produced is affected by many things. Also, if there are pests or insects in morula nuts, then the oil will be less. It is not good to keep marula nuts for so long. It is better to extract nuts from the seeds and start the process of oil extraction within few days rather than keeping it for so long.*

From the excerpt above, Tate Sheehama's comment when he observed Nelago doing it well manifested what Ngcoza and Southwood (2019) termed an appreciative approach. Moreover, the participants' extracting the oil themselves under the IK custodians' guidance also depicted situated and experiential learning (Jusinski, 2021). Division of labour was observed as Nelago volunteered to do the extraction in the second round. Nelago continued with the demonstration under the supervision of IK custodians who were elders and knowledgeable others according to Vygotsky (1978). Klein (2011) regards parents or elders as the key to IK, as they have the skill to educate and transfer this knowledge to their children. Klein (2011) refers to this as a traditional life skill.

I was curious to learn more about Tate Sheehama's comment that marula oil extraction is a tiring process and there must be a division of labour. I thus probed as to how this happens; he responded:

> *It is the process that needs people to assist each other. Crushing and pounding can be done by everyone, but when the oil is about to come, the extraction and separation of oil from the residue can be only done by a specialised person.*

To be a specialist, one should be practically trained to become knowledgeable. While Tate Sheehama (male facilitator) was busy explaining, Panduleni asked him: *"How do you know this marula oil extraction as a male? I thought in some homesteads, marula oil extraction is done by women?"* Tate Sheehama answered: *"I have learnt this while I was young from my grandmother, and I know it very well. It is just a belief and myth that is only for women, but everyone can do it even us males like myself".* It came out that IK is intergenerational and passed on from generation to generation. This was very interesting to the participants, and Panduleni acknowledged him as a more knowledgeable *Tate* (father), highlighting the aspect of gender balance as reiterated by Haimene (2023).

7.7 Extraction of the Oil

Nelago continued pounding and crushing marula nuts until the colour was brownish. Mee Ndatoolomba told the participants that the mixture was ready for warm water to be added. Scientist asked: "*How do you know that you need to add warm water?"* Tate Sheehama explained*: "You know as you start pounding the colour is whitish but when it is ready to add water, it will turn brownish and oily".*

Nelago wanted to know why warm water was added instead of cold water. Tate Sheehama responded:

> *Warm water can melt the nuts and help us to extract oil faster. But some people can also do with cold water but that will take a very long period and I don't think oil will be even more. So warm water is better than cold water* (Tate Sheehama).

The above extract shows that IK custodians understood that speeding up the reaction rate is very important. Scientifically, it takes a certain period for a chemical reaction to take place. The starting materials are called reactants, and the finishing materials are called reactants. In the case of this study, salt and marula nuts were *reactants* and the marula oil and residue were the *products*. If the reactants only take a short period to change into the product(s), the reaction is said to be fast. If the reaction takes a longer period to change the reactants into the product(s), then is said to be a slow reaction.

The IK custodians were cognisant of the factors that affect the rate of the chemical reactions such as the temperature. This was in the form of the warm water that provided heat energy that increased the rate of the chemical reaction. Cold water was regarded as an *inhibiting* factor as it slows down the rate of reaction and according to the explanation, they avoided using cold water. Brave asked if adding more water would result in extracting more oil. Meme Fudheni cautioned: "*Ngee owa wedamo omeya mahapu unene omaadi italeya vali"* (If you add more water, you won't be able to extract oil).

Figure 7.5: Marula oil extraction process

When the oil was extracted, what was left was what Tate Sheehama referred to as *'ezi'* (residue), as shown in Figure 7.5. I asked the IK custodians about the uses of residue. Mee Ndatoolomba indicated: "*Edi ohalilongifwa okuninga osopa yo momunghoka, ohali nyanghaulilwa ashike momeya mashona ove to tulu nee ombiya opo liainge osopa moshivelelwa ngashi ombelela, eeshi, oxuhwa ile ombidi"* (The residue is used to make soup that you can add or put in relish like meat, fish, chicken, spinach, and so on).

Meme Fudheni elaborated: "*Ngeenge opena 'ezi' inopumbwa vali uka lande osopa, olo ashike tolongifa, ohalidulu okukutikwa ndee tokala tolilongifa oule wefimbo lile"* (If there is this residue, you do not need to buy soup in shops anymore, you can just use it as a soup. Also, a residue can be dried for future use or to be used for a very long period). This is food preservation (Tyeda, 2024). Meme Fudheni then demonstrated how the residue was used to make soup. She then broke the residue into smaller pieces and added about half a glass of water, until it dissolved evenly. At that stage, it was then ready to be added to the relish.

7.8 Refining and Preservation of Marula Oil

The IK custodians explained to us that once marula oil is extracted, it is cooked or boiled, but not put in the refrigerator. Nelago asked why marula oil is cooked after extraction. Tate Sheehama made it clear to us that if it is not cooked, it will get rotten within a few days because of the presence of water within the oil. It must be cooked well by someone who knows, and thereafter, it can be kept or used even after two years. This was a very interesting learning experience for teachers to acknowledge that in refining and preserving marula oil there are scientific skills relevant to their teaching of chemistry concepts. In scientific language, it can be said that marula oil is regarded as food for bacteria and other microorganisms if not refined. If the marula oil is left without being preserved, it rots, decomposes, and creates toxins that are poisonous compounds, and this makes the oil unsuitable for human consumption.

In this case, the IK custodians demonstrated the importance of preserving food, and this practice has scientific knowledge behind it. When the IK custodians are heating or cooking the marula oil, microorganisms such as Salmonella, a poisonous bacterium, are destroyed by heat energy. The refining process also exposes the marula oil to a lack of oxygen that is needed by the decomposers to respire.

Figure 7.6: Refinery and preservation of marula oil

The teachers observed and learned that marula oil is preferably refined over firewood. However, the fire should not be too hot, otherwise the oil will burn, and the quality of the oil will not be good. Meme Fudheni, Tate Sheehama, and Mee Ndatoolomba took the following steps and procedures. "*Ngeenge nee watula ombiya pediko, oto kala nee topilula opo itali yaalele"* (Once you have put the pot on the fire, you should keep on stirring to avoid the oil from burning at the bottom of the pot). Meme Fudheni instructed: *"Shaa yatameke okufuluka, ohakukala etutu litoka kombada, lomeya enya twakala hatuwedamo eshi hatuyenge. Etutu ohaleende nee talishuna pedu, shamha nee lapumo otalshiti oyapya"* (When the oil starts to boil, it forms a white foam on top, which is that water that we were adding during the extraction process). I observed that as the IK custodians kept heating the oil, the white foam decreased and disappeared completely – that was a sign that water had evaporated, and the oil was ready.

In this regard, Tate Sheeehama explained: *"Ngeenge omunhu keshishi okuteleka odjove, ota dulu kwii kufapo inaipya ndee tai kaola ile eilungwinife. Ohaitelekwa kwaava vena eshiivo"* (If a person does not know how to cook marula oil, she/he may remove it on a fire while it is not yet ready and it will go rotten or to overburn it. Cooking the marula oil is not for everyone, it needs skills). Theoretical asked the following question: "*How do you know that it is ready and stop cooking the oil*?" Mee Ndatoolomba responded:

> *When the oil starts to boil, it forms a white foam on top, which is that water that we have been adding during extraction process. As we keep on heating the mixture of oil water, water will start reducing and disappear completely and that will be the sign that it is ready.*

It was observed that when Meme Fudheni started heating and stirring the marula oil on a moderate fire, the white foam appeared. As she kept on heating and stirring, the white foam decreased. According to the IK custodians, the white foam was the water that was added during the process of oil extraction. Based on this, the participants learned and reflected that when heating and boiling marula oil, the foam (the water) evaporates, and there is a direct proportion between the heat energy and the water within the marula oil. The more water in the oil, the more the white foam on the marula oil will be observed. The foam completely disappeared when the oil was ready, a nice smell of marula oil was detected, and the pot was removed from the fire.

Meme Fudheni then told the participants, "*Odjove yetu oyo nee ngaha, otaikala mokambiya okafimbo kashona opo ipole"* (Here is our end product, which is marula oil, we will keep it in the pot for few minutes to cool down). The participants reflected on the following:

> *Nelago: Science is happening here.*
>
> *Theoretical: The light residue is settling at the bottom of the pot and the clear oil on the top.*
>
> *Panduleni: Look at the layers separating the light residue and the clear oil.*
>
> *Scientist: Concepts like density, residue is engaging here.*

Tate Sheehama told the participants to wait a little bit for the oil to cool down because it would be stored in a glass container, otherwise, it would break if it were poured while hot. Meme Fudheni explained: "*Paife ohatuka pungula nee odjove yetu mekende omu, omo taikala. Shee hatukala nee hatukufamo opo twiilongife. Ekende oliwa lidule eeplastic"* (Now we are going to store oil in this glass container, whenever we want to use the oil, we will take from here. Bottle containers are more suitable than plastic containers). Mee Ndatoolomba further explained that glass containers are more suitable than plastic containers because the quality of the oil, like the smell and taste, remains even if the oil has been kept for a very long time. Tate Sheehama added to Mee Ndatoolomba's statement and noted that they use glass as they are in towns or urban areas, but clay pots can also be used and are as good as glass containers. Brave reflected:

> *Scientifically it means that glass containers are more suitable because they keep the same quality as it cannot compromise the quality of the smell and taste, and therefore the glass containers are more appropriate to store the oil. The oil is now preserved.*

From the above excerpt, the IK Custodian demonstrated his knowledge about materials and their suitability. Since glass is chemically inert and biologically inactive, it seems like the IK custodians are conversant with these properties as they heated the oil to about 100℃ or more and enclosed it in the glass bottle. The scientific reasoning behind this is to destroy enzymes and bacteria as they cannot enter the sealed glass container. The glass-bottled marula oil remains good to consume for years as long as the bottle is not damaged or broken. To conclude, the IK custodians' act of heating the extracted mixture of oil and water speaks to the purity of the oil concept, ensuring that the oil is free from contaminants.

The demonstrations were enlightening when the IK custodians shared their invaluable knowledge on the extraction of marula oil. Their expertise enriched the scientific understanding embedded in our cultural practices. This helped us to bridge the gap between modern science and Indigenous technologies. To me, this came out as an intersection of science and culture manifested in the principle of Ubuntu. The concept that embodies the spirit of togetherness and mutual respect, *Ubuntu* teaches us that "I am because we are", highlighting the interconnectedness of all humanity through embracing, valuing the knowledge passed down through generations, and recognising the collective contribution to our shared heritage (Gumbo, 2018; Seehawer, 2018).

7.9 Manifestations of Contradictions Within the Education Activity System

Using Engeström's (1987, 2001, 2003, 2023) second and third-generation activity systems, tensions, dilemmas and conflicts were identified when participants attended the IK custodians' presentations, which unpacked the research question:

What expansive learning opportunities are created (or not) for grade 11 chemistry teachers during the presentations by Indigenous knowledge custodians on the indigenous technological practice of oil extraction?

The analysis of Figure 7.7 below helped me understand the emerging contradictions within the activity system. Manifestations of contradictions in the form of tensions, conflicts (critical), and dilemmas arose within the activity system and the elements of the activity system.

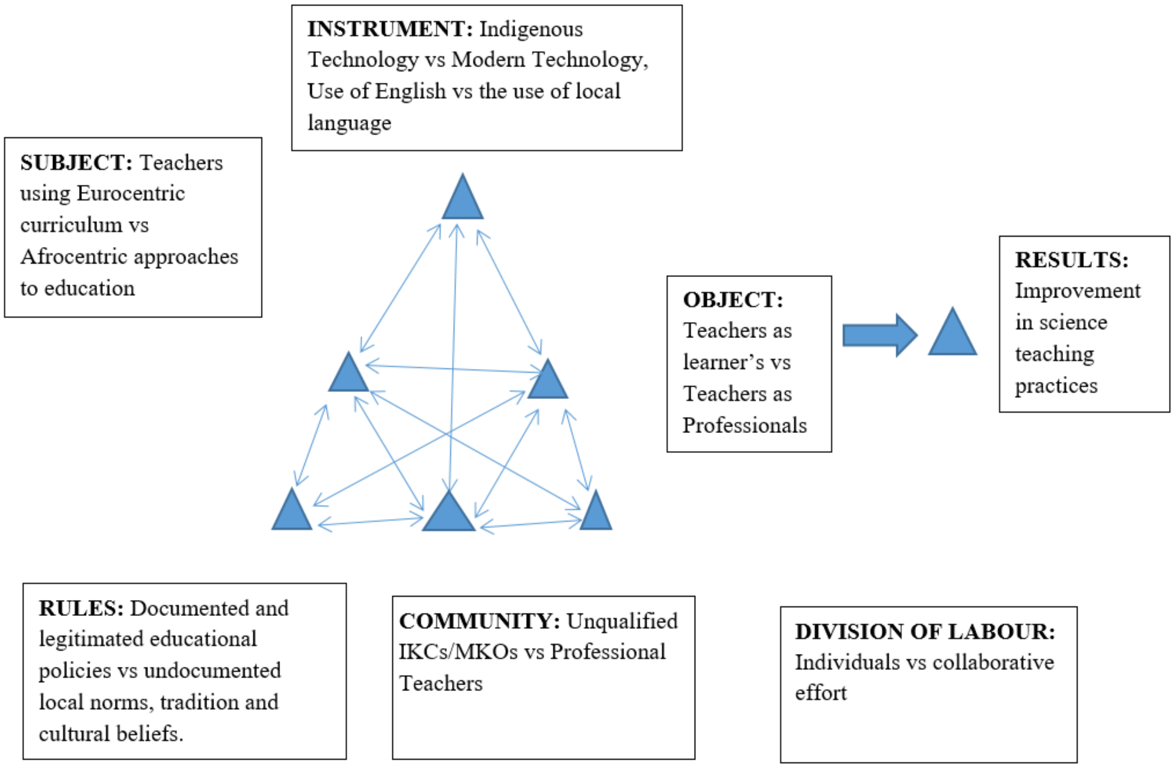

Figure 7.7: Tensions in each element of the activity system

Table 7.1: Manifestations of contradictions in the activity system

Features	Manifestation Level	Manifestation Category
Qualified subject teachers taught by community members	Primary - Between the subject and the community	Critical conflict
Teachers did not use common and formal materials or tools	Primary - Between tools and rules	Dilemma/tension
Community members allocated responsibilities to the teachers	Secondary - Between the subject, community and division of labour	Critical conflict
Teachers were taught in the local language	Secondary - Between object, rules, subject and community	Conflict
Teachers learnt (through integration Indigenous technological practices) new strategies of teaching of teaching chemistry concepts	Tertiary - Between subject and shared object	Double bind
Development of new pedagogical skills of representation	Quaternary - Between subjects, tools and shared object	Double bind
Male community expert facilitators	Secondary – Between subject, community, rules and object	Critical conflict

Source: Adapted from Miles (2020, p. 19)

Using Engeström's (2001) second-generation CHAT tools, the tensions between various elements within the science education activity system were observed as shown above. For example, the tension between the division of labour and the subject (participants) as a hierarchical division of labour emerged as a paradox during the demonstration by the IK custodians. Traditionally, teachers are assumed to be the more knowledgeable members of society, but in this study, this role was taken up by the IK custodians who conducted the practical demonstration lesson. In this case, the level of primary contradictions appeared and manifested as critical conflicts between subjects and the community. This seemed to be the case as Brave reflected: "*Look at the white foam that was said by Meme Fudheni!! My dear these are really experts teaching us as qualified teachers".* Theoretical too lamented:

> *As for me at the beginning I had an understanding that will have challenges to teach us since they are not qualified in education, but to my surprise, I am very impressed by the expertise and knowledge that our community members possess. This means that there is science and technology in our communities, and I have learnt. Even though they did not use scientific terms they demonstrated some scientific skills and technological skills to us. They understand everything very well and know very well what they were doing.*

From the above excerpts, these teachers, with legitimate, formal teaching qualifications, seemed to think that the IK custodians, with their informal practical skills and knowledge of Indigenous technological practices, would not be able to capacitate them well. The motives and objectives of the IK custodians and the teachers concerning their communities were different. The object of the teachers was to teach Westernised science for their learners to pass examinations. The motive of the IK custodians in this study was to share their traditional knowledge with the wider community to pass this knowledge on to the next generation. Here we have the tensions, dilemmas and conflicts that emerged when Indigenous ways of knowing and Western ways of knowing meet. The lens of CHAT enabled me to analyse and understand the tensions, dilemmas and conflicts and harmonise the Indigenous and Western ways of knowing.

Tertiary contradictions take place when the new method is introduced to help achieve the objective (Engeström, 1987). In this case, the level of tertiary contradiction manifested in the form of a double bind between the new and old elements of the activity when teachers learned new strategies for teaching chemistry concepts concerning marula oil extraction within the activity system. Quaternary contradictions emerged when teachers planned a lesson and linked the chemistry lesson to the IK custodians' practical demonstrations. They rearranged their teaching activities and came up with a new strategy for teaching chemistry concepts. This is what Engeström (1987) termed 'reconfiguration'.

Based on Engeström and Sannino's (2011) study, it was evident that the manifestation of contradictions was in the form of a double bind. This is a situation where players in the activity system engage in a reflective space and feel pressured to do something but are unable to act accordingly (Bonneau, 2013). From the IK custodians' presentations, teachers reflected that they lacked creativity, yet they are expected to bring innovation and skills to teach science concepts interestingly. To eliminate this double bind, teachers were capacitated by the IK custodians to be creative, and this helped them reframe their teaching practices and develop new meanings of introducing new strategies to teach chemistry. Engeström (1987) refers to this as expansive learning.

Incongruous, paradoxical situations were observed through interactions and reflections within elements of the activity system. An incongruous paradox is identified when an organisational policy does not correspond to organisational requirements or objectives (Bonneau, 2013). As discussed in Section 1.2, the Namibian curriculum expects teachers to be innovative, use various methods to teach, and acknowledge the learners' prior knowledge and the use of technology in teaching. In this study, teachers as actors in an activity system were able to recognise the paradoxes they face and how to overcome them. Teachers are expected to master new pedagogical strategies and integrate technologies into their teaching, even though there is inadequate training and workshops. In this regard, Brave reflected:

> *You could really see that what we apply or application of their skills for example the crushing of marula nuts, to speed up the rate of reaction or extraction of the oil. Community experts have good potential to train educators. Although they were not formally trained like us teachers but the way they were teaching us was outstanding and we were able to understand very well.*

Based on the excerpt above, it seems like teachers learnt from the IK custodians and there was a shift in understanding the process of marula oil extraction from an everyday explanation to a scientific explanation.

7.10 Transformative Agency

Transformative agency is defined as a critical phase for the creation of new ideas in the changing world of work, which requires collective activity, outside support, and recognition of the development outcomes (Kerosuo, 2017). In this study, transformative agency emerged. As a result, teachers actively participated in the change laboratory workshops. In this study, the IK custodians' demonstration session was regarded as a change laboratory, which was a formative intervention. Based on Sannino (2008) and Engeström (2007c), the type of transformative agency developed from the IK custodians' presentation explicated new possibilities or potentials in the activity system.

In this change laboratory session, for instance, various episodes for the manifestation of contradictions emerged and were analysed using the six elements of an activity system. In this process, I learned that contradictions are useful in the process of learning. As a result, unlike in everyday life, contradictions should not be viewed as a starting point for new ways of understanding (Foot, 2014). Instead, they should be viewed as an opportunity for expansive learning.

In this regard, the CHAT framework enabled me to identify manifestations of contradictions within the activity system, which surfaced the conflicts, tensions and dilemmas between teachers' pedagogical knowledge, IK and curriculum implementation. Using the framework, I was thus able to analyse how the participants were learning and how ideas were developed among the participants through discovery, probing, and directing. As a result, Theoretical, Scientist, and Panduleni seemed to show evidence of transformative agency the most during the change laboratory workshops compared to the other two participants. Besides individual agency, however, I was interested in the interactive development of the collective transformative agency. Participants were learning from the IK custodians, and as the researcher, I was also learning, leading, and directing the change laboratory sessions.

7.11 Expansive Learning Opportunities

Based on CHAT, expansive learning is a creative type of learning in which learners join forces to create something novel. Essentially, it entails learning something that does not yet exist (Sannino et al., 2016). This study was interventionist in that it had to do with coming up with novel solutions to challenges faced by the teachers within their teaching practice activity system. For instance, the participants and I could not predetermine solutions or make assumptions on how things would unfold in this study. The expansive learning happened when the IK custodians and Chemistry teachers' activity systems interacted. During the practical demonstration, teachers were able to relate Indigenous technological practices to scientific concepts that were emerging. In this regard, expansive learning occurred when the IK custodians taught participants through the practical demonstration of marula oil extraction.

It is also acknowledged that tensions, dilemmas and conflicts surfaced during the intervention. For instance, it emerged that teachers were expected to integrate Indigenous technological practices, but they were not trained to do so. This was resolved by involving the community experts. There was a shift in the teachers' understanding and PCK of teaching chemistry concepts. Figure 7.6 shows the adapted expansive learning cycle.

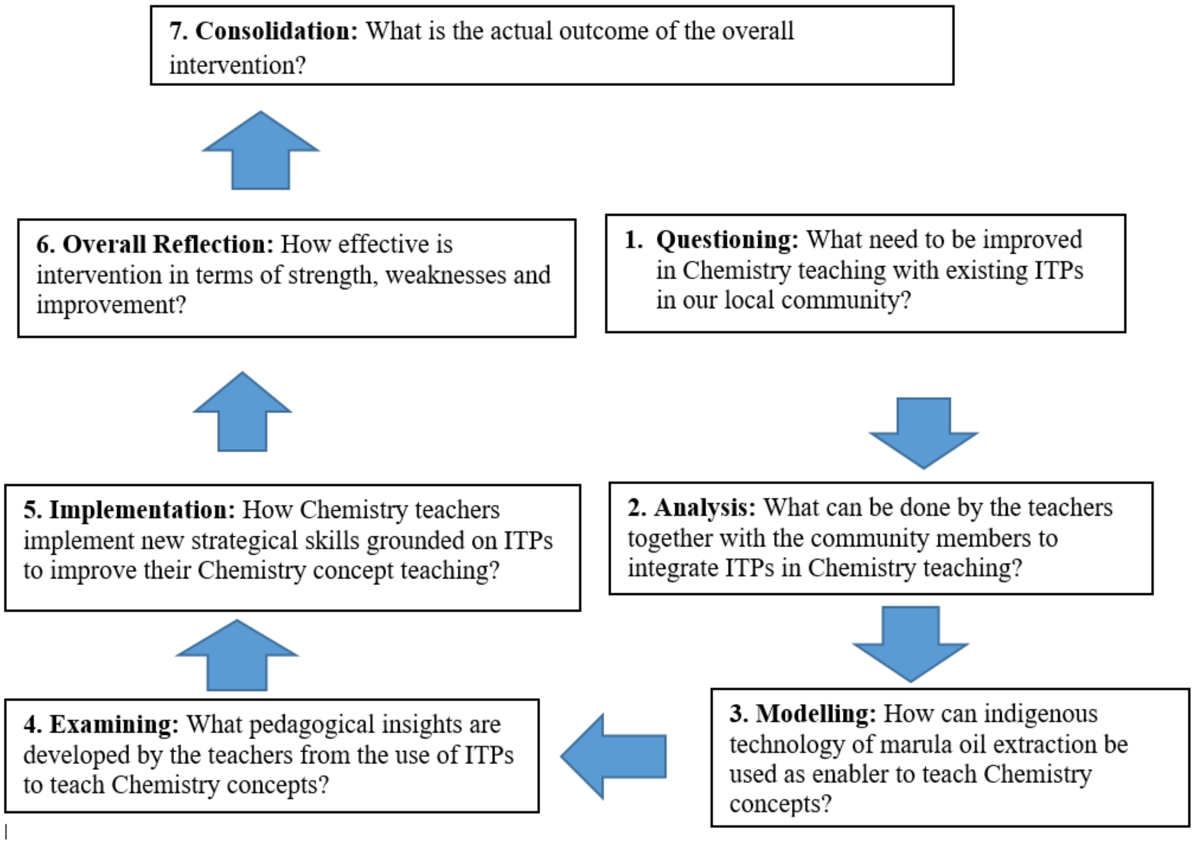

Figure 7.8: Expansive learning cycle with the sequence of learning action (adapted from Engeström, 2000, p. 970)

Similarly to Haimene (2023), I adapted this in the way that reflection was done through learning at every change laboratory. Figure 7.8 shows a *new methodological approach* where reflection was incorporated into every workshop. This differed from the typical CHAT change laboratory cycle that places reflection at the end.

7.12 Chapter Summary

In this chapter, I presented the findings from the presentations by the IK custodians on traditional marula oil extraction. Five chemistry teachers were involved in the practical demonstrations of the IK custodians, and participatory observations were conducted. I thus managed to identify tensions, dilemmas and conflicts and relate them to individual transformative agency and expansive learning. It was evident that Indigenous technological practices can be used to teach chemistry concepts and that the teachers' PCK shifted during the interactions with the IK custodians.

CHAPTER EIGHT: CO-LESSON PLANNING, CLASSROOM OBSERVATIONS & REFLECTIONS

> Making learning significant for students has to do with the application of the six elements of the quality teaching model, namely, background knowledge, knowledge integration, connectedness, cultural knowledge, inclusivity, and narrative. (Killen, 2016, pp. 77-80)

8.1 Introduction

In this chapter, I present, analyse, interpret, and discuss the data generated during the co-lesson planning of the exemplar lesson that integrated Indigenous technological practices, classroom observation, and reflections. This allowed me to observe how teachers co-planned and enacted the lessons that integrated traditional marula oil extraction. Lessons were co-developed, presented, and observed to answer the fourth and fifth research questions:

- What expansive learning opportunities were created (or not) when the grade 11 chemistry co-developed exemplar lessons that integrated traditional marula oil extraction and other Indigenous technological practices?
- How did grade 11 chemistry teachers enact and reflect on the exemplar lessons that integrated traditional marula oil extraction and other Indigenous technological practices in their classrooms?

Two secondary schools were involved, and one grade 11 chemistry teacher at each school presented two lessons.

8.2 Drawing of Mind Maps and Concept Maps

During the co-planning session, the chemistry teachers could reflect on the IK custodians' presentations and discuss the scientific concepts that were linked to traditional marula oil extraction. Each teacher came up with a description of certain episodes that identified certain scientific concepts, with explanations on how they were linked to chemistry teaching. Table 7.1 shows some of the scientific concepts that emerged.

Table 8.1: Scientific concepts that emerged from the mind map and concept maps

Participants	Statement	Scientific concepts
Scientist	*There is also refinery or refining when the woman was boiling the oil to make sure that, water was removed and to be only left with oil.* *Probably the term materials emerged when the Indigenous knowledge custodians were talking about suitability of different materials to store marula oil that was glass container, plastic containers and clay pots.* *The concept of temperature when the charcoal was added as well.*	Change of states of matter Heat energy, evaporation, condensation, temperature etc Types of materials, suitability Flavouring, diffusion, activation energy
Nelago	*The whole process of boiling and refining was done in order to bring about the concept of food preservation.* *The other terms that emerged are densities when the oil was cooling down and the residue settled at the bottom of the container.*	Food preservation, perishable, non-perishable, microorganisms, decomposition, living, non-living Residue, density, etc
Theoretical	*Also mortar and pestle as the instruments that were used to crush the marula nuts. Also, activation of energy, and separation of mixtures.*	Mortar, pestle, separation of mixtures
Brave	*There are also concepts such as catalysts, inhibitors when the hot water was used, and explanations as to why cold water was said not to be good.*	Factors that affect the rate of reaction: catalyst, inhibitors
Panduleni	*When the lady was burning the charcoal in the marula nuts, can be linked to the concept of diffusion.* *Conversion of state of matter or change of state from solid nuts to liquid oil.* *Chemical changes and physical changes also chemical reactions.*	Chemical changes, physical changes, change of states

Figure 8.1 below shows the mind map that was drawn.

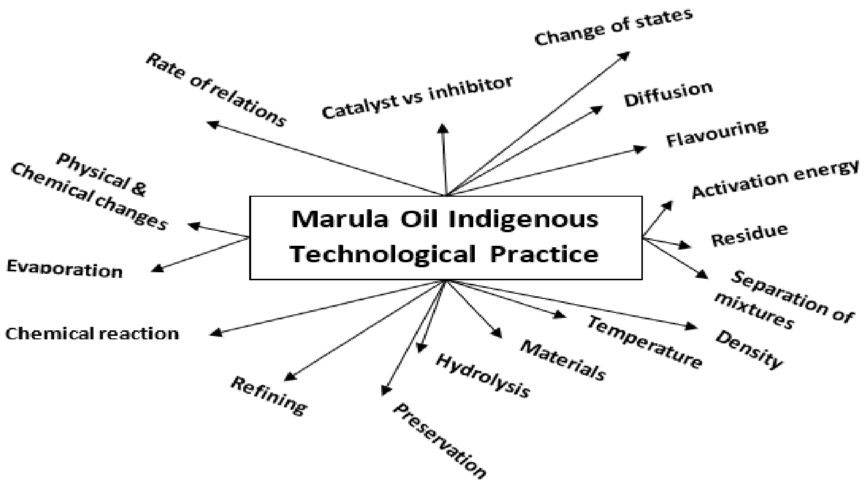

Figure 8.1: A mind map derived from traditional marula oil extraction

From Table 8.1 and Figure 8.1 above, it is evident that traditional marula oil extraction constitutes cultural knowledge that has scientific skills and concepts embedded in it. The chemistry teachers discovered that in traditional marula oil extraction, there is scientific knowledge they can use in their teaching. The application of these two knowledge systems has to do with what Killen (2016) described as the integration of knowledge, which helps learners learn from different perspectives and develop a deep understanding of the concepts they are studying. After drawing the mind map, the teachers linked the different concepts and came up with the concept map as shown in Figure 8.2.

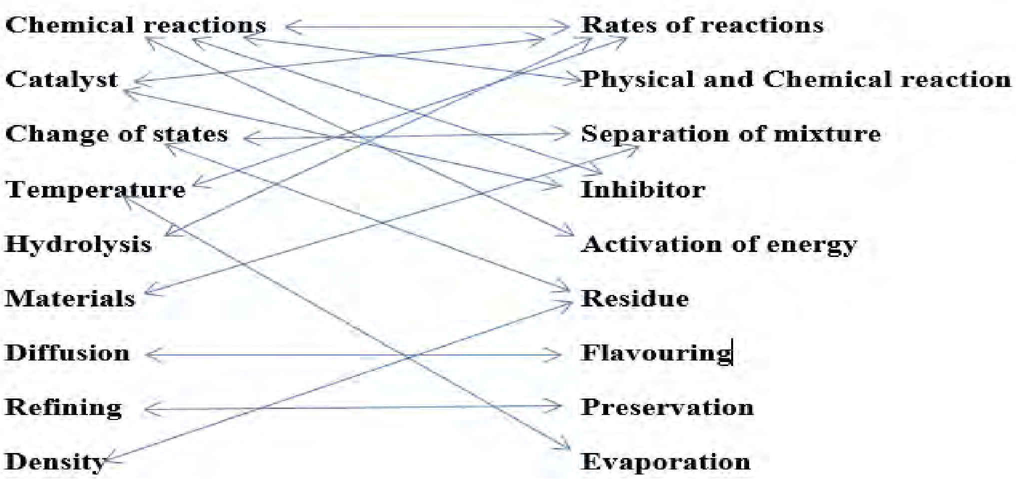

Figure 8.2: A concept map derived from traditional marula oil extraction

8.3 Data from the Planning and Co-development of Exemplar Lessons

After the mind map exercise, teachers linked the concepts to certain topics in the grade 11 Chemistry syllabus. The planning session started with a discussion on what the four chemistry teachers wanted to include when designing and developing the lesson plan that included science concepts from traditional marula oil extraction. The lesson planning was based on the concepts emerging from the IK custodians' presentations and the grade 11 Chemistry syllabus. In the grade 11 Chemistry syllabus (2018, p. 20), the theme of chemical reactions can be linked to the rates of reactions and factors that affect the rates of reactions. Brave pointed out that Section 6.4 on page 20 of grade 11 chemistry talks about factors such as particle size, pressure, collision theory, temperature and light intensity, which are the same concepts that emerged from the IK custodians' presentations.

The collision theory enables us to predict what conditions are necessary for a successful reaction to take place. These conditions include the fact that the particles must collide with each other with sufficient energy to break the old bonds. The IK custodians were able to explain why different conditions, such as crushing or not crushing marula nuts, using warm water or cold water, crushing while sitting or standing and others, would result in different rates of reactions. They were also able to suggest ways to change the rate of a reaction to extract the marula oil faster, for instance, the use of warm water as a provision of heat energy that increased the rate of chemical reaction. A chemical reaction involves breaking bonds in the reactants, rearranging the atoms into new groupings (the products), and forming new bonds in the products. The amount of energy that reactant particles (marula nuts) must have to break the old bonds for a reaction to occur is called the *activation energy*. In this case, the lit charcoal provided not only flavour but also activation energy, which made the reactant particles of the marula nuts have more kinetic energy and collide.

It emerged that chemical reactions can be taught in conjunction with other topics, such as physical and chemical changes, also taught in the grade 11 Chemistry syllabus. For instance, Scientist suggested that Section 1.5 page 8 and Section 6.4 page 21 (see Appendix L) should be considered the first exemplar topic for experimental techniques, whereby the learners' syllabus competencies require them to name appropriate apparatus, explain the change of the states, and outline the importance of purity for substances. All these learners' specific competencies resonate well with what the teachers learnt from the IK custodians; for instance, the naming of appropriate apparatus ‘mortar’ and ‘pestle’ and change of state – solid marula nuts changed to liquid marula oil (Nelago). In addition, Theoretical suggested the importance of purifying substances, observed when the IK custodians boiled the raw marula oil to preserve and refine it. Teachers agreed that experimental techniques should be the first exemplar lesson.

It was also noted that the second exemplar lesson could also be taught from the theme of chemical reactions. For instance, Theoretical suggested that in the grade 11 Chemistry syllabus (2018), pages 20–21, Section 6.4, chemical reactions, and rates of reactions could be a good option for the second exemplar lesson. This was supported by other teachers, such as Brave, who confirmed that the suggested topics went well with what was learned from the IK custodians. Panduleni added that the suggested topics had appropriate competencies that enabled the learners to understand chemical reactions they had to define and explain the terms ‘rates of reactions’ and ‘catalysts’. Nelago supported the suggested topics if the learners could see pictures or videos depicting rates of reactions and factors that affect the rate of reactions. Teachers were able to reflect on the IK custodians’ presentations, identify episodes and link them to chemistry concepts that were part of the lesson planning. This is presented in Table 8.2 below.

Table 8.2: Episodes from IK custodians and the link to scientific concepts

Episode from Community Presentation	**Participant**	**Scientific Topics and Concepts That Can Be Taught from The Episodes**	**Evidence and Link to Grade 11 Chemistry Syllabus**
The use of mortar and pestle	Scientist, Nelago	• Uses of apparatus • Naming appropriate apparatus	Pages 6, 8
Crushing of marula nuts	Brave, Scientist	• Factors that affect the rate of reactions • Particles’ size and surface area • Pressure • Change of states of matter • Physical changes • Chemical changes • Chemical reactions	Pages 20, 21
The use of lighting charcoal	Brave	• Diffusion	Page 35
The addition of warm water	Nelago, Panduleni	• Factors that affect the rate of reaction • Rates of reaction • Catalyst • Inhibitors	Page 21
Heating and boiling of marula oil	Theoretical	• Importance of purity • Refining of substances	Page 8
Storing the marula oil in the glass	Panduleni	• Types of materials • Properties of materials • Suitability of materials	Page 16

Table 8.2 shows that many episodes emerged from the IK custodians' presentations on traditional marula oil extraction. These episodes are rich in scientific concepts evident in the grade 11 Chemistry syllabus (Ministry of Education, Arts and Culture, 2018). When you crush the marula nuts, the surface area is increased, increasing the frequency of collisions and hence the reaction rate. Scientifically, this means that several smaller particles of the nuts have more surface area than one large particle that is not crushed. As the IK custodians were crushing the marula nuts, the more surface area they created for the particles to collide, the faster the reaction occurred. This made the oil extraction quicker because the IK Custodian controlled the aspect of crushing the marula nuts concerning the surface area.

8.4 Co-development of Exemplar Lessons and the Components of TSPCK

Based on Mavhunga and Van der Merwe's (2020) notions of the teachers' competencies, the analysis showed how different TSPCK during the co-lesson planning included the video clips of planned TSPCK (pPCK) and enacted TSPCK (ePCK). Table 8.3 below shows the five components of TSPCK that guided data analysis.

Table 8.3: Components of TSPCK about research

Components of TSPCK	**Relevance to research**
Learners' prior knowledge	How chemistry teachers considered the learners' prior knowledge of Indigenous technological practices when they planned and presented the lessons.
Curriculum saliency	The lessons were planned and presented in a way that teachers organised the learning activities and taught their learners by using the Indigenous technological practices that the learners know to teach the unknown scientific concepts.
What is difficult to understand	How the teachers, organised, planned and mediated the challenging topics such as scientific processes and chemical reactions using Indigenous technological practices.
Representation	How teachers planned and presented the lessons with the help of Indigenous technological practices.
Conceptual teaching strategies	How teachers considered their content knowledge, pedagogical knowledge and their learners' needs and created interest and curiosity among their learners.

The traditional marula oil extraction was used to help science teachers learn from the IK custodians, and this was evident in their co-planning and the lesson presentations. The five TSPCK components were used in this study to co-develop exemplar lesson plans using the learners' prior everyday knowledge (Kuhlane, 2011) and integrate it into chemistry teaching. The *collective* PCK, *personal* PCK, *enacted* PCK and *technologica*l PCK were considered during the co-planning and teaching of chemistry. For instance, the *enacted* PCK helped the teachers to co-plan the lesson that constituted the Indigenous technological practices and the learners' prior knowledge. In addition, certain topics and concepts that were regarded as difficult for learners to understand were easily understood by learners to understand better. Based on this, Brave commented as follows:

> *We will need to have short video clips for certain episodes that show and relate to specific competencies as our learners may understand catalyst as a substance that speeds up the rate of reaction by reducing activation emery theoretically but they may not know how this happens practically.*

Watching video clips plus explanations from the IK custodians was intended to assist the teachers with the planning of the exemplar lessons in a way that the learners could understand scientific concepts better. The TSPCK construct is located within the newly refined consensus model (Carlson & Daehler, 2019). Based on Figures 3.7 and 3.8 of this study, various levels of PCK shown above were manifest in the co-lesson planning and lesson presentation. For instance, *collective* PCK is specialised knowledge held and shared collectively by a broader community. Scientist reflected:

> *For me, it was about the level of knowledge that the community have regarding the indigenous technological practice of marula oil extraction is of higher level. This was manifested by the way they were teaching us and demonstrating the whole process of marula oil extraction to us. This really helping us to plan and teach chemistry concepts.*

The excerpt shows that Indigenous technological practices are within the community and that Indigenous people are skillful. This seems to resonate with Gumbo (2020), who claims that there are Indigenous technologies such as basket weaving, food preparation, traditional medicine and brewing beer. The implication for these Indigenous technologies in education is that they may inspire both Indigenous teachers and learners regarding the subject content. Teachers discussed and agreed to teach the two lessons: scientific processes: experimental techniques and chemical reactions: rates of reactions. Panduleni (from school A) and Brave (from school B) agreed to teach the exemplar lessons. Nelago was responsible for typing all the lesson plans. Scientist, Theoretical, Nelago, and I observed the lessons. The following were the lesson plans that were co-planned and constructed. This talks about the division of labour in terms of CHAT.

8.5 Panduleni's Lessons

Panduleni taught two lessons on experimental techniques and chemical reactions. I now discuss the findings from Panduleni's lessons as follows.

8.3.1 Lesson one - Scientific Processes: Experimental techniques

The lesson was presented at school A and lasted for about 90 minutes (double lessons) although it was planned for about 45 minutes (single lesson).

Figure 8.3: Panduleni presenting the first lesson

The lesson started with Panduleni introducing the lesson by stating that the indigenous technological practice of marula oil extraction would be used to teach and learn scientific processes and experimental techniques. She added that marula oil extraction is a very important technological cultural practice common in the northern part of Namibia, practised by Oshiwambo-speaking people. However, other tribes also do the extraction of oil from marula seeds.

She then asked the learners from different ethnic groups how they extract oil: "*Can I please hear from you how different ethnic groups also extract oil? How do you do it as Nama, Herero, Kavango and any other tribes that I did not mention*?" Learners responded as follows: "*Ms, us Namas we have a!Nara plant that has seeds which can also be used to extract the oil" (L1).* "*I only know about the oil that is taken from the milk cows" (L2).*

As I observed classroom interactions, I analysed the learners' responses, which showed that some learners had some prior knowledge of the indigenous technological practice of oil extraction. It seems like Panduleni was transknowledging (Heugh et al., 2021; Mapfumo, 2024) by inviting and citing different ethnic groups. Similarly to Nyamakuti's (2021) study, this was a multicultural classroom, and I observed that the learners of different tribes were interested and listened attentively during the introduction. Panduleni was pleased with her learners' prior knowledge, and she proceeded as follows:

> *Wonderful, you know we have so many plants that are eatable and give us seeds. Seeds have inner part that is oily and there is a special way that we are going to learn today on how to extract oil. Let us then look at our introduction. It will be better for all of us bring marula fruits or pictures to the class tomorrow. I think we do have the marula trees in our community here.*

Panduleni further explained to the learners that marula oil is a Southern African Indigenous oil extracted from the nuts inside the marula trees' seeds. It is pure natural oil commonly used as a delicacy in the northern part of Namibia and has been honoured and treated as a symbol of respect for guests. She added that marula oil is scientifically proven to be rich in amino acids, vitamins, and minerals for good nutrition, healthy skin, and eyes. Marula oil is called '*odjove*' in Oshiwambo. Panduleni further informed the learners:

> *We are going to watch video clips on Indigenous technological practice of marula oil extraction from our local community of Okahandja. We would like you to learn some experimental techniques, identify appropriate apparatus used, observe refinery and purification techniques of marula oil.*

Panduleni presented the lesson using PowerPoint, a modern technology refers to information communication technology. In this way, modern technology was used to enhance Indigenous technological practices. Nelago helped to co-observe the lesson and helped Panduleni operate the PowerPoint presentation. Before the video clips on the indigenous technological practice of marula oil extraction, Panduleni presented the lesson (scientific processes: Experimental techniques) objectives from the grade 11 chemistry syllabus (2018) (see Appendix L). The syllabus states that learners should be able to:

- name appropriate apparatus.
- indicate that mixtures melt and boil over a range of temperatures; and
- outline the importance of purity in substances in everyday life, e.g. foodstuffs, salt.

When the learners were about to watch a short video clip on how marula oil is extracted, Panduleni told the learners that they needed to watch, listen attentively and relate the video clip content to the lesson objectives and competencies that were presented. Learners were told to feel free to tell the teacher to pause the video when necessary for further explanations. Finally, Panduleni told the learners:

> *I have to let you know that last week we went to our informal settlement of 5 Rand Location whereby we visited some Indigenous knowledge custodians who demonstrated to us how to extract marula oil. In fact, we learnt a lot and that is what I am going to share with you in this lesson. So, you are going to watch how Indigenous knowledge custodians extracted the oil. Although Indigenous*

knowledge custodians used their vernacular language, translation into English was also made. So let us watch now.

Figure 8.4: Panduleni's learners watching the video during lesson one

Learners watched four video clips of about 10 minutes each. These video clips summarised the whole process of traditional marula oil extraction. The video was paused, and some learners started asking questions. L3 commented*: "Ms, I heard Mr Theoretical asking the lady was not using the fine or refined salt. I did not know about that".* Panduleni answered the question based on the IK Custodian's explanation that refined salt was not used, as there is a salt pan in northern Namibia where you can get this coarse salt rather than buying it from the shop. This type of salt is more suitable than refined salt when extracting the oil.

L4: I want to ask, do these Indigenous knowledge custodians extract marula nuts or from the fresh fruits or how?

Panduleni: Marula fruits have juice, first, the juice is extracted, and then the seeds are allowed to dry. Inside the seeds there are marula nuts that are also extracted and that are where the oil is coming from. When we will proceed with our lesson tomorrow, I will show you the whole process from the fruits, juice and the oil.

As I was observing and reflecting on L3's question and Panduleni's response, I realised that the lesson introduction was meant to include descriptions of marula trees, fruits, juices and the extraction of seeds that contained marula nuts. Learners proceeded with the video, and it was stopped at the end. Panduleni directed the lesson activities in a way that learners could observe, ask questions, link the video presentation to certain scientific concepts, and draw conclusions. This resonates with Karabuz and Ogan-Bekiroglu (2020), who stated that using technology may stimulate teachers' confidence and self-efficacy, so they become more successful in their teaching. In other words, the video presentation of the IK custodians was an enabler that triggered the learners' curiosity and motivated them to ask questions. Moreover, learners were able to give correct answers to the questions posted by the teacher and the other learners, as evidenced in this vignette:

L5: Ms Panduleni, why are they adding charcoal? Charcoal in marula nuts?

Panduleni: Yes, that Indigenous Knowledge Custodian that you are watching in the video and the teacher if I can refer to her because she was teaching us that she puts charcoal in the marula nuts after adding the salt. Why do you think, according to the video?

L5: To activate...

Panduleni: Yes that's true, the charcoal was used to lower activation energy as well as for flavouring, that smell that comes with the oil. I am telling you, when we were there, I experienced the smell.

Since this was a multicultural classroom, similar to Nyamakuti's (2021) study, I assumed that some tribes unfamiliar with traditional marula oil extraction might feel excluded or not participate actively. This was not the case as I observed some Afrikaner/Coloured learners (L4 and L5) who were curious and participated actively during the lesson:

L4: But I am a bit worried when the woman was just touching that hot charcoal with her hands, was she not scared to be burnt?

Panduleni: You know when you are an expert you will get used to do certain things that you have to do without any harm. But the issue of adding the charcoal has to do with two main things that we need to take note of Activation energy, that we learnt in grades 9 and10 and Flavouring

L5: But Ms Panduleni when the Indigenous Knowledge Custodian was choosing bigger charcoals and leaving the smaller ones why?

L4: Probably is for more activation energy. I think the bigger one produces more energy.

From the vignette above, it appears that Afrikaners/Coloured learners showed a willingness to learn from the IK Custodian's presentation through their curiosity and active participation. This coheres with Kugara et al. (2022), who recommend that people should change their mindset, attitudes, and practices and that they must be open and willing to learn from the locals who are knowledge bearers. As I was observing, I developed the opinion that Panduleni used the video presentation of IK custodians and what the learners had learnt in the previous grades as prior knowledge. This resonates with the Namibian revised National Curriculum for Basic Education (Ministry of Education, Arts and Culture, 2016), which proposes that effective teaching should embrace the learners' prior everyday knowledge (Kuhlane, 2011).

Panduleni reminded the learners that in grades 9 and 10, they had learnt that when a chemical reaction occurs between reactants, minimum heat energy is needed – this is referred to as activation energy. She further explained that what the learners watched in the video clips was a chemical reaction that took place, whereby heat energy was needed, and that is why the charcoal was used. Such types of reactions are called endothermic reactions, as energy is taken from the surroundings. Panduleni clarified that instead of using charcoal, marula nuts can be exposed to direct sunlight for heat energy, but this would take longer; however, sunlight does not give the nuts flavour, so the IK Custodian recommended using charcoal. Learners were so curious, and some of them started asking the questions shown in the vignette below:

> *L4: Ms Panduleni, how do we call that mortar and pistil in Oshiwambo?*
>
> *Panduleni: Mortar… oshini … pestle … omushi*
>
> *Panduleni: Why do you think the woman is pounding?*
>
> *L7: Ms Panduleni, it has to do with surface area, but there is something.*

Panduleni responded to L7 by saying that it all depended on the context and what was being produced. For example, when someone is pounding mahangu grains (Simasiku, 2022), they need to stand to apply more pressure because mahangu grains are harder than marula nuts. She then showed the marula nuts to the learners to see and feel them. Panduleni remarked that marula nuts are softer compared to mahangu, maize meal and nuts, and that is why the woman was pounding while seated, because they did not need a lot of pressure to be crushed. As the lesson progressed, some other learners asked further questions. For instance, L8 asked why the IK custodians were adding warm water when they were crushing. Panduleni redirected the same question to the class, and L9 responded: "*For the oil to come out".* Panduleni continued with the lesson and asked the learners to analyse and explain what they noticed when the woman was adding water. Here are some of the responses from the learners:

L10: She was adding a little bit by bit but not pouring much at the same time.

L4: She was using her sense of touch to determine probably whether it was the right temperature for the water.

Panduleni acknowledged the learners' responses and emphasised that all the processes the learners watched from the video presentation constituted scientific skills. More learners were coming on board, and L11 asked: "*Why is it that immediately when she adds the warm water, the woman will crush faster than before?"* L4 responded: *"I think it is to maintain the temperature together with the friction and make sure that the hotness is kept bringing the oil".* Panduleni commented: *"You can see the oil has come out now and now she will separate the oil from the residue".* Panduleni directed the learners to the last clip about refining the oil. Based on the video, learners were able to see the IK custodians heating and boiling the marula oil. She then asked the class:

Panduleni: Why do you think she is doing so?

L14: What was extracted was not just oil but the mixture of oil and water. So she boiled to separate the two.

Panduleni: Correct, we have learnt that mixtures can be?

Whole class: Separated.

Panduleni added that heating and evaporation are methods of separation that were used. While the community member was boiling, she kept stirring. *"Why and what is the purpose of doing so?"* L4 replied that perhaps she was trying to spread the heat energy throughout the pot. Panduleni made it clear that the purpose was to make sure that the sediment at the bottom of the pot was not burnt. She concluded the video clips by saying that when the IK Custodian was boiling the oil, all the water evaporated, and the woman removed the pot from the fire. Once the oil had cooled down, it was stored or preserved in a special container, preferably glass or ceramic. She then showed the refined marula oil in the glass container that the learners saw in the video presentation.

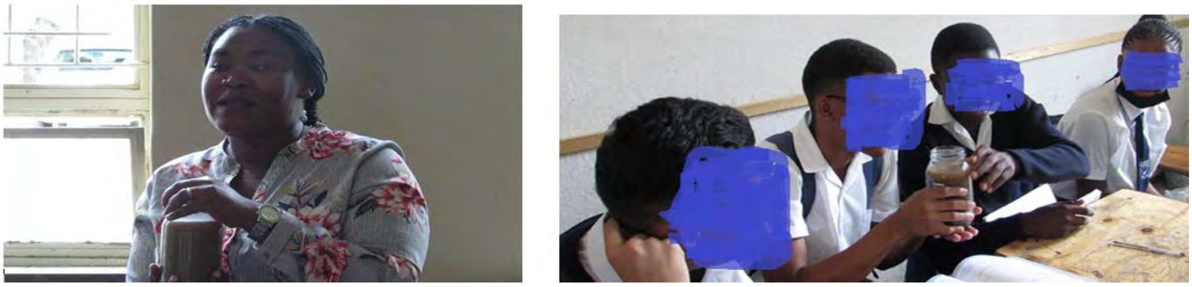

Figure 8.5: Panduleni's learners observing refined marula oil

Panduleni asked the class:

> *What do you think could have happened if the oil was not refined?*
>
> *L14: It will be rotten and decompose because of the presence of water and oxygen within the mixture.*
>
> *L15: Ms Panduleni, we want to see a closely look how it smells and looks like.*
>
> *L16: What happened to the salt that was added?*

Here is Panduleni's response to L16: *"Remember in the video, salt was added for taste, charcoal was added for activation energy and flavouring".* At this point, learners were done watching all four video clips. The teacher wanted to test and see whether the video presentations enabled her learners to learn scientific processes: Experimental techniques. Panduleni rounded up the lesson by testing what the learners had watched and learnt against the syllabus competencies and objectives. She asked the learners to name the appropriate apparatus mentioned/seen in the video, and these were the responses that the learners came up with:

> *Whole class: Mortar and pestle.*
>
> Panduleni demonstrates mortar and pestle to the class: *Here is the Mortar, which is used for?*
>
> *Whole class: Crushing the surface.*
>
> *Panduleni: And the pestle is used for?*
>
> *Whole class: Crushing the particles.*
>
> *L15: Also the pot to boil and refine the oil.*

Panduleni: Oh Yes in the laboratory we used modern apparatus such as beakers to heat/boil but the pot is also appropriate apparatus that our Indigenous knowledge custodians used.

Panduleni further asked the learners about the purification techniques that they had observed in the presentation, and this is what emerged:

L4: Evaporation

L18: Also distillation

Panduleni then further tested the learners on the importance of purity and refining substances such as marula oil, and the learners had these responses:

Whole class: to separate the mixture of oil and water.

Panduleni: Very good, what is the other concept behind refining that we talked about?

L19: Preservation

Panduleni: Wonderful! Yes, purity and refining help us to preserve substances but we have to take note that when we are refining substances, we are removing substances that we do not want and leaving the substances pure. Lastly, we are moving to the part of reflection.

Finally, Panduleni asked the learners to reflect on the lesson, and the following emerged:

L20: Ms Panduleni I have learnt that if this marula oil was not refined, it will go bad.

L9: I have learnt the methods of separating mixtures of marula nuts from the oil.

L4: I have learnt about different apparatus and their uses.

L21: I have learnt that the charcoal that was added was for flavour and activation energy.

L6: Except from the charcoal I have learnt that sunlight can also work but it will not give the good results because it cannot add the flavour to the oil.

The lesson came to an end, and Panduleni presented the assessment activity to the learners (see Appendix K). The purpose of this assessment activity was for the learners to explore other possible Indigenous technological practices that they may know that could also be integrated into science learning. To conclude, Panduleni's lesson one used the video presentations of the IK custodians to enable her learners to master the competencies regarding knowing scientific apparatus and their uses, describing purification methods, and understanding that the mixture of extracted oil and water melts and boils over a range of temperatures.

8.3.2 Lesson two - Chemical reactions: Rates of reactions

The lesson lasted for about 90 minutes as planned. Figure 8.6 shows the objectives from the grade 11 chemistry syllabus (2018).

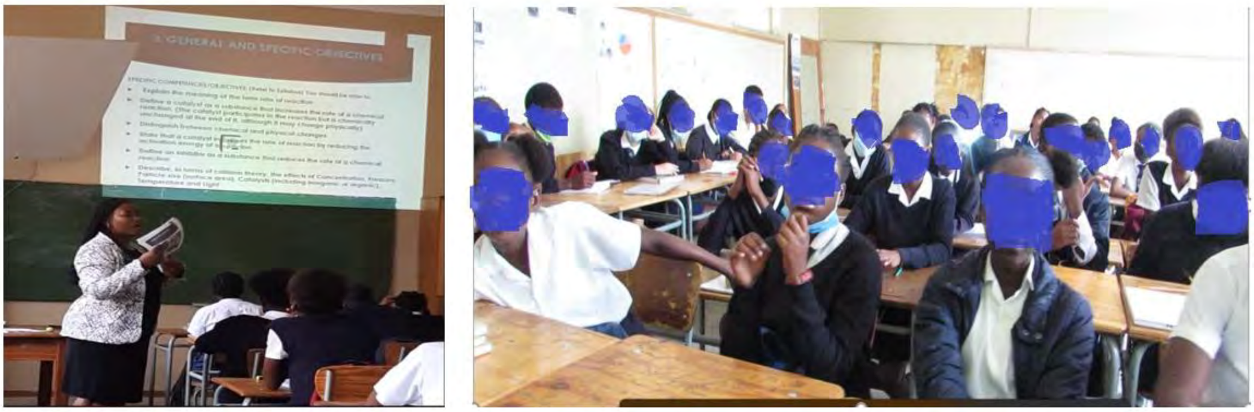

Figure 8.6: Panduleni and the learners during lesson two

Panduleni started by greeting the learners and welcoming them to the second lesson. She reminded them that in the previous lesson, she requested the learners to bring marula fruits and/or pictures of marula fruits or trees. Most of the learners had brought these (see Figure 8.7). Panduleni collected the marula fruits and the pictures of the fruits, and the trees. Based on CHAT, these are the artefacts and cultural tools available in the community and are useful in teaching and learning science. Hence, learning is a socioculturally oriented activity (Engeström, 1987).

Figure 8.7: Panduleni's learners collected pictures of marula trees, fruits, and nuts

Panduleni demonstrated to the class what the marula fruits and the trees looked like. She indicated that the fruits were slightly different; some looked greenish, which meant that they had not yet ripened. Some looked yellowish, which meant that they were ready or ripe to be harvested. When the fruit was green, it appeared to be harder, but when it became yellowish, it became softer and juicier. When it is ripening, the juice is then extracted and the seeds remain, and they are dried for some time or weeks. Within the seeds, there are nuts that are also extracted, and the nuts are the ones that the learners saw in the previous lesson video presentations. Panduleni informed the class:

> *Today we are going to build from our yesterday lesson of scientific processes and experimental techniques. Based on that, today we are going to learn more about the chemical reactions in terms of rates of reaction, catalyst, physical changes, chemical, changes, inhibitors and collision theory.*

Panduleni reminded the learners not to forget that all the learning activities were taking place by relating and linking to the traditional marula oil extraction that the learners watched in the video presentations in the previous lesson. She further informed the learners that the lesson was built from what the learners had learnt in the previous lesson. She told the learners: "*Let us look and from the PowerPoint presentation that I prepared for you for today's lesson; let us see how marula tree and fruits look like".* She explained that during the extraction of marula seeds, there was a common and important juice called *omagongo*. The juice was a seasonal product that was extracted during the rainy season by women.

Omagongo can be fermented and become a mild alcoholic or a strong alcoholic beverage. As per societal beliefs, *omagongo* is consumed by males or men. She showed the learners a PowerPoint presentation. From the first lesson, the way the learners asked questions showed that they did not have the background knowledge of marula oil extraction. Therefore, Panduleni showed the learners, and they watched how marula juice is served in traditional cups to visitors. Panduleni also presented a PowerPoint on the commercialised marula products of marula cream wine, which is sold in the shops, and pure organic marula oil is also sold in the shops to be applied on the skin and the hair. Apart from that, she noted that it could also be sold as a pure oil to put on their food, as they saw in the video yesterday. Figure 8.8 below is a summary of the processes involved before marula oil extraction.

Figure 8.8: Other crucial processes involved before marula oil extraction

Panduleni explained:

> *Yesterday you requested me to show the processes that are involved from the fruits up to the nuts and this is what I am showing you now. Overall, just look at how the grandmother is busy with the processes of extracting marula nuts from the marula seeds. So marula nuts are raw materials that we need to extract the oil. I hope this has helped you to understand different processes that are involved in marula oil extraction.*
>
> *Whole class: Yes, Ms Panduleni.*

Panduleni moved to the general and specific competencies and objectives in the chemistry grade 10-11 syllabus, and she told the learners: "*We are going to achieve these lesson objectives by using the same video that we watched yesterday and what we are learning today. Here are the basic competencies and objectives from the grade 11 chemistry syllabus (2018)".*

- explain the meaning of the term rate of reaction;
- define a *catalyst* as a substance that increases the rate of a chemical reaction (The catalyst participates in the reaction but is chemically unchanged at the end of it, although it may change physically);
- state that a catalyst increases the rate of reaction by reducing the activation energy of a reaction;
- distinguish between chemical and physical changes;
- define an inhibitor as a substance that reduces the rate of a chemical reaction; and
- describe, in terms of collision theory, the effects of concentration, pressure, particle size (surface area), catalysts (including inorganic or organic), temperature and light.

The following are teaching and learning support materials that were used:

- video clips constituting the following: Indigenous materials and apparatus needed in the experiments of marula oil extraction;
- marula nuts;
- pestle & mortar;
- salt;
- warm water; and
- marula oil.

When Panduleni was done with the introduction, she started with the body of the lesson based on the following concepts.

Rates of reactions

Panduleni asked the learners: *"What do you understand by the term rates of reaction?"*

> *L1: It is how fast or how slow the reaction can take place.*
>
> *Panduleni: Thank you L1, based on the previous lesson video presentation, what was done by the Indigenous knowledge custodians for reaction to go faster?*
>
> *L2: They added heat energy in the form of warm water.*

The learners' responses showed that they had prior knowledge of rates of reactions and could relate such prior knowledge to the video presentations, and had a better explanation of what rates of reactions are all about. She then linked this to the video presentation, where learners had seen that the IK Custodian used warm water to increase the rates of chemical reactions. Panduleni asked the learners: *Who can explain this statement about what the rate of reaction is all about based on yesterday's video presentation?"*

> *L4: When a woman poured warm water during the process of crushing marula nuts.*
>
> *Panduleni: Ok. How do we know that warm water that we are saying is a catalyst?*
>
> *L5: During the process of refining and purification, the water evaporated.*
>
> *Panduleni: Yes, you are correct and you have seen there was a foam on top of the mixture and when all the water has evaporated, the foam disappeared. Let us proceed, we are saying that catalyst increase the rate of reaction by reducing the activation energy for the reaction. Now we are going to talk about inhibitors. What is inhibitor?*
>
> *L2: Substance that slows down the rate of chemical reaction.*

As I was observing, I realised that there was a misconception about what a catalyst is. Panduleni and her learners' understanding was limited as they only understood it as a substance that speeds up the rates of reactions. The aspect of the catalyst lowering the activation energy was not fully explained. The use of warm water by the IK Custodian was explained as a catalyst, while it was supposed to be explained that warm water was used to increase the temperature to melt solidified oil into a liquid. Panduleni used the video presentation to teach the concept of an inhibitor, and the learners were able to relate that to the video presentation. She explained and emphasised that the IK custodians avoided the use of cold water as it can slow down the rate of reaction.

Collision theory and the factors that affect the rates of reactions

Panduleni moved to the concept of collision theory and the factors that affect the rates of reactions. She made it clear that when the IK custodians were adding warm water, they were not just pouring large volumes of water at once; they were adding it bit by bit. This was just to make sure that the extraction of quality oil was not compromised.

The learners then watched the video clips again for a few minutes to link the other factors that affected the rates of reactions. The woman was pounding and crushing while she was sitting instead of standing, to make sure that the pressure was not too much. Panduleni explained that if she were to stand and pound, some particles of marula nuts could have spilt out. Although the Namibia Senior Secondary Certificate Ordinary National Examiners' Report (2020, p. 96) revealed that "most learners were merely describing factors that affect the rates of reactions", in this lesson, it was not the case. This was demonstrated when the learners were asked: "*What was the purpose of pounding marula nuts at first place?"*

> *L6: To reduce the size of marula nuts.*

L6's response showed that they understood the IK custodians' explanations given during the video presentations. This was to make the nuts finer so that when the woman added the warm water, they would mix up well and faster. Panduleni further asked the learners: "*How can we explain the act of Indigenous knowledge custodians' crushing marula nuts in relation to collision theory?"*

> *L7: She is increasing the surface area.*

Panduleni explained to the class that the marula nuts are finer when they are crushed. The act of crushing increases the surface area, which allows the particles of warm water to come in contact with the marula nuts as much as possible. When the particles of marula nuts are bigger, the rates of reactions can be slow, and therefore, they are crushed into smaller pieces. When the woman was pounding, the particles were becoming finer and smaller. This created a large surface area for more particles to be exposed to warm water. The Namibia Senior Secondary Certificate Ordinary level national examiners' report (2020, p. 96) revealed that "most learners were merely describing factors that affect the rates of reactions in general form theory without contextualising this to the given chemicals, apparatus and additional guidance". In this lesson, learners were able to describe factors that affected the rates of reactions through the contextualised video presentations of the cultural artefact of marula oil extraction.

Physical and chemical changes

Panduleni wanted to test whether the learners could identify some episodes from the video presentations and classify them as either physical or chemical changes. She wanted the learners to distinguish between physical changes and chemical changes concerning the marula oil extraction video presentations. She then asked the learners: "*Based on the video presentation, what point have you observed that it was physical changes or chemical changes?"*

> *L8: When the women started to pound marula nuts it changed from solid to oil and it is a physical change.*
>
> *L2: The products that are formed are totally different from the reactants. First, there were only nuts and finally oil was formed and it cannot be changed back to nuts.*
>
> *L9: During the process of extraction, water was added to generate the oil but when the oil was refined and boiled the water disappeared during evaporation as a gas and this is a physical change.*
>
> *L10: When the woman added the charcoal to the marula nuts and mixed it with the nuts to bring the flavours, later she removed the charcoal with her hands to separate the two and this was a physical change*
>
> *L5: When the charcoal was added for the favour, there was a smell or a flavour and was a chemical change?*
>
> *L8: The nuts were more of the white but the residue and oil that was formed was more of brownish and I think this was a chemical change.*

Based on the excerpts above, the video presentation of traditional marula oil extraction was an enabler for the learners to distinguish between physical and chemical changes. The use of video presentations in the form of local materials correlates with the Namibia Senior Secondary Certificate Ordinary level national examiner's report (2021, p. 88), which recommends that "teachers are encouraged to use easily accessible and locally available materials to conduct practical activities in the classrooms".

Factors that affect the rates of chemical reactions

Panduleni highlighted the factors that affect the rates of chemical reactions, which are concentration, pressure, particle size (surface area), catalysts, temperature, and light. She further highlighted that when the learners watched the video, it was evident that all the factors that affected the rates of reactions were observed, and this is evident in the following excerpt:

> *L12: All the factors were observed including the light. I can remember someone asked and the women said that if we do not have the charcoal to activate we can put nuts on the sun but it will take longer.*
>
> *Panduleni: Yes, it is true, I do remember also. Do we see that this Indigenous technological practice is really enriching us in the learning of chemistry? So a lot of science is happening in our communities.*
>
> *L13: Ms Panduleni, I want to ask, why didn't they use very hot water but they used warm water?*
>
> *L4: From my point of view is that if you use hot water it may speed up the rate of reaction in such a way that the reaction will be too fast and you won't get the amount of oil that you wanted to extract.*

From the vignette above, it appears that learners were able to describe the factors that affected the rates of reactions properly. This finding contradicts what the National Namibia Senior Secondary Certificate Ordinary level examiners' report (2020, p. 96) revealed earlier that "most learners were merely describing factors that affect the rates of reactions in general form theory without contextualising this to the given chemicals, apparatus and additional guidance".

Learners' reflections on the lesson

Panduleni commented on the learners' responses and related them to a biology concept where too hot water may denature the enzymes (Nyamakuti, 2021). So, with this marula oil extraction process, one could say that the IK custodians applied experimental techniques to describe collision theory. Panduleni asked her learners: "*What have you learnt from the video presentation in particular to this lesson?*"

> *L13: I learnt about rates of reactions.*
>
> *L4: I have learnt that in everyday things that are happening in our community, there is science that we can learn in the class like what we are doing now.*

From the above excerpts, it appeared the learners were excited to realise that the things they do at home are featured in their syllabus and to acknowledge that, indeed, science is within their communities. This culturally responsive pedagogy (Mhakure & Otulaja, 2017) resonates with Engeström (2000, 2001), who viewed learning as a socially, culturally mediated and historically connected process. This provided an opportunity to use cultural tools and easily accessible resources (Asheela et al., 2021) to connect school science to the sociocultural background of the learners (Mavuru & Ramnarain, 2020). At the end of the lesson, Panduleni gave the learners an assessment activity (see Appendices K1 and K2) to explore more Indigenous technologies and link them to scientific concepts.

8.4 Brave's Lessons

Similar to Panduleni, Brave also taught two lessons. The first lesson was on experimental techniques, and the second lesson on chemical reactions. I now discuss the findings from Brave's lessons.

8.4.1 Lesson one - Scientific processes: Experimental techniques

The lesson lasted about 70 minutes and was planned for 90 minutes (double period). School B is an urban secondary school that offers about four different fields of study. It is bigger than school A in terms of learners' enrolment and number of teachers. Similarly to Panduleni's lessons, learners were coded L1, L2, L3, L4, and so on because of ethical considerations.

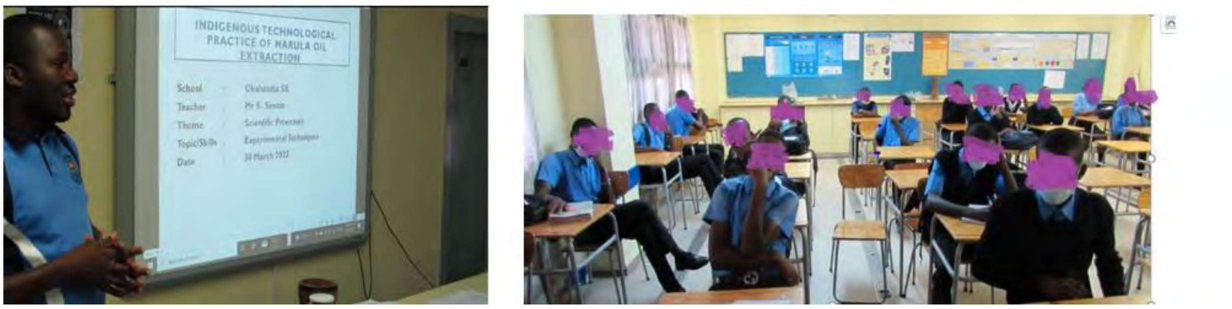

Figure 8.9: Brave presenting the first lesson

Brave introduced his lesson and told the learners that they would have a short lesson presentation under the scientific processes theme, and the topic would be experimental techniques from the grades 10-11 chemistry syllabus. He further told them that they would learn and link or relate lesson one, scientific processes and experimental techniques to the indigenous technological practice of marula oil (*odjove*) extraction. He then asked the learners: *"Is there anyone of you who knows about marula oil (odjove) and how it is extracted?"*

> *L1: I know that marula oil comes from marula nuts that are crushed with some heat to produce such oil.*
>
> *Brave: Alright thank you, there is a lot of scientific knowledge in such practice and that is what we are going to learn today. Our general objective from grades 10-11 syllabus is that you should be able to understand the principles of experimental techniques*

Similarly to Panduleni, Brave informed the class about the specific objectives the learners needed to achieve and that they needed to master specific competencies from the grades 10–11 syllabus. He then asked the learners to watch the video presentation. Theoretical helped to co-observe the lesson and helped Brave operate the PowerPoint presentation. Unlike Panduleni's presentation, learners started to watch all the video clips without pausing. It seems like the rationale for this pedagogical approach was to save time.

Figure 8.10: Brave's learners watching the video during lesson one

At the end of the video clips, Brave told the learners to relate the content of the video presentation to their lesson objectives and competencies. He then asked them: *"According to the video presentation, what appropriate instruments/apparatus you have seen in the video?"*

> *L2: Mortar and pestle.*
>
> *Brave: Correct and what are the uses of these apparatus?*
>
> *L3: To crush bigger particles to become smaller.*
>
> *Brave: What were the other instruments\apparatus that we have used?*

L4: There was also the electrical kettle that was used for warm water.

Brave: What else perhaps?

Whole class: The pot that was used for refining the oil.

L5: Sir! Also the glass container for storing the refined oil.

L6: The spade was used for charcoal.

Brave: Ok. The charcoal was used as?

L7: Catalyst

L8: To produce heat energy.

Brave: What are purification techniques that you have observed in the video?

L2: Boiling and evaporation

From the vignette above, it appears that learners could relate the video clips to scientific concepts and were able to answer the questions. This could be because the lesson started with a video presentation of the traditional practice and prior everyday knowledge (Kuhlane, 2011) that they were familiar with. Brave further emphasised that during the crushing process, the community member added warm water, and when the oil was extracted, it was a mixture of water and oil. So, boiling and evaporation were used to separate the two. Brave proceeded to say that as the IK custodians were boiling the mixture in the pot, all the water evaporated, and the oil was left in the pot. Hence, they needed to talk about the importance of purity and refining of substances. He then asked the learners: *"What do you think is the purpose of refining and purifying marula oil (odjove)?"*
L9: To give it a longer life cycle.

Brave: Yes.

Brave further clarified that refining has to do with preventing the oil from expiring in a shorter period; that is why the IK custodians refined and purified it. He demonstrated the marula oil in the bottle to the learners. He made it clear to the class that once the oil is refined, it can be stored and used for a longer period, even more than a year. He further asked the learners: *"What else can you say on importance of purifying and refining of substances?"*

> *L10: This is just for storage and preservation.*

Brave moved on with the lesson up to the part of general reflections on the video presentation about our topic of scientific processes and experimental techniques. At this point, Brave wanted to test if the learners could relate the video presentation to the science concepts. He then asked the learners: "*What have you learnt from the video presentation?"*

> *L2: I have learnt how people in the community can use their own cultural scientific apparatus and use things in the environment to produce something like oil.*
>
> *L11: Different apparatus that were used and their uses.*
>
> *L12: I learnt that there is also a cultural method of extracting oil apart from the modern method of producing oil.*
>
> *L13: I have learnt that are also certain steps that were used to shorten the process of extraction.*
>
> *L14: I learnt that diffusion is caused by the moving air because there was a smoke when the charcoal was put on the marula nuts and the smell came out.*
>
> *L15: I also learnt that there are specific reactions where pressure is not required much because the woman in the video was relaxing and seated while crushing.*
>
> *L19: I wanted to see the other processes that are involved before extraction of oil. Why was it not shown in the video?*

The excerpts above show that Brave's learners' reflections were like Panduleni's in that within their communities, people used their cultural methods that were linked to science concepts. Brave's learners also wanted to know the other processes involved before the marula oil extraction. To this, Brave assured them he would show the learners these processes during the next lesson. Brave clarified L15's reflection that the IK custodians did not apply too much pressure, which is why she was not standing. He explained that from a scientific perspective, we have learnt that pressure is increased by height. The higher the woman can lift the mortar, the greater the pressure and the lower the woman lifts the mortar, the less the pressure she is applying when crushing the marula nuts. Learners were participating actively, and from their reflections, it seems the video presentation helped them think critically and link the indigenous technological practice of marula oil extraction to the scientific concepts. They were also asking questions and making comments such as:

L10: How long does it take for the 'magma' or 'residue' to expire?

Brave: The most preferable answer is that it will also depend on the environment around it and the conditions around it, for example, temperature, insects, moisture. If you dry it, it can even take or last for more than a year and that's why in our tradition, these types of things are kept in a safe place and throughout the year we do not run out of them at all. When the visitors are coming to your house then you can serve them with these.

L6: Sir, I just want to add that odjove is also used to treat cough, you just drink a small spoon the cough will go.

L19: Why do we only store the marula oil in the bottle container?

Brave commented that learners learned that different materials have different properties that can play an important role in substance storage and preservation. In this case, a glass bottle was more suitable for storing the oil than a plastic container. The teacher concluded the lesson and learners as follows:

Apart from the Indigenous technology of refining and purifying marula oil 'odjove' think of and research any other two Indigenous or local technologies in our everyday lives that involve the scientific processes of refining and purifying.

The homework's purpose was to help the learners link science in their community to school science.

8.4.2 Lesson two – Chemical reactions: Rates of reactions

Figure 8.11: Brave and the learners during lesson two

Lesson two was a continuation of lesson one and it lasted for 90 minutes. Brave reminded his learners that last time they had talked about scientific processes and experimental techniques, and he told his learners:

> *Today we are going to learn about chemical reaction and the rate of reactions by applying and relating Indigenous technological practices of marula oil (odjove) extraction that we talked about in our previous lesson.*

Unlike Panduleni's lessons, Brave's learners did not bring the marula fruits and the pictures of marula trees. Instead, Brave presented a full description that marula oil is a Southern African Indigenous oil extracted from the nuts inside the marula trees' seeds. It is a pure natural oil commonly used as a delicacy in the northern part of Namibia and has been honoured and treated as a symbol of respect for guests. It is scientifically proven that marula oil is rich in amino acids, vitamins and minerals for good nutrition and healthy skin and eyes. Marula oil is called '*odjove*' in Oshiwambo. So, he told the learners that they were going to watch video clips once again on traditional marula oil extraction from their local community of Okahandja.

He then informed the learners that he would like them to learn more about the rates of reactions, catalysts, chemical reactions, chemical changes, physical changes, inhibitors and collision theory. He told the learners that trees grew naturally, and the fruits looked greenish; when they turned yellowish, it meant that they were ready or ripe, and they fell off on their own. When they fell off, women gathered them to extract the juices. After they had removed the first layer of the marula fruits, the juice came out and was collected in a special container. Once the juice was extracted, it was kept for one to three days to ferment. The juice could be fermented in two categories: the soft (non-alcoholic) one, normally for children and the strong one, which is alcoholic, to be consumed by the elders.

He explained that marula products could be commercialised as seen in the slide displayed. The slide showed Amarula cream juice sold in supermarkets, shebeens and liquor stores. There was also commercialised marula oil that they could buy in the shops for food consumption, hair, or skin. After all, he noted that once they removed the juice, the seeds were dried for some weeks. Within the seeds, some nuts contain oil. The outside layer of the seed was hard, and women used instruments such as axes, pestles, and special extractors; finally, the marula nuts were extracted to make the oil. He ended by saying that he hoped the learners now had a detailed background of marula oil. These were the same as Panduleni's specific competencies/objectives from the chemistry grade 11 syllabus (2018). When Brave was done with the introduction of the lesson, he then continued with the lesson and used the video presentation to teach the following concepts.

Rates of chemical reactions, catalysts, and inhibitors

Brave then started with the concept of the rates of reactions. They watched the video presentation for a few minutes once again. After the video presentation, he wanted the learners to relate to and explain some scientific concepts.

> *Brave: What is the meaning of the rate of reaction?*
>
> *L1: It is how faster or how slower the reaction can take place.*
>
> *Brave: Yes, you are correct; it is how fast or how slow the chemical reaction or physical reaction can take place for the products to be formed.*

Brave proceeded with the concept of catalysts and reminded the learners that a catalyst was a substance that increased the rate of chemical reactions. A catalyst participates in a chemical reaction but is chemically unchanged at the end of the reaction, although it may change physically. A catalyst increases the rate of rate reaction by reducing the activation energy of a reaction. Remember that activation energy is the minimum amount of energy needed for the reaction to take place. Brave asked the learners: *"Now in the process of marula oil extraction that you have observed, what catalyst was used and what evidence can you share that it has increased the rate of chemical reaction?"*

> *L2: Lukewarm water was used and when it was added it immediately changed colour to brownish and oily.*

Brave commented that warm water was used to increase the temperature. The evidence was the colour change and the oil that started to be formed. Brave then connected this to the concept of inhibitors. He mentioned that these were substances that reduced the rate of a chemical reaction. From the observation, learners were able to understand the concept of inhibitors by relating it to the video presentation. When Brave asked them, this is how they responded:

> *Brave: From the video clips, what sort(s) of conditions that you think the Indigenous knowledge custodians may avoid as it could have reduced/inhibit the rate of reaction?*

L3: Sir, cold water.

T2: Sir they avoided using the cold water because it could have reduced the rate of reaction.

Based on the above responses, it seems like the video presentation of the practical demonstration prompted them to participate actively. This resonates with Hodson (2009), who observed that learners enjoy practical activities, and this stimulates learning.

Physical changes and chemical changes

Brave stated that if cold water was used, it may generate the oil in low quantities and take a longer period. Cold water was avoided as it would serve as an inhibitor in that extraction process. Brave moved on to the concept of chemical changes and physical changes, whereby he asked the learners to relate them to the video presentation and identify episodes that distinguished the chemical changes and physical changes. This is what emerged from the learners' responses:

L6: A chemical change was observed when the oil was formed and this oil cannot change back to the marula nuts that started the reaction.

L4: When the Indigenous knowledge custodians added the charcoal and mix it with the marula nuts and then later it was separated with her own hands. That was a physical change.

L4: When she added salt into marula nuts was a physical change.

L8: When she boiled the oil, the water started to evaporate, removed from the oil completely and this is a chemical change.

Brave's approach to asking the learners to identify episodes enabled the learners to distinguish physical and chemical changes.

Factors that affect the rates of chemical reactions

Brave directed the learners to apply the experimental techniques of marula oil that they had learnt from the video presentation to describe collision theory; this included factors such as concentration, pressure, particle size (surface area), catalysts, temperature and light. First, he gave the learners an example of when the IK Custodian was adding water, they did not just add any amount of water; they added a little bit by bit. If they had added a huge amount of water at a time, this could have compromised the concentration of the oil that would have been produced. So, they made sure that the water concentration was under control to extract more oil. He then moved to the pressure as another factor. The higher the concentration of reactants, the more particles are available to collide. This enabled the marula nuts as reactant particles to collide more often as they were crowded within the mortar. Learners were able to relate and link scientific concepts to the video presentation, and this was evident from their responses when they were asked:

> *Brave: Who can tell us based from the video presentation where pressure was involved and how it was applied or controlled?*
>
> *L2: When the woman was crushing the marula nuts, she was seated and she applied less pressure.*
>
> *Brave: Very true she was seated to make sure that she applied less pressure.*

Based on L2's response above, Brave reminded the learners that pressure increases with the height of the mortar. If the IK Custodian pounded while standing, she would have applied more pressure, and some of the mixture could have spilt out. The higher the IK Custodian lifted the mortar, the more the pressure, so the IK Custodian controlled that. Brave asked the learners to explain the particle size as the factor that affected the rate of chemical reaction. L2 explained as follows: "*The size of particle was reduced when the lady was crushing to increase the area of the surface"*.

Brave emphasised that the crushing of marula nuts made it possible for the particles to be finer and smaller, and the surface area was increased, which increased the rate of reaction. He moved to the temperature as the other factor that affected the rates of reactions, and L10 explained: "*The temperature was controlled through warm water that was added to the mixture".*

Brave consolidated the lesson and explained the collision theory – that the higher the concentration, the faster the rates of reactions. If the concentration is too much, the reaction would be quicker – that is why they did not add too much water so that the concentration remained high, so they could extract the marula oil at a faster rate. L11 was able to explain further in terms of pressure that "*the lower the height, the lesser the pressure and the higher the height, the more the pressure".* Brave linked this to physics, where pressure is calculated by the formula: Pressure = Force/Area. He asked the learners*:*

> *Brave: When you apply force on certain amount of area, when do you think pressure supposed to increase? It is when the area is small or when the area is big?*

L12: When the force and the area is bigger the area is smaller. That is the reason the motor should not be very big to decrease the pressure.

Brave: What effects do the particles size have on, the rate of reaction?

L13: When the particle size is bigger, they decrease the surface area and when they are smaller they increase the surface area.

Brave: Thank you T13, and how all what you have said affects the rate of reaction.

L14: The larger the particle size, the slower the rate of reaction and the smaller the particle size, the factor the rate of reaction.

From the vignette above, it appears that the learners were able to explain the collision theory in terms of pressure, surface area and concentration. Brave explained, based on L14's response, that the IK custodians crushed the marula nuts to reduce and make the particle size smaller and finer. In this way, the rate of reaction was increased. Finally, he asked about the temperature, and L7 answered that when the temperature was increased, the reaction would be faster. At the end of the lesson, Brave asked the learners to reflect on what they had learnt, and this is what came out:

L3: I learnt how to extract marula oil from marula nuts.

L10: I learnt that collision theory is very true that when you increase temperature, the rate of reaction increase as well. I saw this when the women added the water to the crushed marula nuts, immediately the oil was formed.

From L10's reflection, I observed that this learner did not believe in the principle of collision theory until they watched the video presentation. The teacher's approach to using Indigenous technological practices made it possible for this learner to eliminate misconceptions about collision theory. This is what Mhakure and Otulaja (2017) referred to as culturally responsive or sensitive pedagogies. One can say that integrating Indigenous technological practices into chemistry lessons assisted the teachers in mediating lessons, enabling the learners to master scientific concepts.

L2: I learnt more about physical changes and chemical changes.

L8: Particle size, that the larger the particle size, the smaller the surface areas and slower the rate of reaction.

L3: I learnt that during the extraction of marula oil, both physical changes and chemical changes took places.

Finally, Brave presented the assessment activity to the learners. The learners' reflections showed that they had learnt from the IK custodians' presentation. They participated actively, which proves that the traditional marula oil extraction could be relevant to teaching and learning school science. Therefore, the inclusion of Indigenous technologies in the curriculum is regarded as a significant aspect; it contextualises the Western curriculum and makes it more relevant to diverse learners (Cronje et al., 2015; De Beer, 2016; Mentz & De Beer, 2019).

8.5 Comparing the Lessons of the Two Science Teachers

The purpose of this section is to reflect on how the two teachers (Panduleni and Brave) presented their lessons and come up with similarities and differences. Even though the two teachers had the same lessons at their respective schools, certain aspects were similar, and some were different. Table 8.4 shows these similarities and differences.

Table 8.4: Comparing classroom observations conducted

	Panduleni	**Brave**
Lesson 1 **Topic: Scientific Processes: Experimental Techniques**	• Lesson took longer than what was planned. • Learners from different tribes and races were actively participating. There was one Afrikaner learner who was curious to know and participated more. • Scientific concepts were taught using Indigenous technological practices and Information Communication Technology. • Inquiry-based approach was used. • Teachers asked the learners to reflect on the lesson. • Learners completed assessment activities.	• Lesson was shorter than what was planned • Learners from different tribes and races equally participated • Scientific concepts were taught using Indigenous technological practices • Scientific concepts were taught using Indigenous technological practices and Information Communication Technology • Inquiry-based approach was used • Teachers asked the learners to reflect on the lesson • Learners completed assessment activities
Lesson 2 **Topic: Chemical Reactions: Rates of Reactions**	• Lesson was completed within the timeframe that was planned • Learners brought both marula fruits and pictures of marula fruits and marula trees • Scientific concepts were taught using Indigenous technological practicesand information communication technology • Teachers asked the learners to reflect on the lesson • Learners completed assessment activities	• Lesson was shorter than what was planned • Inquiry-based approach was used • Scientific concepts were taught using Indigenous technological practices and Information Communication Technology • Teachers asked the learners to reflect on the lesson • Learners completed assessment activities • There were no misconceptions

	• There was a misconception based on the explanation of the concept of catalysts and the rates of reactions	

8.6 Five Components of TSPCK Concerning Data Collected

In the following section, I discuss the five TSPCK components that were evident in the chemistry teachers' lessons.

8.6.1 Themes from the exemplar lesson planning discussions

Five components of TSPCK were used to analyse four grade 11 chemistry lessons that integrated Indigenous technological practices. Teachers recognised that learners were rich in cultural capital and prior knowledge of Indigenous technologies. Teachers appreciated such integration and some of them reflected:

> *I thought I knew everything about marula oil extraction, but blending it into Chemistry content, felt like epitome of teaching methods (Nelago).*
>
> *With the aid of Indigenous technological practices, I could define scientific concepts to the learners (Panduleni).*

The five components of TSPCK were considered during the enactment of the lessons.

8.6.1.1 Prior knowledge

Both Panduleni and Brave started their lessons by asking about the learners' prior knowledge of the indigenous technological practice of marula oil extraction. For instance, Panduleni, at school A in lesson one, asked the learners from different tribes how they extracted oil. Learners participated actively as they listened attentively, asked questions, and shared their everyday prior knowledge. This was manifested in some of the learners' responses, for instance:

> *Ms, us Nama we have a! Nara plant that has seeds which can also be used to extract the oil (L1).*
>
> *I only know about the oil that is taken from the cows (L2).*

Both Panduleni and Brave started all their lessons from what their learners knew from their home backgrounds to link it to modern and Western science in the science curriculum. This enabled the learners to be active in the lessons and involved in discussions. Information communication technology was used to enhance the Indigenous technologies of marula oil extraction through a PowerPoint video presentation. It was observed that teaching and learning took place as the learners were able to visualise the whole process of marula oil extraction and link it to science concepts such as experimental techniques, rates of reactions, catalysts, inhibitors, physical changes, chemical changes and collision theory. Learners were very happy, and this is what Aikenhead and Jegede's (1999) seminal work on border crossing and Gumbo's (2016) perceived, that the integration of Indigenous technological practices in education has the potential to be a practice of hope and bridge the gap between the home and school by addressing authentic problems in learners' environments.

8.6.1.2 Curriculum saliency

Curriculum saliency has to do with the teacher identifying the main concepts to be taught and relating them to Indigenous technological practices. Based on Mavhunga and Rollnick (2013), teachers are expected to arrange topics in the order they will be taught. The process of marula oil extraction has a consistent sequence that enables the emergence of certain scientific concepts that were taught. For instance, Panduleni and Brave in the exemplar lesson presentations did not start with the concept of refining and preservation, which was the last stage in the IK custodians' presentation, as it could have confused their learners. There was a certain order in teaching concepts that were aligned with the steps in the IK custodians' practical demonstration of marula oil extraction. One could say that curriculum saliency was considered a useful component in both the IK custodians' practical demonstration and exemplar lessons.

Teachers started the lessons by arranging the lesson activity ingredients needed to extract the marula oil – apparatus such as a mortar and pestle. It was observed that teachers were able to direct the teaching and learning activities in a way that their learners could identify the apparatus and mention their functions before the process of marula oil extraction started. For instance, when the teachers presented the video clips to the learners, at the very beginning, when the IK custodians added the salt and charcoal, concepts such as flavouring, diffusion and activation energy unfolded. Learners could explain these concepts in a sequence that was in tandem with the video presentation and the grade 11 Chemistry syllabus. After that, the IK custodians started pounding and crushing marula nuts using a mortar and pestle and the teachers directed the learners to the concepts that were further emerging such as physical changes, chemical changes, pressure, concentration, increasing surface area and residue. All these were logically explained, and the learners were able to bridge the concepts that were explained first to the new ones. Therefore, sequencing was very important.

Teachers consolidated the lesson by bringing in the concept of collision theory after all the other concepts were explained first; this helped the learners to sum up the lesson as they had already grasped sufficient knowledge of the indigenous technological practice of marula oil extraction.

8.6.1.3 What is difficult to understand?

This component is defined based on the teacher's understanding of which topics or concepts are difficult to teach. For example, the IK custodians used the example of marula oil extraction to explain scientific concepts during the practical demonstration. This helped the teachers explain certain concepts that are regarded as difficult for the learners in a better way. Concerning this, the Namibian Namibia Senior Secondary Certificate Ordinary National Examiners' Report (2020, p. 96) revealed that most learners were "merely describing factors that affect the rates of reactions in general form theory without contextualising this to the given chemicals, apparatus and additional guidance".

Chemistry teachers learnt from the IK custodians that adding warm water to the crushed marula nuts provided heat energy which increased the temperature and speeded up the rate of reaction. The use of warm water by the IK custodians was explained concerning the factors that affect the rates of reactions. The IK custodians avoided the use of cold water as it would slow down the rate of reaction. This was connected to the concept of an *inhibitor* which was also explained. In addition, chemistry teachers learnt that crushing marula nuts while seated has to do with controlling pressure. If the IK custodians were to crush marula nuts while standing, the pressure would be higher, and some particles of marula nuts might spill out. With the assistance of the video presentation of the IK custodians' demonstration, it was very easy for the teachers to explain the relationship between pressure and height: *The lower the height, the lesser the pressure and the higher the height, the more the pressure.*

The concept of physical changes and chemical changes was practically demonstrated, and this helped the teaching. For instance, during the oil extraction process, warm water was added to increase the temperature so that the solidified oil could melt into liquid. When the oil was refined and boiled the water disappeared during evaporation as a gas – this was a *physical change*. Before the nuts were crushed, they were whiter and the end product (*residue)* and oil that was formed were completely different from the marula nuts. This was a *chemical change*. The concepts of *refining*, *purifying* and *preservation* were also presented, and teachers were capacitated by the IK custodians.

This enabled their learners to understand the importance of refining and purity of substances. In terms of food preservation, teachers were taught by the IK custodians that if marula oil is not refined, it can decompose because of the water present. Therefore, the refined marula oil was stored in a glass container; this helped solidify other concepts such as *types of materials*, *properties of materials* and *suitability*.

The use of practical demonstrations and classroom video presentations enabled difficult concepts to be easily understood by the teachers and their learners. Therefore, the change laboratory session that we had with the IK custodians helped the teachers to be innovative and come up with better pedagogical strategies to teach scientific concepts. The mind and concept maps that we came up with during the exemplar lesson co-planning change laboratory workshops assisted me in understanding how teachers' PCK shifted concerning the topics that integrated Indigenous. As per my observation, the concepts that emerged during the practical demonstration and workshops were integrated and this helped teachers to shape their understanding.

8.6.1.4 Representations

This component has to do with how the teachers planned and presented the lesson with the help of Indigenous technological practices. Mavhunga et al. (2016) stressed that representations can be in different forms such as demonstrations, illustrations, experiments and others that teachers can use to help the learners understand better. In this case, practical demonstrations and classroom video presentations were used to enable the teachers to link science concepts to the indigenous technological practice of marula oil extraction. The two topics that were taught at both schools A and B were experimental techniques and chemical reactions. Teachers compared the modern commercialised uses of oil marula products with the traditional uses of marula products.

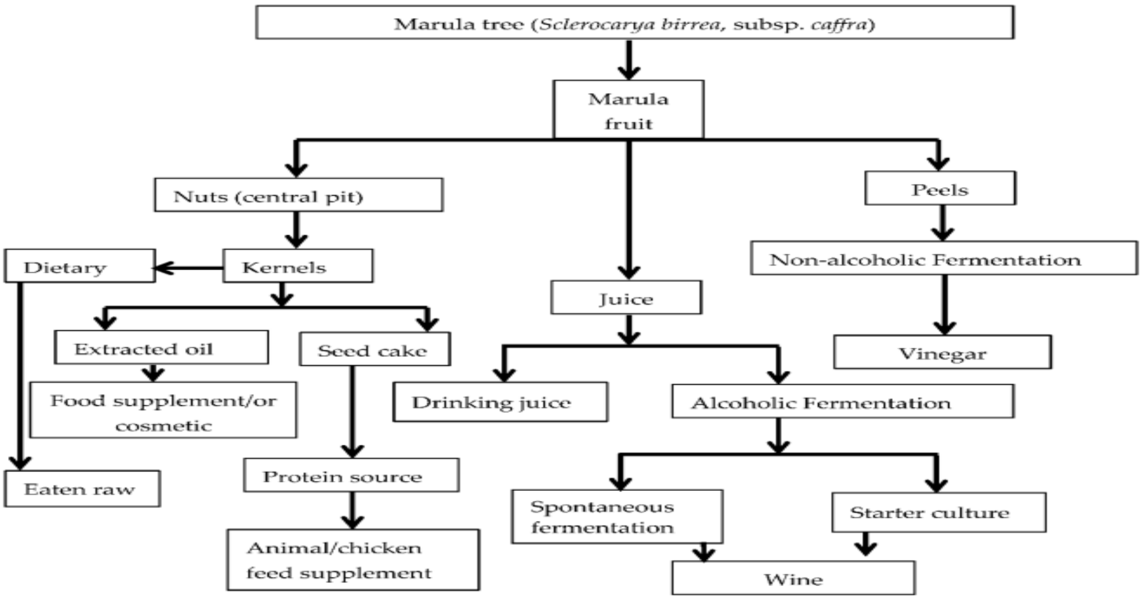

Figure 8.12: Bioprocessing of marula tree to produce value-added products (Legodi et al., 2022, p. 3)

Using this comparison helped the learners explain and envisage what they knew from their home backgrounds and in a modern Western context. It also enabled learners to participate actively during the lessons.

8.6.1.5 Conceptual teaching strategies

How teachers consider their content and pedagogical knowledge, and their learners' needs, and create interest and curiosity among their learners is very important. Teachers decided to use an inquiry-based approach that led them to discovery learning. Discovering new ideas is an integral part of learning science. Students themselves have to discover new ideas and concepts during their classroom engagements. I observed that learners were asking questions, and they were included in every concept explained. An inclusive education approach was used. Inclusive education is the best basic educational approach to teaching and learning, emphasised by the Namibian National Curriculum for Basic Education (Ministry of Education, Arts and Culture, 2016). Chemistry teachers were made aware of the TSPCK components considered during the co-lesson planning and lesson presentation.

8.7 Teachers' Reflections on the Lessons

Teachers reflected on the lesson deliveries and the entire intervention process, as Otulaja and Ogunniyi (2017) suggested that reflection-on-action should take place after the lessons or learning activities. Table 8.5 shows the themes and sub-themes that emerged from the teachers' reflections on the mediated exemplar lessons discussed in the following sections.

Table 8.5: Themes that emerged from the teachers' lesson reflections

Themes	Sub-themes	Literature	Theory
1. What teachers learnt from the exemplar lessons	• Scientific Indigenous technological practices • Usefulness of Indigenous technological practices	Shinana et al. (2021) Shizha (2016) Breidlid and Botha (2015)	TSPCK CHAT
2. Usefulness of the exemplar lessons	• Teachers' understanding of Indigenous technological practices concerning scientific concepts • Link prior everyday knowledge to teach Chemistry concepts • Classroom interaction between teachers and the learners	Mhakure and Otulaja (2017) Kuhlane (2011) Gumbo (2016) Mavuru and Ramnarain (2020) Aikenhead and Jegede (1999) Ogunniyi (2007a)	CHAT TSPCK
3. Views on integrating Indigenous technological practices into chemistry lessons	• Material technology and information technology • Conceptual teaching • Inquiry-based approach	Munabete and Umar (2014) Mavhunga and Rollnick (2013) Shinana et al. (2021)	TSPCK
4. Insights on working with the researcher and Indigenous knowledge custodians in professional learning communities	• Link Indigenous knowledge custodians to science classrooms • Community participation in professional learning communities	Taylor and Cameron (2016) Engeström (2000, 2001) Seehawer (2018) Zinyeka et al. (2016) Tikly et al. (2018) Mhakure and Otulaja (2017)	CHAT
5. Shift in pedagogical practices	• Expansive learning • Transformative agency	Engeström (2003) Sannino et al. (2016) Lotz-Sisitka et al. (2015) Kerosuo (2017) Haapasaari et al (2016)	CHAT
6. Areas of improvement	• Time management • Intensifying training opportunities • Video presentations	Shizha (2007) Mika (2019)	CHAT

8.7.1 What teachers learned from the exemplar lessons

From the lesson reflections, it appeared the teachers learned something. This shows a shift in their understanding of and agency in integrating Indigenous technological practices into their teaching, contrary to Figure 7.2 where teachers had a negative perception of and resisted the idea of indigenous technological practice integration. For instance, teachers reflected on the following:

There are Indigenous knowledge that are scientific and Indigenous technological practices can be used to teach chemical reactions and it can be integrated into science teaching (Theoretical).

The use of Indigenous technological practices in teaching is the way to go. I was so touched by how the lessons were just going on, how learners were asking questions which I did not expect. We really need to think about bringing the use of Indigenous technological practices into the education (Scientist).

It is very possible to teach the topics of Chemistry even if you do not have all the supplied materials. Indigenous technological practices make it possible and the lesson was very interesting (Brave).

The teachers' reflections show that they have learnt new knowledge from these exemplar lessons and these findings resonate with the explanations by scholars such as Shinana et al. (2021), Shizha (2016) and Breidlid and Botha (2015). In this regard, Shinana et al. (2021) recommended using easily accessible materials in science teaching and learning. In addition, Shizha (2016) noted that some traditional skills and techniques are used in producing arts, crafts, weaving, and brewing, among others that represent Indigenous technologies in Africa. Similarly, Breidlid and Botha (2015) averred that IK offers interesting possibilities for including alternative cultural activities in learning and teaching practices (Ogunniyi, 2007a). On the same note, Ogunniyi (2007a) asserted that the curriculum requires new instructional approaches in terms of contextualisation and indigenisation (Ogunniyi, 2007a). In summary, one can say that using Indigenous technologies can promote learners' participation and understanding.

8.7.2 Usefulness of the exemplar lessons

The chemistry teachers in this study were asked about the usefulness of the exemplar lessons that integrated Indigenous technological practices and three of them responded as follows:

It was very useful because learners got to link everyday experiences and concepts to what they are taught in their Chemistry lessons (Nelago).

Yes, it has scaffolded the learners, as some had no understanding of factors that affect the rate of reactions, but during the lessons they were asking many meaningful questions, meaning that their understanding and interest were stimulated (Scientist).

Yes, because the scientific processes and chemical reactions could be easily explained easily with Indigenous materials and video presentations (Brave).

From the above excerpts, Nelago's quote resounds with Aikenhead and Jegede's (1999) notion of cultural border crossing and Gumbo's (2016), who perceived that the integration of Indigenous technologies into education has the potential to be a practice of hope and to bridge the gap between the home and school by addressing authentic problems in learners' environments. Remarkably, Panduleni reflected that learners from different cultures were all engaging and identified the scientific reasoning behind how *okuyenga* is done (Nyamakuti, 2021). These outcomes fit with Mavuru and Ramnarain (2020) who assert that integrating learners' sociocultural backgrounds in education is important. This type of approach to teaching and learning is what Mhakure and Otulaja (2017) referred to as pedagogies that are culturally responsive or sensitive.

8.7.3 Views on integrating traditional practices into Chemistry lessons

It emerged that teachers had different views regarding integrating Indigenous technological practices into chemistry teaching and learning. For instance, Scientist reflected that integrating material technology is the best as it really makes teaching and learning easier and meaningful and saves time. Nelago reflected that she did not know there was something called material technology, although it is in the curriculum documents. It came out strongly in Panduleni's reflection that the two types of technologies need to be used in collaboration and that there is no material technology without information technology when integrated, it is more effective and saves time. Nelago and Panduleni's reflections are associated with Munabete and Umar's (2014) work in their understanding that Indigenous technological practices and IK are closely linked and that there is no way to comprehend Indigenous technological practices without IK. In other words, Indigenous technological practices cannot be separated from IK as IK is the umbrella under which all Indigenous technological practices are situated. Theoretical and Brave reflected on the reasons the exemplar lessons were successful:

> *Learners were able to relate Indigenous technological practices to scientific concepts like purity of substances, experimental techniques and factors that affect the chemical reactions. Learners gained interest and linked their prior knowledge to science concepts (Theoretical).*
>
> *It enabled me as the teacher to teach science concepts easier. All the lesson objectives were all mastered (Brave).*
>
> *The integration enhances conceptual understanding, and this could be seen from active participation of the learners (Nelago).*

It yielded maximum interaction between teachers and the learners. Learners asked more questions more than the usual lessons. When learners reflected, they really showed understanding (Panduleni).

The excerpts above revealed that integrating Indigenous technological practices into chemistry teaching enabled and enhanced the effective teaching of science concepts. This promotes conceptual teaching strategies advocated by Mavhunga and Rollnick (2013). Concerning this, Karabuz and Ogan-Bekiroglu (2020) directed that using technology might stimulate teachers' confidence and self-efficacy to become more successful in their teaching. This is connected to what Shinana et al. (2021) encouraged, that Indigenous technological practices use accessible resources to promote inquiry-based approaches in rural schools.

8.7.4 IK custodians' insights into working with the researcher in a professional learning community

The practical demonstration was a platform for the IK custodians to be involved in grade 11 Chemistry teaching of scientific processes and chemical reactions. For example, Theoretical revealed that it was so good because we were linked with IK custodians who were more knowledgeable, and this assisted them in teaching chemistry concepts. Theoretical's reflection relates to the overlapping perspective of integrating Indigenous technological practices to bridge the gap between science and IK in the classroom (Zinyeka et al., 2016). Taylor and Cameron (2016) considered that the difference between the two types of knowledge domains is important in understanding their uniqueness.

It came out from the reflections that the video presentations during the lessons helped the teachers connect what the IK custodians were showing to what they were teaching the learners. For instance, Scientist reflected that she was happy about the exemplar lessons because it made teachers' work easier and more enjoyable, especially when interacting with more knowledgeable ones from the community. This resounds with Seewaher (2018), who states that individuals exist through the community, while Engeström (2000, 2001) viewed learning as a socially and culturally mediated and historically connected process of interacting factors within activity system (s). The teachers felt proud to work with the IK custodians in professional activities. This was evident from their reflections:

It is a good experience and felt the spirit of Ubuntu among us and very professional at the same time (Nelago).

It was very helpful as it really showed me how Indigenous technological practices could be integrated and was very good for my professional development as we could link documents to practice (Panduleni).

Nelago's reflection aligns with Seewaher's (2018) understanding that Ubuntu research agendas contribute to strengthening methodologies that include community based, relational and participatory approaches like local ethics protocols and Indigenous epistemologies. In this research, the principles of Ubuntu are regarded as an effort towards decolonising educational research. Along the same line, Tikly et al. (2018) acknowledged the importance of connecting IK system and informal knowledge to secondary school science. This is what Mhakure and Otulaja (2017) and other scholars referred to as culturally responsive pedagogy in teaching and learning.

8.7.5 Shift in pedagogical practices

It seems like there was a shift in teachers' pedagogical practices through learning. It was evident from Theoretical's reflection that he learnt that there was IK that was scientific, that Indigenous technological practices can be used to teach chemical reactions and be integrated into science teaching. Similarly, Panduleni reflected that integrating Indigenous technologies enabled him to teach science concepts more easily. Theoretical and Panduleni's reflections resonate with what Sannino et al. (2016) refer to as expansive learning – a creative type of learning in which learners join forces to create something novel – essentially learning something that does not yet exist; this can lead to transformation agency. Similarly, Engeström (2003, pp. 30-31) stresses that expansive learning is initiated when "some individuals involved in a collective activity take the action of transforming an activity system through reconceptualisation of the object and the motive of activity embracing a radically wider horizon of possibilities than in the previous mode of activity".

Scientist reflected that it was helpful when the learners watched the video presentation of the oil being extracted because they could link the scientific concepts to the process. She learnt that using the IK custodians' video clips would make his lessons more interesting. This is linked to what Kerosuo (2017) termed as 'transformative agency', which is a critical phase for creating new ideas in the changing world of work that requires collective activity, outside support and recognition of the development outcomes. On the same note, Lotz-Sisitka et al. (2015) state that expansive learning creates what is referred to as transformative, transgressive social learning, which is based on rethinking higher education in terms of pedagogical development in the stream of sociocultural theory and CHAT.

8.7.6 Misconceptions and areas for improvement

It was indicated in Table 8.3 that there was a misconception about the explanation of catalysts concerning warm water during Panduleni's lessons. The participants in this research seemed to have misconceptions about interpreting physical changes, chemical changes and factors that affect the rate of reaction. All these were noted, and a workshop was conducted where critical reflections were made and misconceptions were resolved in a session I arranged. During the engagements and discussion, clarity was gained as to why the IK custodians used warm water. It was agreed and emphasised that warm water provided heat energy, which increased the temperature and eventually increased the rate of reaction. Teachers reflected and came up with constructive suggestions (see Appendix N) to avoid misconceptions in future indigenous technological practice lesson integration. They suggested that there was a need to watch the IK custodians' presentation video together and rehearse or pilot the planned lessons. In other words, teachers proposed the mini-lesson presentation themselves before the actual lesson enactments. This may improve the quality of the lessons. When the teachers were asked to reflect and share their views on where to improve if other Indigenous technological practices are mediated in science lessons, these are their responses:

> *More teachers to be trained by Indigenous knowledge custodians on how to integrate Indigenous technologies (Theoretical).*
>
> *More video presentation presentations from the community are required (Scientist).*
>
> *We need more time on preparation and include more different cultural practices (Nelago).*
>
> *Integration of Indigenous technologies to be done on different cultures on other subjects like Physics, Biology and others (Brave).*
>
> *We need to rehearse or have the mini-lesson before the actual lesson presentation (Scientists).*
>
> *We need to critically examine the impact of Indigenous technology on teaching and learning (Theoretical).*
>
> *We should work with our Indigenous knowledge custodians to train us and provide us with more cultural tools (Panduleni).*
>
> *We need to watch the video together to pick out some possible misconceptions that can hinder teaching and thereafter, peer teaching to help us to identify any possible misconceptions that can arise (Panduleni).*

Furthermore, certain elements/aspects came out from the above excerpt, that for these types of lessons to be successful, teachers must be more culturally responsive. For one to be culturally responsive, one needs to consider community involvement, embrace cultural diversity, use culturally responsive tools, include teachers' professional needs and examine cultural knowledge and teaching. With these elements, we developed a culturally responsive teaching reflective tool that we used to improve the quality of the exemplary lessons. The reflective tool in Figure 8.13 was relevant as it helped validate the study's research findings.

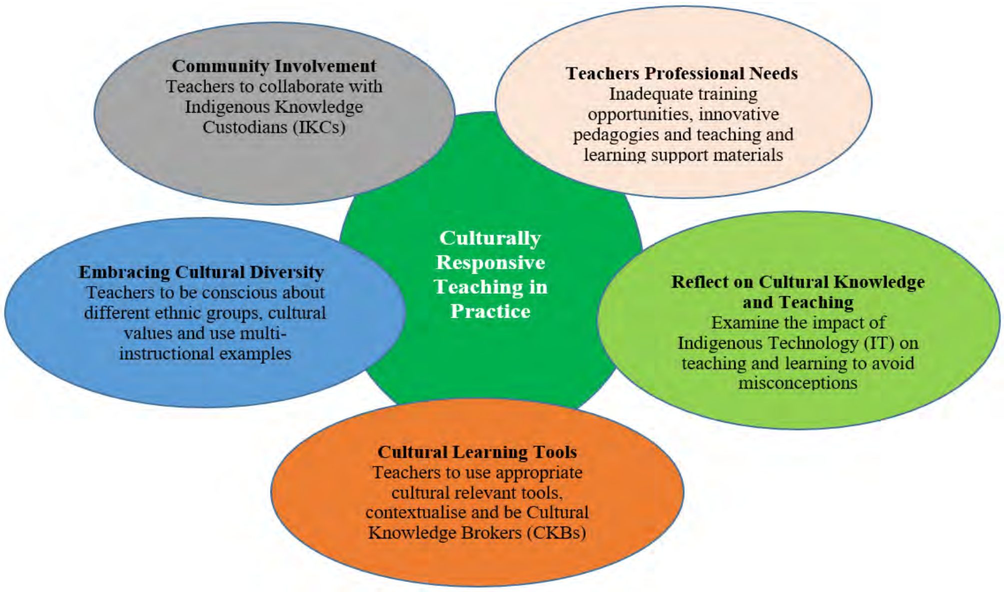

Figure 8.13: Culturally responsive teaching reflective tool (Mika, 2024)

Figure 8.13 shows a reflective tool that was developed during the reflective session to resolve the misconception that emerged in Panduleni's lesson enactment (see Appendix O). As we addressed the misconception, aspects such as community involvement, embracing cultural diversity, cultural learning tools, teachers' professional needs and reflection on cultural knowledge and teaching were brought up. From these aspects, we developed a reflective tool for culturally responsive teaching that is relevant in this study. Some of these aspects correspond with Gay's (2018) characteristics of culturally responsive teaching. Regarding the aspect of community involvement, teachers and communities need to collaborate and share cultural knowledge that impacts the classroom environment.

Teachers' professional needs are characterised by a lack of teaching and learning support materials and a lack of relevant teaching pedagogies and training. This can be resolved by working with the IK custodians and coming up with culturally responsive professional development ideas. Embracing cultural diversity is the teachers' understanding and consideration of multicultural classrooms to ensure that they bridge the gap between the learners' cultural practices and school science. In terms of cultural learning tools and resources, science teachers need to be cultural knowledge brokers who can use the tools based on the learners' background and promote the voices of IK custodians. Reflection on cultural knowledge and teaching has to do with critical examination of teaching and learning to improve the quality of lesson enactments. Similarly, the cultural knowledge brokers framework for teaching and learning was developed. This is shown in Figure 8.14 below.

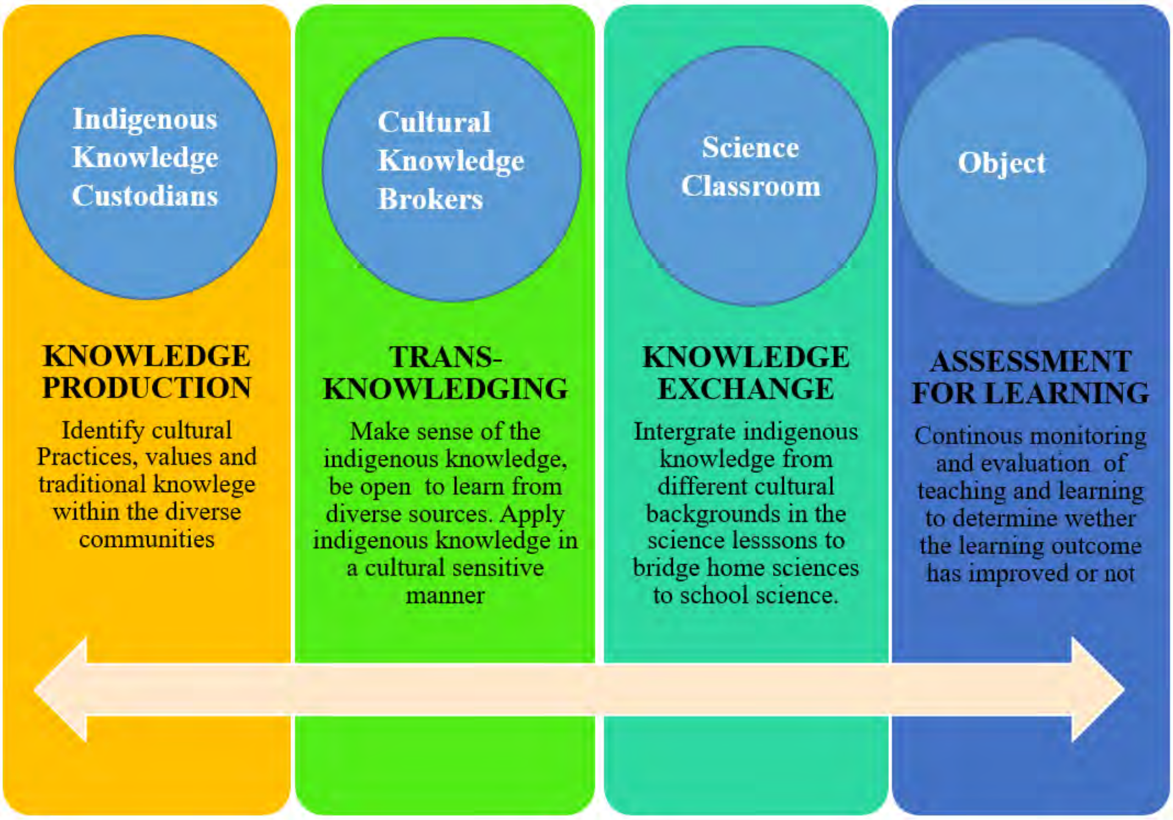

Figure 8.14: Cultural brokerage framework for science teaching and learning (Mika, 2024)

Figure 8.14 shows a cultural brokerage framework that was developed for science teaching and learning (see Appendix P). The framework shows the four components involved in the process of cultural brokering for science teaching and learning. The first component is the IK custodians, who were regarded as the knowledge producers in this study. The second component has to do with the cultural knowledge brokers who translate and scrutinise the knowledge from the IK custodians and make it accessible for diverse cultural groups. In this study, the cultural knowledge brokers were the chemistry teachers. The third component is about integrating Indigenous technologies into science classrooms in a culturally sensitive manner. Teachers as cultural knowledge brokers are expected to use what Heugh et al. (2021) referred to as transknowledging pedagogy by using different cultural examples, code-switching and translation to assist learners in concept meaning making and sense making. The fourth and last component is the object, which is about assessment for learning. This can be done by continuous monitoring and evaluation to determine whether there is improvement (or not) in the learning outcome. Feedback was also given to the IK custodians.

8.7.7 IK custodians' experiences and reflections

In this section, I report on how IK custodians reacted when I gave them feedback about the study's findings concerning their practical demonstration and how it impacted the teaching of grade 11 Chemistry. During the feedback session, the IK custodians shared their views. Meme Fudheni mentioned this:

> *Onduudite etumba eshi ounongo wetu wopamifyuululwakalo wafimanekwa nashi yoo nda kufa ombinga nokukwafela mehongo lounona vetu. Eemhito da tya ngaha, oda fimana kufye eenghulungu nonghee oha ndii indile opo eyambidido nekufombinga letu litwikile* (I am so proud because my cultural knowledge is respected as I participated and assisted in educating our children. Such opportunities and platforms are important to us Indigenous experts and therefore I am urging that our participation and contributions continue).

Tate Sheehama had this to say:

> *Onda pendula unene eshi mwa ninga omapekaapeko kombinga yokuninga odjove, osho shili tashi pendulapo nokuhumifa komesho omufyuululwakalo wetu fyee ovawambo. Namibia eshi lamanguluka, omifyuululwakalo detu oda kanifa ongushu nounona vahapu unene tuu meedolopa kavena ounongo uhapu kombinga yomifyuululwakalo detu. Omapekaapeko eli ngaha ngee taa ningwa momidingonoko detu otaa kwafele okuyambulapo omifyuululwakalo detu.* (I am very grateful for this research about marula oil extraction, which is reviving and preserving our cultural practice for us Oshiwambo people. Since Namibia got independence, our cultural practices have lost value and many of our children especially in urban areas do not know much more about our cultural practices. Such types of research are helping to resuscitate and promote our culture).

Similarly, Mee Ndatoolomba commented:

> *Onduudite etumba eshi twafanekwa eshi kwali hatumuhongo kmbinga youninga odjove. Onduudite nawa eshi ndauda kutya ouvideo vetu ovalongifwa mongulufikola. Onda hafa*

> *eshi ounongo wetu walongifwa kovahongi nosho yoo ovanafikola moshilongwa shounongononi. Onda hala oshiima shatya ngaha shi ningwe meefikola dihapu.* (I am so proud that during our presentation on marula oil extraction, we were video-recorded and that our video clips were used in the classrooms in science subjects. I am so happy that our expertise can be used by the teachers and the learners. I want this to be done in many schools).

Based on sharing circles, IK custodians expressed that they were happy because of their participation and contribution to science teaching and learning. It seems like the IK custodians realised that Indigenous technologies are relevant in science classrooms. The other aspect that came out from the sharing circles is that the IK custodians viewed this research as a platform to revive, preserve and promote cultural practices. This has an affinity with McCarty and Lee (2014), who proposed a critically culturally sustaining and revitalising pedagogy. Cultural revitalisation helps to preserve and promote cultural diversity and the unique cultural heritage of different communities (Cocks et al., 2012). Through collaborative efforts with communities, this study contributes to the revitalisation of cultural practices, traditions and values that may have been overshadowed and lost due to colonisation, globalisation. Marula oil extraction aligns with broader efforts to preserve the IK system, enabling global recognition of Indigenous technological practices and advocating for their inclusion in sustainable development policies. Such initiatives are seen as vital for reconnecting younger generations, especially those in urban areas, with their cultural roots.

8.8 Chapter Summary

In this chapter, I presented, analysed, interpreted, and discussed the data gathered from the co-planned exemplar lessons and the lesson observations. The five components of TSPCK were used to help teachers co-plan and present the lessons that integrated the indigenous technological practice of marula oil extraction. It seems that most of the teachers in Namibia do not teach with a particularly African/Ubuntu context. The culturally responsive perspectives need to be expressly taught and experienced by both students and teachers. Students need to be exposed to Indigenous materials to create interest. A reflective tool for culturally responsive teaching was developed and used to reflect and validate the findings of the exemplar lessons. The chemistry teachers' PCK shifted when capacitated by the IK custodians. It was observed that by integrating the indigenous technological practice, the teachers enabled their learners to participate actively, improving their understanding of scientific concepts.

CHAPTER NINE: SUMMARY OF FINDINGS, RECOMMENDATIONS AND CONCLUSION

> There is a need to approach research, teaching and outreach in a discipline that incorporates knowledge generated in the local context. African knowledge system can be tapped into as foundational resources for the social-educational transformation of African continent. Introducing IK as a tool of Africanisation assists students to engage in and facilitate process where local knowledge is linked and blended with existing academic knowledge. (Saurombe, 2018, p. 38)

9.1 Introduction

As stated in the above epigraph, Saurombe (2018) reminds educators that introducing IK as a cultural tool for the Africanisation of the curriculum is about social-educational transformation. Thus, like Mutanho's (2021) study and others, this study endeavoured to decolonise the science curriculum through the integration of Indigenous technological practices as recommended by Saurombe (2018). However, for science teachers to be able to integrate Indigenous technological practices or IK, they need to be supported so that they can be cultural knowledge brokers (Simasiku, 2022; Wyatt et al., 2017). This was central in this study, and using CHAT (Engeström, 2001) enabled this process.

This chapter presents a summary of the findings, recommendations and conclusion of this study. The chapter starts with an overview of the research process, followed by the key findings, new knowledge and limitations of the study. Finally, the chapter discusses my reflections on my research journey, recommendations, areas for future research and conclusion.

9.2 Overview of the Study

The goal of this study was to explore and establish an understanding of how integrating Indigenous technological practices can contribute to science teaching and how a professional learning community could be expanded and/or constrained by such integration. It emphasised the integration of Indigenous technological practices which focused on recognising and engaging the learners' home cultural background practices to localise and indigenise the curriculum (Mutanho, 2021). The study provided an opportunity for innovation in teaching and modernisation of Indigenous technological practices. The Namibian National Curriculum (Ministry of Education, Arts and Culture, 2016) encourages teachers to integrate learners' IK and technology, but it does not explicitly guide or support them on how to put this into practice. Hence, this study is significant for its capacity building and initiation of more professional learning communities that can be expanded through integrating Indigenous technological practices into science teaching and learning. The study further improved my technical skills in how to run workshops for teachers and enabled teachers to improve the quality of their teaching through professional learning communities. It also enhanced teachers' creativity in co-developing learning and teaching support materials grounded in Indigenous technological practices.

The goals of this study were to:

- Support grade 11 chemistry teachers in learning how to integrate Indigenous technological practices into science teaching and learning.
- Examine how integrating Indigenous technological practices could contribute (or not) to science teaching and how professional learning communities could be expanded or constrained by such integration.

The following research questions were formulated:

1. What were grade 11 chemistry teachers' pedagogical insights regarding integrating Indigenous technological practices into science teaching and what contradictions emerged?
2. What contradictions regarding the integration of Indigenous technological practices surfaced when grade 11 chemistry teachers co-analysed the curriculum documents and textbooks?
3. How did the practical demonstrations on traditional marula oil extraction by the IK custodians enable and/or constrain the grade 11 chemistry teachers to become cultural knowledge brokers?
4. What expansive learning opportunities were created (or not) when the grade 11 chemistry teachers co-developed exemplar lessons that integrated traditional marula oil extraction and other Indigenous technological practices?
5. How did grade 11 chemistry teachers enact and reflect on the exemplar lessons that integrated traditional marula oil extraction and other Indigenous technological practices in their classrooms?

The study was conducted in three phases. First, there was a *mirror data generation phase* aimed at finding out what grade 11 chemistry teachers' pedagogical experiences and insights into the integration of Indigenous technological practices were. Semi-structured interviews were employed to generate data. Second, the *intervention for capacity building and expansive learning phase* engaged with facilitating and directing workshop discussions and reflections. Third, the *post-intervention* phase focused on participatory lesson observations of the mediated co-developed lessons, which were videotaped and observed with the participants' permission. The study was informed by Engeström's (2001) CHAT as an overarching theoretical framework. Mavhunga and Rollnick's (2013) TSPCK model was used as an additional analytical framework.

9.3 Key Findings of the Study

This section highlights and summarises the key findings that emerged from the study. I present the findings concerning my research questions.

9.3.1 Findings from the mirror data generation phase

The mirror data generation phase (Engeström, 2001) aimed to establish the grade 11 chemistry teachers' pedagogical experiences and insight into integrating Indigenous technological practices. Semi-structured interviews were conducted to answer the first research question:

> What were grade 11 chemistry teachers' pedagogical insights regarding integrating Indigenous technological practices into science teaching and what contradictions emerged?

The findings revealed that three teachers seemed to understand Indigenous technological practices as types of local technology and cultural practices mostly practised at home. These included using natural resources to produce cultural products that could make life easier. They felt that learners might understand science better if they could be brought into the classroom. These teachers' understandings seem to resonate with Munabete and Umar (2014), who viewed Indigenous technological practices as anything designed, fabricated, adopted and used in an environment for the advancement of the people of that environment. It also coheres with Ankiewicz (2016), who understands that Indigenous technological practices are all about associated practices that have been and are still being used by Indigenous people for existence, survival and adaptation in various environments.

However, the three teachers indicated that there are tensions, dilemmas and conflicts manifested between the home science activity system and the school science activity system. These two systems seem to operate in isolation, and integrating Indigenous technological practices would help close that gap. In this regard, one teacher suggested that involving local expertise in teaching could assist teachers in improving their PCK through the approach that Scientist termed ‘bringing home-in-school perspective’. This has an affinity with Aikenhead and Jegede’s (1999) seminal work on border crossing. In this regard, Gumbo (2016) proposed that the integration of Indigenous technological practices in education has the potential to be a practice of hope and to bridge the gap between the home and school. By addressing authentic problems in learners’ environments, Otulaja (2017) referred to such pedagogies as being *culturally responsive or sensitive.* This is where learners’ sociocultural contexts are considered, as reiterated by Mavuru and Ramnarain (2020).

The research findings further revealed that these teachers were at different zones of proximal development (Vygotsky, 1978) regarding integrating Indigenous technological practices into the curriculum. Two teachers indicated that they faced a dilemma in their teaching practices as the curriculum lacks clear guidelines for indigenous technological practice integration into science teaching. These teachers’ insights agree with Seehawer (2018), who discovered that a lack of clear guidelines in the curriculum hindered teachers in integrating Indigenous technological practices.

However, the research findings showed that there are manifestations of contradictions such as tensions, conflicts and dilemmas that constrained these teachers from integrating Indigenous technological practices into their science lessons. The first manifestation of contradictions in the form of tensions, conflicts and dilemmas was that the curriculum supports the integration of Indigenous technological practices but does not provide guidelines on how this should be done. This left the teachers with the dilemma of not knowing how to do it as Western science and Indigenous technological practices are generally viewed as antagonistic bodies of knowledge (Mutanho, 2021). Teachers have to reconcile two contradictory knowledge systems whose ontological systems and methodological roots are completely different.

Teachers revealed that in the teachers’ workshops and training sessions; examples of Indigenous technological practices are not cited enough because they are not documented. This supports the literature where some African scholars believe that the science taught in African schools does not carry the African identity. That is, teachers do not recognise Indigenous technological ways of knowing (Mawere, 2014; Seehawer, 2018; Semali & Kincheloe, 1999). In addition, Kazhila (2015) noted that there are challenges such as a lack of documentation, the non-scientific nature of IK and the different cultural backgrounds of students and lecturers.

The third manifestation of contradictions in the form of tensions, conflicts and dilemmas is that teachers do not know how to handle the issues of cultural diversity within their classrooms when integrating Indigenous technological practices. The fourth manifestation of contradiction arises with the activity 'system stakeholders and the roles they play in science education. For instance, there is tension between tertiary institutions that train teachers and teachers in schools that have not been trained on culturally responsive pedagogies (Haimene, 2023; Mhakure & Otulaja, 2017). Science teachers are not trained to integrate elements that can make science subjects more interesting. Gwekwerere (2016) emphasised that teachers need to make the subject matter comprehensible, relevant and accessible to their learners. The fifth manifestation of contradiction is a conflict in the sense that there is knowledge within communities, but no documentation that encourages inviting IK custodians to collaborate with teachers or schools. The community expertise is not well acknowledged in education. Consequently, stakeholders like the Directorate of Education, teachers and IK custodians operate in isolation.

The sixth manifestation of contradictions in forms of tensions, conflicts and dilemmas emerged between activity systems such as the textbook publishers, the Directorate of Education, teachers and IK custodians as the tool makers, and the school. Textbook writers fail to acknowledge IK custodians; this places teachers in the situational dilemma of not having the necessary tools to integrate Indigenous technological practices. This is linked to the findings of the Otjozondjupa Directorate of Education, Arts and Culture's (2012) physical sciences classroom observations, which concluded that most of the teachers observed were facing pedagogical challenges in integrating learners' sociocultural backgrounds. It seems like this caused ignorance among the teachers and a negative disposition towards indigenous technological practice integration.

9.3.2 Findings from the intervention for capacity building and expansive learning phase

I was engaged in facilitating and directing change laboratory workshop discussions and reflections. The intervention for the capacity building and expansive learning phase responded to the following research questions:

- What contradictions regarding the integration of Indigenous technological practices surfaced when grade 11 chemistry teachers co-analysed the curriculum documents and textbooks?
- How did the practical demonstrations on traditional marula oil extraction by the Indigenous knowledge custodians enable and/or constrain the grade 11 chemistry teachers to become cultural knowledge brokers?
- What expansive learning opportunities were created (or not) when the grade 11 chemistry teachers co-developed exemplar lessons that integrated traditional marula oil extraction and other Indigenous technological practices?

The above research questions were answered when the participants attended a series of five change laboratory workshops.

9.3.2.1 Change laboratory workshop two: Document analysis

The outcome of document co-analysis enabled chemistry teachers to develop an expanded view of technology. Teachers developed an understanding that even though the curriculum mainly focuses on modern technology to assist the learners, they could improvise by using Indigenous technological practices to assist their learners. This is what Sannino et al. (2016) termed as expansive learning. For instance, the teachers identified numerous examples of Indigenous technological practices that can be integrated into grade 11 chemistry lessons and linked to scientific themes and concepts.

The study revealed there was a shift in some teachers' transformative agency regarding integrating Indigenous technological practices from a state of fear, uncertainty and tension to a state of confidence and action-oriented commitment to integrating Indigenous technological practices in science lessons. At this stage, the two-eyed seeing (Hatcher et al., 2017) and two-ways-thinking (Michie et al., 2018, 2023) pedagogical approaches manifested and were embraced by the participants. This was evident because of the willingness and commitment to integrate Indigenous technological practices into science teaching, as observed in their action-oriented phrases. Teachers also analysed grades 10–11 chemistry textbooks from different publishers such as Living Oxford, Solid Foundation and Namcol. They discovered that of the three publishers, only Solid Foundation cited a few examples of Indigenous technological practices. It is evident that IK is not well documented, as stated by Shizha (2007, 2013).

Finally, the research findings revealed that there are possible examples of Indigenous technological practices that can be used in science teaching. Some of these are: making traditional drinks, oil extraction (Nyamakuti, 2021), turning fresh milk into sour milk, natural herbs, soap making (Neporo, 2022), water purification, types of materials, making traditional cakes, filtration using Indigenous plants and crushing of mahangu grains (Simasiku, 2022). Some of the examples identified by the teachers are also suggested by scholars such as Shinana et al. (2021) and Shizha (2016), who stated that some traditional skills and techniques are used in the production of arts, crafts, weaving, and brewing, among others, that represent Indigenous technological practices in Africa (Shinana et al., 2021; Shizha, 2016).

9.3.2.2 Change laboratory workshop three: IK custodians' presentations

It was evident that when the teachers were observing the IK custodians' practical presentation, they interacted socially. Moreover, learning took place as they were able to link their observations to scientific concepts. It seems that the cultural tools used by the IK custodians stimulated the teachers to be active as they asked questions, reflected and gave full descriptions of scientific processes. They further linked such concepts to chemical experimental techniques and chemical reactions. This observation resonates with Engeström (2000, 2001), who viewed learning as a socially, culturally and historically connected process of interacting factors within an activity system.

Notwithstanding, manifestations of contradictions arose within the activity system as shown in Table 8.1. For example, the tension between the division of labour and the subject (participants). The tension between the culturally more advanced activity system and the subject (teachers) was also observed. That is, teachers who had formal qualifications to facilitate teaching and learning activities were taught by the IK custodians who had informal practical skills and knowledge of Indigenous technological practices.

Before the IK custodians' presentation, teachers reflected that they lacked the creativity, innovation, and skills to integrate Indigenous technological practices into their chemistry teaching. This challenge of a double bind was eliminated when the IK custodians empowered the teachers to be creative; this helped them reframe their teaching practices and develop new meanings of introducing new strategies to teach chemistry. Engeström (1987) refers to this as expansive learning.

9.3.2.3 Change laboratory workshop four: Lesson co-planning

It is evident, as shown in Table 9.1, that the indigenous technological practice of marula oil extraction contains cultural knowledge that includes scientific skills and concepts. Applying these two knowledge systems has to do with what Killen (2016) described as integrating knowledge to help learners learn from different perspectives and develop a deep understanding of the concepts they are studying. This is congruent with what Michie et al. (2023) and Hatcher et al. (2017) referred to as ‘two-ways thinking’ and ‘two-eyed seeing’ respectively.

9.3.3 Findings from the implementation phase

This phase aimed to answer the fifth and final research question:

> How did grade 11 chemistry teachers enact and reflect on the exemplar lessons that integrated traditional marula oil extraction and other Indigenous technological practices in their classrooms?

The findings revealed grade 11 Chemistry teachers' understanding of integrating Indigenous technological practices when mediating their exemplar lessons. It seems that the professional learning community was effective in reshaping their teaching and learning (see Chapter Eight, where two teachers presented culturally sensitive or responsive lessons). These grade 11 Chemistry teachers had acquired the relevant skills to be able to integrate Indigenous technological practices. For instance, Scientist and Brave reflected that using Indigenous technological practices in teaching is the way to go because, during the enactment of the exemplar lessons, the learners asked questions that she did not expect. She thus concluded that it is possible to teach chemistry topics even if you do not have all the supplied materials. Indigenous technological practices acted as double stimulation, which made it possible, and the lesson was very interesting. The video presentation of the oil being extracted was helpful, and teachers learnt that using the video clips of the IK custodians could make their lessons more interesting.

9.4 New Knowledge

Contrary to the ‘top-down cascade model’ used by the Ministry of Education, where teachers’ needs are often not considered, what this study did differently was to start by exploring the teachers’ needs before the change laboratory workshops. The workshops were then tailor-made to meet their identified needs. What this study has shown is that teachers are capable of generating innovative ways of teaching science if they are given the agency to transform their practice. This is new knowledge, especially in the Namibian context, where continuing teacher professional development seems to be imposed from above.

The second contribution to new knowledge is that although several scholars, particularly De Beer (2016), view Indigenous technological practices as a powerful vehicle to achieve curriculum decolonisation, not much research has been done on how to decolonise secondary science education curricula using Indigenous technological practices. The concept of technology implied in our curriculum has largely been confined to Western or modern technology, excluding other technologies such as Indigenous technological practices. This Eurocentric bias in understanding what constitutes technology also manifests itself in the Indigenous technological practices-science debate, where many studies are silent about integrating Indigenous technological practices into teaching science.

For example, even though several Namibian studies on Indigenous technological practices have been conducted, I did not come across any study focused on integrating the indigenous technological practice of marula oil extraction in chemistry teaching. This study created new knowledge of Indigenous technological practices in Chemistry teaching grounded in Indigenous manufacturing and food technologies. In so doing, it shifted the teachers' pedagogical insights and created new ways and strategies to help decolonise science curricula by integrating Indigenous technological practices.

A third contribution to new knowledge is based on the methodological approach of IK custodians participating in a professional learning community. The IK custodians acknowledged that their knowledge and skills were valued, respected and used to support the teaching and learning of their children. The partnership and collaboration with the IK custodians used the new culturally sustaining and revitalising pedagogy based on mutual benefit (Mutanho, 2021) for science teaching and learning. The new knowledge here is that the IK custodians were given a *voice* and platform to capacitate teachers to become cultural knowledge brokers (Simasiku, 2022; Wyatt et al., 2017); in so doing, they contributed to authentic teaching and learning of science. In addition, while the change laboratory cycle was followed, similar to Haimene (2023), this study infused reflections throughout the research process instead of placing them at the end of the cycle. Through the constant reflections, nuanced data was generated and knowledge co-constructed, which influenced the course of the study.

The fourth contribution to new knowledge is the reflective tool for culturally responsive teaching (see Figure 8.12 & Appendix O), which participants and I co-developed. The tool has five elements that teachers need to consider and reflect on to be more culturally responsive or sensitive in their teaching. These elements are community involvement, embracing cultural diversity, culturally responsive tools, teachers' professional needs and examining cultural knowledge and teaching.

The reflective tool is useful to improve the quality of exemplary lessons. The reflective tool was relevant as a way to validate the research findings. Some of these elements correspond with Gay's (2018) characteristics of culturally responsive teaching. Moreover, we also co-developed a cultural knowledge brokerage framework for science teaching and learning (see Figure 8.14 and Appendix P). This framework has four components, namely knowledge production, transknowledging, knowledge exchange and assessment for learning. These components are very useful, and teachers as cultural knowledge brokers need to consider them when integrating Indigenous technological practices into their multicultural classrooms.

The fifth contribution to new knowledge is the study's contributions to expansive learning opportunities and the development of new concepts. For instance, this study adapted the concept of Indigenous technological practices and referred to them as Indigenous technological practices, while modern technologies are referred to as modern technological practices. Indigenous technological practices use technological skills and knowledge transmitted from one generation to others within cultural contexts for the community members to satisfy their needs and wants.

The sixth unexpected contribution to new knowledge is based on the shift in the teachers' perspective of modern technology and Indigenous technological practices. Technology in education was only viewed as devices like computers and other digital devices that can be used to enhance teaching and learning. Initially, the participants seemed to understand IK without knowing about the technology part of it. So, the old perspective of IK is just *knowledge*, while the new perspective of IK is that it can also be *technological*. The old perspective of educational technology *was just about* information communication technology *and digital devices*, while the new expanded perspective of IK includes Indigenous technological practices.

The seventh and final contribution to the new knowledge within the Namibian context, I have gained significant insights by intertwining ethical Afrocentric Indigenous paradigms, perspectives of Ubuntu, and local paradigms alongside Eurocentric perspectives. This innovative approach allowed me to address complex ethical issues from a holistic viewpoint that acknowledges the value and relevance of diverse epistemologies.

Incorporating Afrocentric principles and the ethos of Ubuntu, which emphasises interconnectedness, compassion, and communal well-being, provided a culturally relevant framework that enriched my analysis and findings. Simultaneously, using Eurocentric methodologies ensured that my research maintained rigorous standards and benefited from well-established local Indigenous ethics and research protocols. This synergistic fusion of paradigms fostered a comprehensive understanding of the research subject, bridging cultural divides and highlighting the importance of integrating local and Indigenous ways of knowing with global academic practices. As a result, my research offers a transformative lens that champions inclusivity, respect for cultural heritage, and the coalescence of multiple perspectives to foster innovative solutions and advancements.

9.5 Limitations of the Study

I intended to interview my participants face-to-face so that I could take note of their body language and ask probing and follow-up questions based on that. However, phase one of this study was conducted during the COVID-19 lockdown and state of emergency. As a result, I could not travel from Otjiwarongo to Okahandja in the same region where my participants were based.

As an alternative, I interviewed six teachers telephonically to talk about their pedagogical insights into integrating Indigenous technological practices into science teaching. Sadly, one participant only managed to participate in the research during the first phase. Due to her mother, who was critically ill, she could not proceed and be involved in the other phases of the study. However, she indicated she was still interested in the study. Fortunately, she gave consent for her mirror data to be used in the thesis and for future publications. Notwithstanding, I acknowledge that her inability to be involved in the intervention workshops might have limited the quality and quantity of data generated in this study.

Also, the scope of the study was limited to six participants and limited research areas, as it could have also included harvesting marula and processing marula juice. I acknowledge this as a potential limitation of the study. However, further studies can be conducted on other processes such as harvesting of marula fruits, extraction of marula juices and possible others with the involvement of IK custodians.

The main study was conducted in the Otjozondjupa Directorate of Education, Okahandja constituency with five chemistry teachers from four schools in the Okahandja circuit. Four schools and five teachers do not represent the bigger population of all the schools and all the grade 11 Chemistry teachers in the Otjozondjupa region. However, I am mindful that case studies are not intended to generalise findings. For instance, the study provided some pedagogical insights into how grade 11 Chemistry teachers developed chemistry ideas from IK custodians to improve the teaching and learning of scientific concepts.

There was a misconception and misinterpretation of concepts such as physical changes, chemical changes and catalysts. I noticed this during the lesson observations. However, this misconception was cleared during our critical reflections post the post-intervention workshops. For instance, during the engagements, argumentation and discussion, clarity was gained as to why the IKCs used warm water and a change of state. It was agreed and emphasised that warm water provided heat energy, which increased the temperature and eventually increased the rate of reaction. However, that did not mean that warm water was a catalyst.

Teachers further reflected and came up with constructive suggestions (see Appendix N) to avoid misconceptions in future lessons that integrate Indigenous technologies. The culturally responsive teaching reflective tool (Mika, 2024) and cultural brokerage framework for science teaching and learning (Mika, 2024) were developed to address this challenge.

Similarly to Simasiku's (2022), Liveve's (2022) and Mayana's (2024) studies, conducted in Namibia and South Africa, respectively and consistent with the Indigenous research paradigm (see Section 4.2.2), I would have liked to give feedback to my participants and IK custodians face-to-face. Unfortunately, some situations did not allow me to meet all of them face-to-face. They were not in one place due to personal commitments. Therefore, I gave them feedback telephonically, and they were grateful for that.

Because of the above limitations, if I were to conduct this study again, I would make some improvements. For instance, like Liveve (2022), I would observe four grade 11 Chemistry teachers to generate more pedagogical insights and experiences about integrating Indigenous technological practices. I would also invite some curriculum developers, so they get the opportunity to witness the IK custodians sharing their cultural heritage and skills.

9.6 My Reflections

My PhD journey emanated from my master's study in science education in 2018, conducted with grade 9 teachers. It focused on mobilising the use of local knowledge to teach the science concepts. During the lessons, when the teachers used wood ash to teach the concept of neutralisation, they reflected that the practical activity and experiments conducted were interesting Indigenous technological practices. I became curious about Indigenous technological practices, and I decided to do a study on Indigenous technological practices in the Namibian context.

Moreover, two quotes inspired and encouraged me to focus on this study. The first quote is: "Do what you can, with what you have, where you are" (Theodore Roosevelt, 27/10/1858–06/01/1919). As for me, this advocates efficiency, effectiveness and contextualisation. Everyone can do something; everyone has something within their context. This means that as educators, we have Indigenous technological practices in our context and can integrate them into our science teaching and learning.

The second quote: "If you always do what you have always done, you will always get what you have always got" (Henry Ford, 30/07/1863–07/04/1947). This quote seems to advocate improvement, innovation and creating new strategies and approaches regarding our science education. Essentially, the historicity of African education came from a background of exclusion; this quote encouraged me to come up with a study that promotes the decolonisation and indigenisation of science curricula (Mutanho, 2021).

Notwithstanding, it was not an easy exercise to be a public servant, family member and student at the same time. The major challenge was always time constraints for me and my participants, who were teachers. My study was negatively affected during COVID-19, in particular, as I became infected and could not be as productive as I wanted. Moreover, COVID-19 control measures such as national lockdowns also affected and prolonged the study. However, during this difficult time, I received support from my supervisors and fellow PhD scholars.

Certainly, this study allowed me to learn a lot as I acquired numerous skills such as research, expanding teachers' professional learning communities, developing learning and teaching support materials grounded in Indigenous technological practices, and administrative and communication skills. I also developed mutual relationships with the teachers and community members who, in this study, are referred to as IK custodians. I was inspired through this study to read more about CHAT and its implications for teaching and learning, postcolonial Indigenous paradigms and culturally responsive pedagogy.

Reflecting on my research journey, I am struck by the profound complexity and learning that have shaped my experience. The journey was tough with moments of intense frustration, particularly during the long wait of about a year for the final results. The extended examination process tested my patience, and the comments received were heavily focused on making changes based on Eurocentric research protocols. When the results were finally released, the timing was less than ideal, giving me only a short window to address the comments. This created significant pressure as I raced against the clock to meet the deadline.

Amid these challenges, however, I recognised the critical importance of integrating Afrocentric, local, and Indigenous principles such as Ubuntu into transformative African research studies. This enabled me to balance between Eurocentric and Afrocentric perspectives has been a challenge in understanding research protocols and research approach. While the journey was challenging, the research journey has provided invaluable lessons in navigating and harmonising different research methodologies.

Despite the hurdles, I have emerged with a deeper appreciation for the diverse methodologies and the necessity of incorporating holistic, inclusive frameworks in research. This experience has undeniably enhanced my capacity to conduct meaningful and impactful research that respects and honours both global and local perspectives.

I see this study as an effort to contribute to decolonisation and transformative strategies for improving the teaching and learning of science in Otjozondjupa and Namibia. Today, I am proud because I have contributed something to the scientific body of knowledge.

9.7 Recommendations and Areas for Future Research

This study revealed that the indigenous technological practice of marula oil extraction has potential as a cultural tool for mediating teaching grade 11 Chemistry concepts. The study thus recommends that chemistry teachers collaborate with IK custodians to learn more about Indigenous technological practices that could be integrated into their teaching. Involving the IK custodians in education promotes cultural knowledge brokerage in education.

Teachers' continuing professional development and professional learning communities should integrate Indigenous technological practices. This might capacitate the teachers to become cultural knowledge brokers (Simasiku, 2022; Wyatt et al., 2017) and hence become more culturally responsive in their teaching (Haimene, 2023; Mhakure & Otulaja, 2017). In addition, during the curriculum panel for curriculum revision, curriculum developers are urged to include clear guidance for integrating Indigenous technological practices and conduct workshops for effective implementation. This may assist teachers in having a uniform understanding and implementing the curriculum correctly.

I recommend that senior education officers for professional development should render adequate professional support to teachers and ensure that they are innovative to improve their pedagogical strategies that support quality teaching and learning.

This study also recommends that textbook writers include and cite more examples of Indigenous technological practices. To resolve this, textbook writers should consult IK custodians and teachers who are cultural knowledge brokers, tap into their knowledge and integrate Indigenous technological practices into science textbooks. This may help teachers and learners address the issue of the learners' sociocultural backgrounds (Mavuru & Ramnarain, 2020) and prior everyday knowledge (Kuhlane, 2011).

This research can be regarded as a reference point for further research that advocates Indigenous technological practices and culturally responsive teaching and learning. Therefore, the study provides suggestions for studies such as conducting research with community members of different cultural backgrounds and focusing on aspects such as the role of curriculum developers and education officers regarding IK integration, extraction of marula fruits, juice and nuts.

9.8 Conclusion

The study used the indigenous technological practice of marula oil extraction to support teachers in developing exemplar lessons that integrated Indigenous technological practices. The study revealed that teachers seemed to support indigenous technological practice integration as it enables effective teaching. Such integration has the potential to improve understanding of science concepts. After the intervention, the chemistry teachers in this study embraced culturally responsive teaching and two-eyed-seeing and two-way-thinking approaches; they were able to transfer knowledge acquired from the IK custodians into their own teaching. This study contributes to the decolonisation of Eurocentric curricula that exclude Afrocentric pedagogies. It also contributes to the body of new knowledge in terms of the conceptual framework and theoretical and methodological approaches. For instance, we co-developed a reflective tool for culturally responsive teaching and a cultural brokering framework for teaching and learning science. Finally, the study recommends more professional learning communities for teachers to engage and explore more indigenous technological practice possibilities that can be integrated into science lessons.

EPILOGUE

> *Confronting ethical dilemmas between Eurocentric and Afrocentric paradigms revealed the urgent need for inclusive research ethics that honour participants' voices and cultural truths. In the spirit of Ubuntu, knowledge creation is communal and not hidden. Recognising participants as co-creators of the knowledge rather than the subjects redefines ethical considerations in decolonised research. (Journal Entry, May 2025)*

The reflection above encapsulates my unique research journey marked by resilience, ethical dilemmas, intellectual expansion, and a commitment to decolonising education. Embarking on a PhD journey is often described as a transformative endeavour, replete with challenges and triumphs. The journey was a journey within journeys with manifestations of contradictions. Indeed, manifestations of contradictions in my PhD journey epitomise tensions between paradigms, illuminating the need for scholarly persistence, adaptability, and intellectual bravery. For me, this journey was particularly distinctive as it centred on the integration of Indigenous technologies into science teaching, a subject deeply rooted in cultural identity and educational innovation. This work has been a testament to hard work, resilience, intellectual growth, and support for decolonised research paradigms, of which I am not apologetic.

Throughout this journey, I confronted numerous obstacles, including an extended examination process compounded by inconsistent and Eurocentric-based external examiners' reports. The addition of a fourth examiner, for instance, further prolonged the timeline, introducing stress and discouragement. However, I remained steadfast in my commitment to achieving this milestone. As Tinto (2017) emphasises, perseverance is integral to scholarly success, and indeed, my ability to adapt in the face of these challenges was instrumental in reaching this point.

Ethical dilemmas also emerged, shaping my understanding of research integrity. One such instance involved a participant who called herself Happiness. Unfortunately, Happiness could not continue due to her mother falling critically ill. As a result, she had to leave her town where she worked to go to her village (approximately 700km) to fetch her mother and transport her to a hospital in Windhoek. Understandably, her mind was mainly on her mother, and she forgot to communicate with me about her absence. After some time, when we had completed the data gathering process, she told me about her unfortunate circumstances. Luckily, her mother recovered.

Despite this challenge, however, she indicated that she was still interested in being involved in the study. As a result, she granted consent for her interview data to be used (see Appendix R). Worth mentioning is that Happiness gave herself this name as she indicated that she was happy to be a participant in this research, although she ended up unhappy. Sadly, this was interpreted as a 'withdrawal' by some external examiners. Consequently, they recommended that I omit her data as it was a breach of ethics. I thus faced the critical task of navigating ethical expectations from both Eurocentric and Afrocentric perspectives. This experience underscores the need for a more inclusive approach to research ethics that harmonises diverse paradigms, an argument echoed by Chilisa (2012) in her work on Indigenous research methodologies.

Another significant moment arose when my participants, embodying the spirit of Ubuntu, openly expressed pride and honesty in contributing to this research. My participants were so happy and proud to be part of the research. They were honest and uncomfortable with their identities being hidden using pseudonyms and blurring their faces in their photographs. Since they had contributed to the construction of knowledge in this study, they expressed that their identities should not be hidden. Their preference for maintaining their identities, rather than adhering to anonymisation practices, highlighted a cultural divergence in ethical considerations. Although some examiners deemed this a violation of ethical standards, I chose to authentically represent their voices and experiences, advocating for the recognition of Indigenous paradigms in ethical research. It could be argued, therefore, that this resulted in the tensions between the Eurocentric and Afrocentric ethical perspectives. This stance aligns with Smith's (2012) call for decolonising methodologies to respect IK systems.

The application of CHAT in my research brought another layer of complexity. Initially, the broad term 'contradictions' seemed to dominate my analysis, leading to misunderstandings. However, through extensive reading and reflection, I gained a deeper comprehension of CHAT and its nuances, refining my interpretations to include manifestations such as tensions, conflicts, and dilemmas as reiterated by Engeström (2001). This intellectual growth was a cornerstone of my scholarly development. Tensions, conflicts, and dilemmas within me emerged, and that expansive learning and transformation took place. I have learned a lot.

Notwithstanding these challenges, I had the privilege of contributing to Namibia's sustainable National Indigenous Knowledge Policy. This opportunity reinforced the urgency of preserving cultural heritage, which is increasingly overshadowed by globalisation. My research illuminated the multifaceted challenges of integrating Indigenous technologies in science teaching, including misconceptions encountered during the presentation of model exemplar lessons. These reflections led to the development of a culturally responsive teaching reflective tool and a cultural brokerage framework (see Sections 8.13 and 8.14), which aim to enhance the quality of science education in culturally diverse contexts to which I am committed.

This research is a voice advocating for the inclusion of Indigenous knowledge custodians in education, culturally responsive pedagogies, and the transformation of the African curriculum. It has demonstrated that a decolonised approach to research and education is not only necessary but also profoundly enriching. I am proud of the resilience I have exhibited and look forward to sharing the insights gained through publications that might hopefully contribute to the broader discourse on decolonised education.

In conclusion, my PhD journey has been both a challenge and a privilege. It has deepened my understanding of the interplay between culture, education, and research, and has prepared me to continue advocating for the integration of indigenous knowledge systems in academia. As I reflect on this journey, I am reminded of the words of Freire (1970), who championed education as a practice of freedom, a principle that has guided my work and will continue to inspire my future endeavours.

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APPENDICES

Appendix A: Research Ethics Clearance

RHODES UNIVERSITY
Where leaders learn

Rhodes University, Education Faculty
Research Ethics Committee
PO Box 94, Makhanda, 6140, South Africa
Tel: +27 (0) 46 603 8393
Fax: +27 (0) 46 603 8028
email: e.rosenberg@ru.ac.za

https://www.ru.ac.za/researchgateway/ethics/

17 February 2022

Prof Kenneth Ngcoza

Education Department

K.Ngcoza@ru.ac.za

Dear Prof Kenneth Ngcoza

Your application An Interventionist Study Exploring the Integration of the Indigenous Technological Practice of Marula Oil Extraction in Grade 11 Organic Chemistry Teaching, 2022-5254-6569 has been reviewed by the Education Faculty Research Ethics Committee [EF-REC].

Ethics approval has been granted pending the required Permission Letters being obtained from the organisation(s) listed in your application:

Director of Education

Circuit Inspector

School Principals

Your application can be downloaded as a PDF version and forwarded with your permission letter request. Please refer to the Applicant User Guide for how to do so.

Please forward the required permission letter/s, once received, to the EF-REC Chair (E.Rosenberg@ru.ac.za) and to the Education Research Ethics Coordinators (g.chakona@ru.ac.za; d.devos@ru.ac.za) in order for your approval to be finalised.

Sincerely

ERosenberg

Professor Eureta Rosenberg

Chair: Education Faculty Research Ethics Committee

Appendix B1: Permission Letter to the Regional Director

Ms Rauha T. Mika
P O Box 1129
Otjiwarongo
Cell 0813244931
Email: rihalwa@gmail.com

To: Regional Education Director
Directorate of Education, Arts and Culture
Otjozondjupa Regional Council

21 February 2022

Subject: Request for Permission to Conduct Educational Research in Otjozondjupa region

Dear Ms Mutenda

My name is Rauha Tufilonghenda Mika, currently registered as a part-time PhD student (full thesis) Science Education student (student number: 15M8769) at Rhodes University, and a Senior Education Officer for the Otjozondjupa' Teachers' Resource Centres based at Otjiwarongo TRC. I am hereby requesting a permission to conduct a research study at [redacted] during the period of March to May 2022. My research focus of interest is *to investigate the effect of an intervention on the integration of indigenous technological practice of (indigenous technological practice) of marula oil extraction in Grade 11 Organic Chemistry teaching.* The Namibian revised National Curriculum for Basic Education for 2016 highlighted that integration of technologies in education is significant as it contributes to the foundation of knowledge-based society. This is believed helping teachers to enable their learners to develop a better understanding of science subjects. However, there is lack of clarity of possible Indigenous technological practices that can be integrated in science teaching. Instead, the technology that is integrated in science teaching seems to be more influenced by modernised technologies. Similarly, it seems like there is inadequate and inconsistent continuing professional development programmes for science teachers and sometimes not aligned to the teachers' needs. It is against this background that an interventionist case study will be conducted to explore how to support grade 11 chemistry teachers co-develop and enact exemplar science lessons that integrate Indigenous technological practices. The challenges that I have mentioned earlier in this letter prompted me to carry out a research by looking at the ways to integrate Indigenous technological practices (Indigenous technological practices) in grade 11 chemistry lessons, to see if it can mediate effective teaching. The main goal of this study is to explore and gain understanding on how an integration of Indigenous technological practices (Indigenous technological practices) can contribute to science teaching, see whether continuous professional development activities and professional learning communities can expand or constraints such integration through expansive learning cycles. Should I be granted permission, I will apply the principles of research ethics accordingly. Upon completion of the study, I undertake to provide you and the participants with access to the research findings. Attached kindly see the clearance ethics certificate from Rhodes University. If you may have any concerns, you are to contact me at or my Supervisor Prof Kenneth M. Ngcoza (E-mail: K.Ngcoza@ru.ac.az). I hope this request will receive your humble consideration and I am looking forward to hear from you soon.

Yours sincerely

M s Rauha T. Mika

PhD Science Education Student - Rhodes University

Appendix B2: Permission from Regional Director

REPUBLIC OF NAMIBIA
OTJOZONDJUPA REGIONAL COUNCIL

DIRECTORATE EDUCATION, ARTS AND CULTURE

Tel no: 264 67 308000
Fax no: 264 67 304871
Enq: J. Sikeso
Email: jsikeso05@gmail.com

Private Bag 2618
Erf. 280, Sonweg Street
OTJIWARONGO
Namibia

22 February 2022

Ref No:16/1/4/16

Dear Ms. Mika

SUBJECT: PERMISSION TO CONDUCT EDUCATIONAL RESEARCH

Your letter dated 18 February 2022, bears reference and is hereby acknowledged.

Regarding the above mentioned subject, the Directorate of Education, Arts and Culture is pleased to inform you that permission is granted to conduct research at the two selected secondary schools in Otjozondjupa Region. **NB: Please present this letter upon arrival at the school.**

Kindly be reminded that your research does not disrupt the teaching and learning process at the schools, and the COVID-19 procedures should be observed at all times.

The office wishes you the best of luck in your study.

Yours faithfully

OTJOZONDJUPA REGIONAL COUNCIL DIRECTORATE OF EDUCATION OFFICE OF DIRECTOR 2022 -02- 22 PRIVATE BAG 2618 OTJIWARONGO OTJOZONDJUPA REGION

....
MS. J. MUTENDA
REGIONAL DIRECTOR

Appendix C1: Permission Letter to the Circuit Inspector

Ms Rauha T. Mika
P O Box 1129
Otjiwarongo
Cell 0813244931
Email: rihalwa@gmail.com

To: Okahandja circuit Inspector
Directorate of Education, Arts and Culture

22 February 2022

Subject: Request for Permission to Conduct Educational Research in Okahandja circuit

Dear Mr Tjivikua

My name is Rauha Tufilonghenda Mika, currently registered as a part-time PhD student (full thesis) Science Education student (student number: 15M8769) at Rhodes University, and a Senior Education Officer for the Otjozondjupa' Teachers' Resource Centres based at Otjiwarongo TRC. I am hereby requesting a permission to conduct a research study at [redacted] during the period of March to May 2022. My research focus of interest is *to investigate the effect of an intervention on the integration of indigenous technological practice of (indigenous technological practice) of marula oil extraction in Grade 11 Organic Chemistry teaching.* The Namibian revised National Curriculum for Basic Education for 2016 highlighted that integration of technologies in education is significant as it contributes to the foundation of knowledge-based society. This is believed helping teachers to enable their learners to develop a better understanding of science subjects. However, there is lack of clarity of possible Indigenous technological practices that can be integrated in science teaching. Instead, the technology that is integrated in science teaching seems to be more influenced by modernised technologies. Similarly, it seems like there is inadequate and inconsistent continuing professional development programmes for science teachers and sometimes not aligned to the teachers' needs. It is against this background that an interventionist case study will be conducted to explore how to support grade 11 chemistry teachers co-develop and enact exemplar science lessons that integrate Indigenous technological practices.

The challenges that I have mentioned earlier in this letter prompted me to carry out a research by looking at the ways to integrate Indigenous technological practices (Indigenous technological practices) in grade 11 chemistry lessons, to see if it can mediate effective teaching. The main goal of this study is to explore and gain understanding on how an integration of Indigenous technological practices (Indigenous technological practices) can contribute to science teaching, see whether continuous professional development activities and professional learning communities can expand or constraints such integration through expansive learning cycles. Should I be granted permission, I will apply the principles of research ethics accordingly. Upon completion of the study, I undertake to provide you and the participants with access to the research findings. Attached kindly see the clearance ethics certificate from Rhodes University and permission from the Regional Director. If you may have any concerns, you are to contact me at or my Supervisor Prof Kenneth M. Ngcoza (E-mail: K.Ngcoza@ru.ac.az). I hope this request will receive your humble consideration and I am looking forward to hear from you soon.

Yours sincerely

Ms Rauha T. Mika
PhD Science Education Student - Rhodes University

Appendix C2: Permission Letter from the Circuit Inspector

[l;

REPUBLIC OF NAMIBIA
OTJOZONDJUPA REGIONAL COUNCIL
DIRECTORATE: EDUCATION, ARTS AND CULTURE
DIVISION: PROGRAMMES AND QUALITY ASSURANCE
OKAHANDJA CIRCUIT

Tel no: 264 62 500438
Email: okahandjaco@gmail.com
Enq: U.C Tjivikua

P.O Box 1269
Erf. 82, Kahimemua Street
OKAHANDJA
Namibia

24 February 2022

To: Ms. Rauha T. Mika
PHD Science Education Student
Rhodes University

Dear Madam

REQUEST FOR PERMISSION TO CONDUCT EDUCATIONAL RESEARCH IN OKAHANDJA CIRCUIT

Your letter on the above subject, dated: 18 February 2022 bears reference.

1. Receipt of your letter is hereby acknowledged.
2. First and foremost I would like to thank you for taking your studies to a level of PHD and wish you all the best with your studies.
3. I have no reservation whatsoever for you to conduct educational research at J.G van der Wath S.S and Okahandja S.S during the period of March to May 2022.
4. However, I would like you to ensure that your research (interventions) would not disrupt the normal programmes of the schools and/or derail the implementation of the scheme of work of the Chemistry subject.
5. In line with your inference in the letter, I equally wish that your intervention would enable the learners to develop a better understanding on how indigenous (technological) practices can be integrated in science teaching.

Regards,

OTJOZONDJUPA REGIONAL COUNCIL
DIRECTORATE: EDUCATION
PRIVATE BAG 2618 OKAHANDJA
2022 -02- 24
TEL: 062-500483
INSPECTOR OF EDUCATION
OKAHANDJA CIRCUIT

Yours faithfully,

U.C Tjivikua
IoE: Okahandja Circuit

24.02.2022

Learners who receive the best possible education will represent us well in future as future leaders – Nelson Mandela

Appendix D1: Permission Letter to the School Principals

Ms Rauha T. Mika
P O Box 1129
Otjiwarongo
Cell 0813244931
Email: rihalwa@gmail.com

To: Principals
Directorate of Education, Arts and Culture

22 Februaay 2022

Subject: Request for Permission to Conduct Educational Research at [redacted]

Dear Mr Nuugulu & Mr Williams

My name is Rauha Tufilonghenda Mika, currently registered as a part-time PhD student (full thesis) Science Education student (student number: 15M8769) at Rhodes University, and a Senior Education Officer for the Otjozondjupa' Teachers' Resource Centres based at Otjiwarongo TRC. I am hereby requesting a permission to conduct a research study at [redacted] during the period of March to May 2022. My research focus of interest is *to investigate the effect of an intervention on the integration of indigenous technological practice of (indigenous technological practice) of marula oil extraction in Grade 11 Organic Chemistry teaching.* The Namibian revised National Curriculum for Basic Education for 2016 highlighted that integration of technologies in education is significant as it contributes to the foundation of knowledge-based society. This is believed helping teachers to enable their learners to develop a better understanding of science subjects. However, there is lack of clarity of possible Indigenous technological practices that can be integrated in science teaching. Instead, the technology that is integrated in science teaching seems to be more influenced by modernised technologies. Similarly, it seems like there is inadequate and inconsistent continuing professional development programmes for science teachers and sometimes not aligned to the teachers' needs. It is against this background that an interventionist case study will be conducted to explore how to support grade 11 chemistry teachers co-develop and enact exemplar science lessons that integrate Indigenous technological practices.The challenges that I have mentioned earlier in this letter prompted me to carry out a research by looking at the ways to integrate Indigenous technological practices (Indigenous technological practices) in grade 11 chemistry lessons, to see if it can mediate effective teaching. The main goal of this study is to explore and gain understanding on how an integration of Indigenous technological practices (Indigenous technological practices) can contribute to science teaching, see whether community professional communities activities and professional learning communities can expand or constraints such integration through expansive learning cycles. Should I be granted permission, I will apply the principles of research ethics accordingly. Upon completion of the study, I undertake to provide you and the participants with access to the research findings. Attached kindly see the clearance certificate from Rhodes University permission from the Regional Director and the Circuit Inspector. If you may have any concerns, you are to contact me at or my Supervisor Prof Kenneth M. Ngcoza (E-mail: K.Ngcoza@ru.ac.az). I hope this request will receive your humble consideration and I am looking forward to hear from you soon.

Yours sincerely

Ms Rauha T. Mika

PhD Science Education Student - Rhodes University

Appendix D2: Permission Letters from the School Principals

JG VAN DER WATH SECONDARY SCHOOL

P. O. BOX 40 OKAHANDJA
TEL.062 – 501491 FAX: 0886509158
Email : jgvwath@iway.na

3 March 2022

Dear Mrs Mika

Subject: **Permission to conduct Educational Research**

Your letter dated 18 February 2022 on the above mentioned subject bears reference and is hereby acknowledged.

Regarding the above mentioned subject, the management of JG Van Der Wath Secondary School is pleased to inform you that permission is granted to conduct research at our school during the period of March to May 2022. However, I would like to ensure that your research would not interrupt the normal programme of the school and the Covid – 19 protocols should be observed at all times.

The Management of JG Van Der Wath Secondary School wishes you all the best in your PhD study.

Yours Faithfully

Mr R. Williams

Principal

2022 -03- 03

Okahandja Secondary School

Private Bag: 2033, Okahandja
Okahandja, Namibia
Peter Katjavivi Street
Phone: +264-62-501 639
Fax: +264-62-501 249
EMAIL: [illegible]
WEBSITE: [illegible]

Inquiries: Mr. T. Nuugulu

02 March 2022

To: Ms. Rauha Mika

P o Box 1129

Otjiwarongo

0813244931

Re: request for Permission to Conduct Educational Research at Okahandja SS

Your letter dated 18 February 2022 bears reference.

I am pleased to inform that your request is approved and that permission is granted for you to do your research at our school.

Kindly make available to us your recommendation and findings after your study. This will go a long way in making our school a better place for the teachers, Learners and Parents community.

I thank you

Nuugulu Teofilus

School Principal

MINISTRY OF EDUCATION
OKAHANDJA SEC. SCHOOL
0 2 MAR 2022
P/BAG 2033, OKAHANDJA, NAMIBIA
OFFICE OF THE PRINCIPAL

Appendix E1: Informed Consent Participants

Subject: Invitation to participate in an educational research study Research Title

Exploring the impact of Indigenous technological practices integration in the Namibian Secondary Science Teaching: Pedagogical Insight and Expansive Learning Prospects

Rauha T. Mika (15M6987), currently a PhD student at Rhodes University, has requested my permission to participate in the above-mentioned research project.

The nature and purpose of the research project and of this informed consent declaration have been clearly explained to me in a language that I understand.

I am therefore aware that:

1. The purpose of this interventionist study to investigate the effect of an intervention on the integration of indigenous technological practice of (indigenous technological practice) of marula oil extraction in Grade 11 Organic Chemistry teaching.

2. I am made aware that this study will be conducted in four phases.
   Phase 1: During this phase data will gathered by conducting interviews that will be audio recorded.

   Phase **2**: The intervention for this study will consist of **two** 1h30 - 2 hours long workshops. During the workshops, data will be gathered through; videotaping of participant discussions, document analysis and reflective journaling. The workshops will be conducted at a place and time that is appropriate to me and the other participants.

   Phase 3: Participants will visit a community members and expert in Indigenous technological practices to attend a **third** workshop. The experts will practically present and demontrate indigenous technological practice of marula oil extraction. Participatory observation and reflections will be made.

   The participants will come together for a **fourth** workshop that will enable them to co-develop the lessons that integrate Indigenous technological practices. Two teachers will then teach two lessons each and other professional learning community members will be observing as critical friends. Lessons observations will be video-recorded.

3. I will be interviewed individually and all the COVID-19 protocols will be observed. Should the COVID-19 restrictions be in force, Google Meeting or Zoom or WhatsApp will be used with my permission. The interview will take approximately 30-45 minutes and will be audio recorded with my permission.

4. By participating in this research project I might be contributing towards working with science teachers in creating knew knowledge on how to integrate Indigenous technological practices in science lessons.
5. I will participate in the project by workshop the chemistry teachers on the process involved on exploring technology lying within cultural heritage of marula oil (odjove) production. As community member my role will be guiding me during practical demonstration for me to tap out technological experimental techniques and relate science concepts involved in the process.

6. My participation is entirely voluntary and should I at any stage wish to withdraw from further participation, I may do so without any bigotry.

7. I understand that participating in this study is voluntary and that I will not be compensated for participating.

8. The researcher intends publishing the research results in the form of *thesis, conference presentation, conference proceedings, book chapters and journal articles.*
9. They may be risks associated with my participation in the project. I am therefore aware that of the following steps:

   a) All information shared in the group is strictly confidential and will not be used for purpose other than of the above-mentioned research project.
   b) All the data collected will be kept in a locked cupboard and electronic data will be kept in a computer only accessible through a secure password.
   c) The researcher intends to publish the research findings in the form of a thesis towards a PhD degree in Science Education, and later present it in papers conferences or journal articles; still, confidentiality will be maintained.

10. Any further questions that I might have concerning the research or my participation will be answered by the Rhodes PhD student (rihalwa@gmail.com) or the supervisor Professor Kenneth Mlungisi Ngcoza (K.Ngcoza@ru.ac.za).

11. By signing this informed consent declaration, there are no legal implications.

12. A copy of this informed consent declaration will be kept in a safe place by the researcher.

I, ………………………………………………………………………………have read the above information or confirm that the above information has been explained to me in a language that I understand. I am therefore aware of this document's contents. I have asked all questions that I wished to ask, and these have been answered to my satisfaction. I fully understand what is expected of me during the research.

I have not been coerced or pressurised in any way. I therefore voluntarily agree to participate in the above-mentioned research project.

………………………………….. ………………………….

Participant's signature Witness

Date ………………….. Date ………………….

Appendix E2: Informed Consent Parents

Ms Rauha T. Mika
Cell 0813244931
P O Box 1129
Otjiwarongo
22 February 2022

Dear Parent

My name is Rauha T. Mika, a part-time student at Rhodes University and also a Senior Education Officer for the Otjozondjupa' Teachers' Resource Centres based at Otjiwarongo TRC. I am carrying out a research study together with chemistry teachers in the Okahandja circuit (at [redacted]), in which we will work on the inclusion of Indigenous technologies into the science lessons. I write to humbly request your child to participate in my study. My research focus of interest is *to investigate the effect of an intervention on the integration of indigenous technological practice of (indigenous technological practice) of marula oil extraction in Grade 11 Organic Chemistry Teaching.* Your child's chemistry teacher is participating in this study during the period of February and April 2022. I am going to visit this teacher's chemistry lessons twice in this year 2022, to explore and establish understanding on how an integration of Indigenous technological practices (Indigenous technological practices) can contribute (or not) to science teaching.

I am kindly ask you to grant me permission for your child to be included in the research during my presence at the grade 11 chemistry lessons; I will take notes on the teaching, for example, on conversations between learners and teacher, on the teacher's explanations or on learners' contributions. Possibly, some of the chemistry lessons will be audio recorded.

All information will be treated confidentially: Nobody except myself and the group of four participating teachers will access the information. After finalising my PhD thesis (planned for 2023) the audio recordings will be deleted and the written materials will be made anonymous. I will write several journal articles about my research. Whenever mentioning my observations from the classrooms or my conversations with the students, I guarantee that your child's particulars will not be revealed. I will use pseudonyms and no information will be given by your child could be identified.

The aim of the research project is to make grade 11 chemistry lessons more interesting and familiar with the learners' local Indigenous technologies. There is no foreseeable risk involved in your child participating in the research activities named above. Please note that all participation is voluntary. If you or your child do not wish that he/she be part of the research, I will not include him/her. Also, you are free to withdraw your permission at any time without giving a reason. A decision not to participate in the study will not have any effect on your child's participation in the science lessons.

If you have any question(s) about the research, please feel free to contact me on 0813244931, rihalwa@gmail.com or Prof. Ken Ngcoza (k.ngcoza@ru.ac.za) at the Education Department. Thank you for taking time to read this letter. If you agree for your child to participate in this research, please complete the consent form below.

Yours sincerely

Ms Rauha T. Mika

Rhodes University: PhD in Science Education Student

I____ (full name of parent/guardian), the father/mother/guardian of _________________________________ (full name of child) hereby confirm that I understand the content of this document and the nature of the research, and I consent to my child participating in the research study. I also understand that my child is at liberty to withdraw from participating at any time without any disadvantage.

Reply slip for Parent's/Guardian's

I agree and authorise my child to participate in the research and I understand that my child can withdraw from participation without any effect.

Parent's/Guardian's Full Name____

Parent's/Guardian's Signature_______________________Date_________________

Contact numbers____

Appendix E3: Letter to the Community Member [English]

22 February 2022

Dear Sir/Madam

Re: <u>Participation in Research on Integration of Indigenous technological practices in the teaching of science</u>

My name is Rauha T. Mika, a part-time student at Rhodes University. I write to humbly request you to participate in my study. My research focus of interest is *to investigate the effect of an intervention on the integration of indigenous technological practice of (indigenous technological practice) of marula oil extraction in Grade 11 Organic Chemistry teaching*.

The study will be conducted in four stages. The first, second and fourth involves teachers and Education Officers. The third stage includes community of practice members will visit a community member who is in this reseach is regarded as an expert in Indigenous technological practices to attend workshop. The expert will practically present and demontrate Indigenous technological practices which is cultural heritage for marula oil production. Participatory observation and reflections will be made. The expertise may be useful in raising awareness on integration of Indigenous technological practices (indigenous technological practice) of marula oil extraction in science teaching. You will be the main presenter and during your presentation to the teachers will be observing, free to ask questions.

Your participation in this research study is appreciated as it may contribute to the science technology in teaching and learning. Kindly take note that your involvement is voluntary which means that you can accept or decline the invitation or withdraw at any time if you may feel doing so. With your permission, your presentation will be video-recorded, for data collection and analysis purpose. The data that will be collected in this study will only be used for educational purposes and shall not be accessed by anybody without your consent. Your identity participant and opinions or contributions will be treated with confidentiality and anonymity as it will not be revealed to anyone without your consent.

Yours sincerely

Rauha T. Mika
PhD Science Education Student – Rhodes University

DECLARATION BY THE INDIGENOUS KNOWLEDGE CUSTODIANS

- I will participate in the study and I understand that I am free to withdraw at any time
- Video-recording can be done during my presentations

Name………………………………………………………….

Signature………………………………………………………

Contact number……………………………………………..

Appendix E4: Letter to the Community Member [Oshiwambo]

22 February 2022

Kuye Omufimanekwa

Oshinima: **<u>Ekufombinga momapekaapeko okuhonga ounongononi wopamifyuululwakalo mehongo loilongwa yopaunongononi meefikola.</u>**

Edina lange aame Rauha T. Mika, ndili omuhongwa koshiputudilo shehongo lopombada Rhodes University. Ohandipula ekwafo loye opo ukufe ombinga moprojeka yomapekaapeko okuhonga ounongononi wopamifyuululwakalo mehongo loilongwa yopaunongononi meefikola. Onda hala kukoonaakona nghee ounongononi womufyuululwakalo wokuninga odjove tau dulu okulongifwa mofikola moshilongwa shopaunongononi mondodo 11.

Omapekaapeko aa otaa kanigwa paenghatu dili nhee. Onghatu yotete onhivali nonhine oya kwatelamo ovahongi voilogwa yopaunongononi novakwanambelewa vehongo. Onghjatu oya kwatelamo ovahongi taveya vekutalelepo peumbo loye opo uva ningile omadeulo nghee ondjove hainingwa. Ounongo woye neshiivo loye lokuninga omaadi eengongo (odjove) ouli wafimana mokukwafela ovahongi okuhonga oitwa yanyama kodjove moshilongwa shopaunongononi mondodo 11. Onghee kala wa manguluka onga omudeuli tokadeula ovahongi tavakatala nghee to yenge voo tavekupula omapulo. Ekufombinga loye momapekaapeko aa otali pandulwa neenghono adishe notashikakwafela okunghonopaleka nokuhwahwameka ehongo lounongononi wopamifyuululwakalo moilongwa yopaunongononi meefikola. Kala wakoneka kutya ekufombinga loye ita lidengele, ndele nee otashidi kehalo loye mwene, notodulu okulikufamo momapekaapeko ngee ouudite ito dulu vali okukufa ombinga. Neefelo loye, ashishe tokaninga momadeulo otashi ka fanekwa nokukakonaakonwa. Omauyelele aeshe taakaongelwa otaakakwatwa nawa nootaakalongifwa nomalalakano okuhwepopaleka ehongo lounongononi meefikola. Omauyelele aa itaakayandwa nande okovanhu vamwe velili pehena eefelo loye. Oyeetwapo yoye aishe naashishe osho tokayambidida nasho otaikakwatwa nawa na itaka yandjwa nande okuvamwe pehena epitikilo loye.

Woye
Rauha T. Mika

Omunafikola wondodo youndokotola
Oshiputudilo shopombada sha Rhodes University

Etambuleko lokukufa ombinga momapeekaapeko
- Ohandi ka kufa ombinga momapekaapeko, nondaudako kutya ondina oufembe okulikufamo momapekaapeko ngee nduudite ndahala keshe efimbo
- Ashishe handikaninga momadeulo otashi ka fanekwa

Edina…………………………………………………………

Eshaino………………………………………………………..

Onomola yongodi……………………………………………..

Appendix G1: Semi-Structured Interview Schedule Adapted from Bowen (2009)

Introduction: Thank you for agreeing to participate in this interview. I am interviewing you to better understanding of your pedagogical insights towards integration of Indigenous technological practices in science teaching. We would like to see whether integration of Indigenous technological practices can contribute or (not) to science teaching. What you think about [integration of Indigenous technological practices in science teaching] and your contributions can improve the way we teach science. So there are no right or wrong answers to any of our questions, we are interested in your own experiences. Participation in this study is voluntary and your decision to participate, or not participate, will not affect you. The interview should take approximately 30 – 45 minutes depending on how much information you would like to share. With your permission, I would like to audio record the interview because I don't want to miss any of your comments. All responses will be kept confidential. This means that your de-identified interview responses will only be shared with research team members and we will ensure that any information we include in our report does not identify you as the respondent. You may decline to answer any question or stop the interview at any time and for any reason. Are there any questions about what I have just explained?

Research goal: To explore how to integrate the indigenous technological practice of marula oil extraction *(odjove)* in grade 11 chemistry teaching.

Research Questions:

What are grade 11 chemistry teachers' pedagogical insights and contradictions towards the integration of Indigenous technological practices in science teaching?

Establishing Rapport: It would be nice if you could tell me a little bit about yourself, what are your qualification and your teaching experience?

Starting with interview questions:

	Questions	**Justification**
1.	how do you understand the concept "technological indigenous practices" (Indigenous technological practices)?	To establish teachers understanding of the concept.
2.	What are your views, experiences on integration of Technological Indigenous Practices (Indigenous technological practices) in teaching grade 11 chemistry concepts?	To find out about their pedagogical insight regarding integration of Indigenous technological practices in grade 11 chemistry lessons.
3.	Could you please share with me some possible examples of any Indigenous technological practices (Indigenous technological practices) that you think can be integrated grade 11 chemistry lessons?	To identify possible focus area of integration within broad chemistry subject.
4.	Could you please share with me **benefits** of integrating Technological Indigenous Practices (Indigenous technological practices) in chemistry lessons?	To find out if there are benefits for Indigenous technological practices inclusion in chemistry lessons.
5.	What do you think could be the **challenges** for integrating Technological Indigenous Practices (Indigenous technological practices) in chemistry lessons?	To identify possible challenges for Indigenous technological practices inclusion in chemistry lessons.
6.	What else would you like to share with me regarding the integration of Technological Indigenous Practices (Indigenous technological practices) in chemistry lessons?	To explore and consider any other contributions based on integration of Technological Indigenous Practices (Indigenous technological practices) in chemistry lessons?

Conclusion: Is there anything else that you would like to comment on that I haven't already asked you about? We have come to the end of our interview session. Thank you very much for your time and the information you shared today.

Appendix G2: Collated Semi-Structured Interviews

Collated Semi-Structured Interview Data

Participants: Theoretical, Scientist, Nelago, Panduleni, Brave,

Research Question: What are grade 11 chemistry teachers' pedagogical insights and contradictions towards the integration of Indigenous Technological Practices in science teaching?

Question	Theoretical	Scientist	Nelago	Panduleni	Brave	Happiness
How do you understand the concept Indigenous technological practices?	Indigenous technological practices has to do with local experience, local methods or methods that are used by the Indigenous people who are occupying a certain geographical area for a quiet long time. What I do understand is that these are the	the way I understand this concept or this term is like Indigenous Practices that involve making use of technology be it as machines or any style of doing it as long as it is linked to Indigenous so it is kind of local technology involved in practices, yeah!!	I would basically say that these are our everyday lives practices and I think in most instances we misunderstand this can make our lives easier and used to teach our learner to learn better.	For me I can maybe start defining the family's words like indigenous Practices which is looking at practices that we do in our everyday lives and this includes making tools to make our lives at home easier for example making basket at home and these baskets used in other	Well Picking it from the word Indigenous is something that is used locally and in short those are just important activities that are taking place in different Cultural practices across the country using their natural resources around them to make certain products that are Culturally products. It is	This has to do with integrating Indigenous knowledge and mostly what we do at home and try to bring it into the classroom to make our learners understand more better.

	symbols, technological skills that have been used by our forefathers or some of the Indigenous people and these are not documented in case of our country. Most of the symbols that are technological that is not documented but if you look in comparison to what is happening in the Western culture which is documented. It always surprise us when we get our formal education as from what we learnt already from environment			Practices such as preparation of food and local beverages that are practice at home. So Indigenous technological practices are just practices that we do at home in order to make our lives easier. But if I am to include technology, technology is just the term that we came across at the school that includes maybe learners that are doing technology by dong subjects such as drawings, designing structures. If I am to link Indigenous technology	actually that those things that used locally and mostly in the villages.	

	and from home to see what our parent are doing and so on, it is just a technological practices that has been used by our forefathers has been using to solve problems in our environment.			with Practices with technology it has to do with coming up with tools in our environment that can help our work to be easier at home. But if I am to bring it to the context of the school, it makes sense that when we teach science we need to bring in and link what happens at home to the science concepts in the classroom. For example, that making of basket, making of "omushi" is also a technology. Now we need to show them what it that is		

				involved scientifically is. I think that is all.		
What are your views, experiences and pedagogical insights on integration of Indigenous technological practices in teaching grade 11 chemistry lessons?	Alright! As I said that in most cases we are just comparing with Western world, and even if you look at our syllabus it does not even have the new concepts that we are talking about here. But some teachers of chemistry or Science are trying on their own to use the local experience. But in my view I feel like that, if we happen to	OK, the views and experience on integrating Indigenous technology Practice, Ok, I think this will make the work easier for both teaches and the learners in the Teaching of the chemistry concepts so it is something will make the work easier for the learners to understand concepts better or to understand	This is one thing that I believe that it has been neglected in our day-to-day teac hing methods. We do not really get to integrate Indigenous technological or methods in our teaching when teaching science concepts. Our syllabus talks abou t Indigenous knowledge that can be incorporated in daily lessons and maybe it is because it is not explicit	Let me start this way, these is the concepts of fomentation, distillation and others. My pedagogy is all about how I was trained to teach but not much more on integration. We are much more on finishing the syllabus, prepare the learners from examination. But the reality is that science should be interesting but today a lot of learners are very scared of	First of that all, maybe I can explain the word integration which is how do we make use of some of those concepts in schools in relation to what people in our local community are doing a lot of things that are unpublished but they do not really know how it may be relevant to the School. People in the community are the using materials can be scientifically	Let me try to connect this modern way and if you look at what is used in practical experiments are more on modern methods. But with integration of Indigenous technological practices you can bring in Indigenous or local people with expert to assist us. It will be much great of assistance when it comes to the content and pedagogical knowledge in grade 11 in chemistry. It

	incorporate the Indigenous Technological Practices in Science teaching, this of course will close the gap between what we lack because there are lot of examples that can be used to do experiments for example, doing things like making "odjove" and look at it, the whole process is to make oil but if we try to incorporate this in Science teaching, this will open up to teachers to teach science concepts based from	certain context better or also may be to make it easier for the teaches to be able to explain concepts or certain context to the learners and make them understand. OK, well, thank you! This concept involves Indigenous and the way I understand it is like technological practices that is more local, that is involve culture, so it is something that the learners already know and	explained it could be the reasons why we are not incorporation it is our lessons. At the end of the lessons, the lessons are not going to be "Wow" to the leaners because we are giving them things that they are not used to and not even linked to what they know or do at their home background situations. So our learners are finding it difficult to cope with science subjects. Yes, very much neglected and maybe what I can add is that when you see	taking science subject. I think science teachers need to bring in the elements that can make science more interesting. However, we need to expose our learners to technological practices on how to go about it and integrate it. In our society as Oshiwambo-speaking people, we have been making ombike that in our lives distillation, fermentation in order to produce ombike. So these practices can be arranged for the learners to be exposed	used in our chemistry syllabus or a set up in the normal industries. This means that the Containers that they use when they are making their products at home, So the integration at the School could be as that in school we call it appropriate and that means that culturally community members are along experiments while in our classes we use a recognised scientific apparatus that are already provided. For example, when you are measuring	will be much easier and also find a right method that will bring the learners to different learning styles and understand better.

	the learners' background. But looking at our Science Syllabus, it allows the teaching that focus on Western and modern technologies than Indigenous technology. Even when the learners are being taken to a tour, they are just taken to modern industries that are sometimes that are not located in their school environment. For me to integrate Indigenous Technological Practices in Chemistry teaching, it will bring	already known by the teachers. Integrating such type of technology in the teaching of chemistry, will make it easier for teachers to teach and the learners to understand since they are learning about it or maybe making use of it and they are using their local knowledge, because this now involving Indigenous kind of and that is how I understand. If it is involving Indigenous, obviously, learners	teachers coming from the workshops, when the specific things are presented for example when we attended our revised curriculum trainings and workshops, only few methods of local technologies were presented, but these things are not even documented or used regularly. If this Indigenous technological practices examples are documented in our curriculum and textbooks it will be better.	provided that teachers are rained on hoe to integrate Indigenous technological practices. Such integration one may need a more knowledgeable other to either teach the learners and the teachers more on Indigenous technological practices.	volume, culturally they do not use calibrated apparatus but rather do estimation. When they carry out certain specific process to produce something, then they do have and mastered certain materials that they follow. Just the same with the where there are techniques and Procedures on how to carry out experiments.	

	about comfortability with the teachers because sometimes as a teacher you are explaining the concept but yourself you don't even use any examples from local knowledge, you are just giving examples from the books that most of the learners are not familiar with. But me as the teacher, if I give an example of "odjove", or local Gin brewing, it will be easier and comfortable to teach because I have local	might have knowledge about it and that will make it much easier for them to understand other concepts. To me this will bring in home-in-school perspective".				

	examples and experiences Indigenous technological practices rather just me talking or referring to things that are just in the textbooks.					
Could you please share with me some of the possible examples of Indigenous technological practices that can be integrated in grade 11 chemistry lessons?	I would like to start with the brewing of the Gin what we call "Ombike" in my vernacular language. This includes most of the processes such as filtration, distillation, etc. because this one is just alcohol that is made from scratch but if you look and visit	OK, like I have said at the beginning, that some Indigenous Practices that involves technology but this technology is more on or from the cultural practices. So I think, and as a chemistry teacher, I could think of or give an example of	you have talked about marula oil extraction in your research and I think that one can be used as an example. When we are talking about separation in chemistry and also we have got the process of making "Ombike" we can relate to distillation that is done	"Ombike" that I have stated earlier could be the first example, this is also "oshikundu" because of the fermentation process that is in value and also gases that are involved like carbon dioxide, etc. Me: any other examples that you may think of?	Ok. Let say number one, we can talk about the brewing of traditional alcohol let's say "Oshikundu" things like "Otombo" and all those brewing process that involved fermentation that are done traditionally. I can also think about some herbs that we	"Ombike" is produced through the process of fractional distillation, monitoring, temperature, Indigenous people use cold water and warm water, sometimes, control condensation and this is part of traditional technology. "Odjove" is another

	at the site where Indigenous technological practices are taking place and take the pictures to see how these people are doing it, it will be very very impressive. If you happen to look at the subject chemistry where we are looking at alcohol there are given steps on how alcohol can be prepared through the processes of distillation, filtration and other processes until the end product is formed. Now if you have to go to the modern	making or extraction of alcohol by fermentation process and that is one of the common practices that our elders do at home and sometimes they are getting assistance from the children who are our learners, obviously if you bring that to class room it will make it easier for the learners as they know it from home. The other example can be maybe making traditional cakes; you know when	or practiced by our Indigenous people. We also have the process of making "Omagadhi goontanga" the oil from watermelon seeds. Those are the few methods that can be integrated in our chemistry lessons as a foundation or introduction hat all? Yes	Nelago: Not really.	collect naturally from our environment to treat either flue, coughing, when bitten by the snake. I am also thinking about preparation of food for example Crushing of mahangu grains to make mahangu porridge and other things whereby you need to crush certain grains to come up with some products. Me: Mh..Mh. it seems like we have a lot of local examples of Indigenous technological practices that we can	example, whereby we use lukewarm wafer but not just cold water due to what heat can do to the rate of reactions. There is also the process of making "Oshikundu" whereby Indigenous people us soghoum, water, Mahangu flour and boiled water. Sometimes people add sugar increase temperature to increase the rate of reactions. This also has technology in itself that can be integrated in chemistry lessons.

	industries of producing liquor, there a lot of machinery are involved and so on, but if you visit these local Indigenous people that have technological expertise and see how they brew “Ombike”, you can tell that these people are well equipped and specialised in many Indigenous technological practices. They know which raw materials to use and how they can mix them up to get the end product(s), how they are boiling and measure the	you bake cakes, practically and locally at home they put it in a traditional\local kind of oven and then expansion is taking place, carbon dioxide is produced. Bringing such type of example one can do it involve Indigenous technological practices because this is something in a modern life that a learner can refer to traditional practices. This may benefit learners. Other things are like maybe cooking:			integrate in our science lessons. Brave: Yes, yes we can still even talk about crushing of grains to make things like porridge, flow in order to come up with food and other products that can feed animals.	

	temperature. So they know everything but it is not documented. If you are using for example the Palm fruits, *oombeke* to produce liquor and others, if they mix that, they make sure that they mix it effectively, ferment it properly and also that they will be able convince us and tell us that we have some Indigenous technological practices in our local environment that we use in school. Also the other example is milk, you can get the milk	making a pap or "porridge" is also one of the examples. So we learnt about a lot of things in chemistry such as purifying things, like a dirty water we need to purify by using sort of purifies that lies within cultural practices, locally they have their own ways of doing it and all those things if they are brought to the classroom context, they might be also be some of the good examples that will force the integration of Indigenous				

	from the cow but if you can imagine what we do when we get back to our village, there is certain root of a tree that we cut and put it in the milk to make it sour. Of course if you go to pastel process of milk, changing to sour, there is also a process in chemistry on how to the substance are treated but we concepts such as enzymes but reflecting from our cultural practices of turning fresh to sour milk, we use that root of a certain plant or all the things are not documented. Again I can	technological practices. So the examples are many…. Well, it seems like there are possible example of practices that we can integrate in our chemistry teaching and that would be beneficial if there are a lot of or varieties of those practices that are in our local environment. Scientist: Yes, I may say that, as a chemistry teacher, almost every suggested practical				

	give you an example of brewing "*Oshikundu*" looking at concepts of osmosis, diffusion, are involved but we do not bring them in our Science teaching. Instead we only use examples of modern wine production industries. When teaching concepts of fermentation, distillation, etc. But the amazing fact is that we do not even produce those wines in Namibia, but our local homesteads prepare and brew Oshikundu on daily basis.	activity in the school curriculum to a particular Indigenous technological practices. It is just a matter of thinking about how we can bring it to the classroom. For example, I mentioned about baking of cakes, there are many concepts that relevant in chemistry teaching. Examples are many and things like soap making as well. Me: Meaning that there are a lot of examples out there and then a I am very much				

	Maybe the last example we can look at the production of tiles for the floors, I would like to talk about the substances that are used there and link it to ceramics that we teach in chemistry and clay pots that we culturally produce in our local communities. Sometimes we use them as containers to cook food, storing liquid substance to cool down and others. We use them because of their properties as	interested in saying that most of almost all cultural practices that our elders are practicing they are linked to chemistry concepts isn’t? Scientist: Yes, Exactly! Me: Meaning that in every topic, we can link it to cultural practices? Scientist: Yes, because chemistry topics most of them are environmental-based and that Indigenous or cultural practices that are done in				

	such as good conductors of heat, good insulators. But the fact will remain that we don’t use these local examples in our Science teaching when we teach the chapters of “Materials”. Where we teach different types of materials such ceramics, plastics, etc. and which ones are conductors and insulators. But we never linked this chapter of materials to the Indigenous technologica l practices of ceramics,	the local community are also environment – based. It only that maybe we did not know like these things are just coming in my mind now when you may be introduced your research topic to me, so chemistry topics and Indigenous technological practices are environment – based and most of suggested examples can offer wide range of apparatus in the classroom context. At homes, in the local communities’ people are doing those things, as we				

	particularly our clay pots that are locally made.	talked about purifying water, some people are drinking water from Oshana, which is not clean, but they clean it themselves by using some other things. Me:What are those other things? Scientist: Yes, it seems like at the class we use a sieve but locally there are some other types of plants like grass, they use to filter water or they can place the water somewhere so that the water and impurities can settle down. We				

		have a lot of things locally but the challenge is on how to bring it to the classroom.				
Could you please share with me, some benefits of integrating Indigenous Technological Practices in Chemistry lessons?	Ok, Number one I can say "Comfortability". If teachers are going to use Indigenous technological practices that are local knowledge of what they know already and incorporate in chemistry lessons, they will be very comfortable to present those lessons because they are presenting of what they know, what is available in their	The benefit here is just straight forward as it will just make the work easier through the teachers to learners. The teacher will be able to explain concepts better to the learners because in our schools, not all the schools are better equipped with Science Laboratory equipments, some school do not even have science laboratories. In many cases the teacher will	This will be a "wow" moments for the learners and it will be a learning curve already because it will sound interesting to the learners. learners can do more research, they learn and understand science concepts better. So if these practices can be used or incorporated in the lessons most of the leaners will find it interesting.	In chemistry books, and the learners are expected to contextualise but they should not just learn to memorise, one need to know and link science concepts to local technologies that they practice at their houses. It can also arouse their curiosity to explore others topics or concepts to what they practice at homes. It can	Ok. Once learners learn these in schools, they may develop more interest by relating the Indigenous technological practices and science Concepts to their everyday household practices rather than just teaching them in general. It will also promote cultural practices whereby	It will make learning more fun, as nowadays if you look at the learners, they are looking for new ways that are interesting to learn but in actual sense they do not really get what they want but if we happen to integrate what they know they may have interest, have more clue or start to think out of the box. In terms of teaching and learning materials, they may able to

	environment or what is being done by the community members, what they have been seeing since they have been growing. This will create a comfort class whereby the teachers will not even struggle. Same applied to the learners, they will also feel comfortable because these materials are all available in their environment and they have seen all these in certain cultural practices in their	just explain things theoretically but the moment we integrate Indigenous technological practices and bring it to the classroom, it will make it easier because will be able to see it and in the case of not having Laboratories or Science apparatus obviously the teacher will just teach, just showing pictures but if we integrate Indigenous technological practices, for example, motor and pestle to crush. Some particles to become	As we are in the cultural diversity in our country, we can source for more Indigenous technological practices from different tribes to enrich the teaching of Indigenous technologies in the schools. Me: So you are saying that due to our multicultural set up in our schools, it will be wise to consider, include or to be more inclusive to different tribes? Nelago: Yes, so there will be no left out and that should be all covered.	also open up discussions between the teachers and the learners that can lead to better understandings. The learners are able to share their own opinions; participation is also enhanced. Such integration can also create an opportunity for the teachers and the learners to do practical activities in the classroom.	teachers and the learners can learn more about our diverse culture. The other benefit is once interest in subject is there, then we can produce more academics in that specific field. The other things are that such integration may provide an opportunity to the learners to learn science concepts from different perspectives and relate them to Indigenous technologic	bring some materials from home as they may readily available. Learners may develop curious mind, learn more, make the learning more fun. Me: If I may follow up on that, in terms of teaching what do you think as possible benefits perhaps? Happiness: It will be beneficially in sense that we will access to learning materials from Indigenous expects, it may also create an

	communities. That was number one, number two: It will help the learners to improve their performance because they learn through what they know to bridge from what they know to what they do not know. Bridging will be easier to them because they are learning and building from what they know to what they do not know. If they are learning in this way this can help to improve their reasoning capacity and develop some new	smaller, learners will be able to see it and link it to what they do at home like pounding Mahangu but they didn't know what they were crushing particles to become smaller, but rather just thinking of coming up with flow. When this home practice is brought to the classroom context they will not forget even to have and how to use that apparatus because they are familiar with it from their home. So the benefit here is simply to make the work easier for the learners,			al practices as well as to other subjects. Me: Very good, I may say that there are some benefits in such integration. Brave: Yes there are a lot of them, the other benefit is that this may great employment once research is conducted, recommendation are considered by curriculum develops, there will be the need of Indigenous people to participate earn some money that can even improve their	opportunity to invite community experts to come and present certain practices to the teachers and the learners. So basically as the teachers you will find and make the learning much easier that can lead to "discovering learning".

	knowledge. This will be also similar to the teachers because of that bridging. Number three: Is to enrich availability of teaching and learning resources since I have already stated that most of the teaching and learning support materials that we use are mainly based on modern technology. I am saying that once we have integrated Indigenous Technological Practices in Science teaching, we will be able to make use	teachers and the country is well because the performance of the learners will improve because learning is made easier for them.			standard of living.	

	of available teaching and learning materials in our communities unlike modern technological teaching and learning support that are expensive and they are even lacking in some of our schools. Number four: Is the involvement of community that will create a good relationship between schools and the community. For example, teaching a lesson where you are going to present brewing or fermentation of alcohol					

	and then you call some of community members to come and make demonstration on how to brew, distil alcohol or even making "Odjove", community members may get excited demonstrating these things to the teachers and the learners. In this way a good relationship is created and these can improve our education. It will also improve the local knowledge and technology, what do I mean with this? The					

	more we use this more the local knowledge and technology will also become advanced. If you talk about “odjove” people in Europe or America they might be not knowing about this and how it is produced, but the moment we make use of local knowledge and expose it to the learners, we might have some scholars who will have interest in the field of Indigenous technological practices and do more research and					

	who knows we might improve our local Namibian industry that produce "Odjove" being bottled, being exported to other countries. This one will also improve because we will do more research, more knowledge will be shared and improve our curriculum by bringing in new things, challenges because the main issue is to solve problems.					

What do you think could be challenges of integration of indigenous technological practice in Science lessons?	Number one can be "ignorance". It will be quite hectic to convince the people to be involved local technological knowledge in Science teaching because at the moment most of the teachers that we have went through the teaching of Western culture which means that the syllabus has been implemented in Western cultures ever since. If know we try to implement or integrate Indigenous Technologica l Practices in Science	Ok, Challenges could be also being there, and the first one can be due to the fact that schools are in the different regions, with different tribes for example in Namibia we talk about Oshiwambo Culture, they use their own practices and they have their own ways of doing thing which may differ from other tribes. Let say the way on Oshiwambo-speaking prepare a porridge is differ from the way Caprivians, Damara-Nama are doing it and other tribe. You will find that some of	The first challenge is abo documentation these Indigenou technological practices due to our multicultura set up and this v require some to into deep rural areas for differe culture or those Indigenous peo and come with effective integration. The other thing coul be teachers who are not well trained and hav challenges to integrate as suc to the learners. Therefore, teachers need training to effectively integrate Indigenous technological practices I n multicultural se up school environment.	I think the challenge could be that for you to integrate Indigenous technological practices, one need to be exposed to it and guided professionally . It is also time consuming as one need more time like double lessons. But as for me the benefits will outway the Challenges and therefore we can just embrace this opportunity to integrate it. Me: Thank you apart from the challenges of time and guidance that you have raised is there any	The first challenge it will be costly for this integration to be effective because it will require a lot of research and money is need to travel to places where Indigenous people are situated. It will also require a lot of time to prepare, bringing in Indigenous people with certain expertise up the lesson presentation. Another challenge could be lack of participants due to the mentality of some people that Modern technology is more important than Indigenous	Challenges depends on environmen t and places. Sometimes like our schools are situated in urban areas and some learners may not know about certain practices. You might not find an expert to present a certain practice as the especially in towns. Perhaps materials might not be easily accessible at some places. Multicultural set up of the school might have some barrier as not all the

	teaching, we must know that some people may feel that we are going back to old things with simple technology rather the modern complex technology that speaks well to the Western or developed countries curriculum. Some teachers may ignore local knowledge. But if it is practiced more and more for teachers to be exposed more, they might open up and understand the significance of such integration,	the tribes like Oshiwambo tribe; they have a lot of practices of different practices. It will be little bit of challenging because they are a lot of different practices that practice in different area by different cultures. So it may happen or appear in a way that some learners are learning things that are a little bit different although they carry the same message. TE: So you are now referring to multi-cultured set up? Scientist: Yes, Exactly!!	Me: Ok. we are almost done and our last question is that what else would you like to share with me about integration of Indigenous technological practices that I have not asked you about? Nelago: I think I have said all but what I can add is that there is always a link between Indigenous knowledge and technology is only that we have not realised such link we should not deplete Indigenous resources at	others challenge that you can still think of? Panduleni: Time to prepare and maybe if we involve the learners to bring in materials they may not bring all of them.	technological practices. Me: Ok. Let us turn it in this way, let's say that you as an individual teaches if we integrate this in your chemistry lessons what challenge perhaps can you think of in your classroom? Brave: It will be a new approach to the learners and it should be integrated across the curriculum which means that it should start from lower grades up to higher grades, whereby learners need to learn through this integration	students are aware about certain practices. For example, some learners are from Okavango, Hardap, Ohangwena, Oshana, Otjozondjupa and may be it might be very difficult to learn, understand and adapt different culture.

	in sense that it is all about using our local Indigenous knowledge, be comfortable with it in teaching and learning. That was number one. Number two is about the resources which can be available but we may have the shortage in terms of physical and human resources. In other words, we need these resources to carry out experiments. For us to get a community member who can be able to perform or demonstrate to our	Because like you have mentioned here about the extraction of marula oil, this practice is mostly done by Oshiwambo people. Well it is a lot of culture, tribes like Ndonga, Kwambi, Kwaluudhi, Kwanyamas they are the majority but there are those who do not do such practices so the Oshiwambo learners that schooling the schools that are located in Oshiwambo Region will benefit more and understand better	the expenses technology and I think Indigenous resources should be used in a sustainable way, "One action does not negatively impact the life of many individuals and future generation".		but by what we call spiral curriculum. It might also be a challenge to some learners from a specific tribe may question or have a concern as to why practice from tribe A or B? Why not my tribe? Some learners may view it as discrimination which could be a barrier to effective learning.	

	learners. Some people even of our generation may not know even how to make "Odjove" and other cultural practices. Me: You mean by expertise may be lacking? Theoretical: Nowadays we became town people and we do not know some of the cultural and local Indigenous technological practices. We feel that we are more advance now, we are in the new era and it may be a challenge to get this	because that practices are more familiar to them, meaning those teachers are good in explaining and integrating such practices in chemistry lessons. Me: Meaning that those learners who's their tribe are cultural practice are integrated, they can benefit? Scientist: Yes, they can benefit more because they can understand so fast, so quick, so easily but the others for examples, I				

	expertise especially in urban areas. Like I have said earlier, some people also just got used to Western or American culture that is highly influenced our education Science, Technology, Engineering and Mathematics. They got this comfortability and not used anymore to the practices of their culture for example, this practices that we do like "Oshikundu", "Ombike". Some people today are no more interested in Indigenous technological	am Oshiwambo and I know how marula is extracted, so when I explain that topic to the learners, I can explain it 100% and someone who is teaching in Zambezi Region for example invite me to go explain that topic, I may still explain it very well but to those learners that are not Oshiwambo-speaking, they may struggle to understand because they are not Familiar with the practice. But I am not saying that only those				

	practices, feeling that those things are for low classes with simple technology, they may not even feel comfortable with integration of Indigenous Technological Practices in Science teaching. The other thing is time, just for you set up to integrate and try to fit in the lesson of 45 minutes. For example, when integrating "Oshikundu" to teach the processes involved it may take more time as you cannot prepare "Oshikundu	who are Oshiwambo learners will benefit because another practices are also well done in Okavango or Zambezi Region, meaning that those learners may understand it better than other tribes. So this type of indigenous technological practice is beneficial and the benefits are more than challenges because the learners can adapt and get used to any practice that can be integrated. Teachers and learners can				

	and get the results the same day, is like you prepare, let say today and you came back again the next day, observe what happened, report back and all these need enough time and also the time for expertise person to come to the school and present these to the learners may be also challenging. Those are some of the challenges that I think but also lack of finances, maybe some of this expertise people may need to be paid or	also learn the cultural practices of others tribe. In general, it is kind of balanced, challenging but the teachers to be kind of innovative when it comes to such integration.Me: If I may follow up on your response to this question, apart from multicultural challenges, what are other challenges that you may think of? Scientist: The other challenges that I may think of is on the side of the teachers themselves, because some of the teachers can be in the area where a lot of things				

	funded to share their expertise. The other challenges could be also about developing new concepts such as Indigenous technological practices it might be a challenge to us to come up with the concepts that are well understood even though that should be done for us to involve locally expertise in our areas.	are practice that will linked to the subject content but some teachers might not have an idea on how to bring in to the classroom context or teaching and learning. It might be difficult also like teachers may know and understand certain practices but thinking it to the learning context may be difficult. Me:So you mean the practices may be available in the local community but the innovations to bring it into the classroom is lacking, is that what you mean?				

		Scientist: Exactly, and I also trying to saying that, something need to be planned, Maybe teachers need to be workshopped, to be taught because even if you know something you might not know how to bring it in different environment. You see just like our parents at home they know how to do things culturally and when they know Science but you know you cannot go and take a parent home to come and teach Science at school who is not a teacher. Some				

		teachers they may know those things but I think they need help on how they should may link it to the teaching and learning, how they should design to be in line with experiments and how they will may be linked those steps that are done at home in to syllabus experimental techniques because mostly when you do experiments using technology, at school we need also consider the components of learning. So the teachers need to be help inducted and				

		assisted on how to go about it. The same applied to the usage of modern technologies in teaching and learning, For example, a teacher can be trained on how to use a projector and how it works. Me: I picked something that teachers need to be workshopped, can u may be explain a bit on what types of workshops and who should provide those workshops? Scientist: You know as teachers when we teach we use a curriculum that is developed				

		and somehow that emphasise the use of local knowledge, integration of local knowledge not only technology but local knowledge. Perhaps curriculum developers, subject advisors may be to organise something like a workshop that base on integration of indigenous technological practice and teaching and learning. This may help teachers to have a clue on how to link indigenous practices to the learning competencies, objectives				

		and experimental techniques. Me: I got it, and you have shared some wonderful challenges that I think. Scientist: That was the biggest challenge.				
What else would you like to share with me regarding the integration of Indigenous technology Practices in chemistry that I have not asked you already about?	What I would like to share with you in this regard could be in terms of chemistry teachers. I think this has to do with integration of Indigenous technological practices. During my year of teaching, I have never heard about	I feel like this Indigenous technological practices is good thing and I would like to suggest that I see a need of not only to integrate in chemistry alone but also in other subject like physics where learners are learning about telescope	I think I have said all but what I can add is that there is always a link between Indigenous knowledge and technology is only that we have not realised such link we should not deplete Indigenous resources at the expenses technology	I am just interested to know what is at that I am going to learn from the study that would help me to integrate Indigenous technological practices.	ould like to conclude that indigenous technological practice is a good approach to teach science concepts and hence I would like to encourage more research to be carried out Promote integration of Indigenous technological practices, produce	Integration of Indigenous technological practices will be for a greater help to our learners and teachers of integrated in Science lesson and curriculum. Most of our studies are just based on Western ideology but if we research more about what we have, it may

	Indigenous technological practices mentioned in our curriculum and I would like to encourage and motivate my fellow teachers to integrate Indigenous technological practices in their teaching, use local languages to clarify concepts, and improvise by using Indigenous technology, to make our teaching interesting across all the grades. Finally, I would like to say I am very much interested in your research and I would	work, how a cathode may oscilloscope works and these things are the things people use at hospitals industries and there are also those now are not modern and at home they use local ladder, lifter and other things, so I think such integration should be also introduce to other subject apart from chemistry. I also think integration of Indi genous technological practices should be shared and discuss with curriculum developers of different	and I think Indigenous resources should be used in a sustainable way, "One action does not negatively impact the life of many individuals and future generation" is my great pleasure to be part of this research and I am looking forward for a positive result and I hope this research will capacitate me to improve many teaching practices to create a "Wow" moments for my learners.		more local products to benefit Education Sectors and the whole nation at large. These type of integration should be part of our own academician. I think that is all. TF: I would like to thank you as well and I have learnt a lot from this interview.	improve our education Science, Technology, Engineering and Mathematics and keep our learners, not far from where they came from and that is their backgrounds, and cultural norms. This study can keep us close to our roots rather than just depending and focusing on Western ideas. We have a lot that we can work on research and solve on problems. For example, we have more technological in our local plants that we

	like to suggest that perhaps different platforms can be created by people such as you, Education Officers to set up subject research groups to enlighten teachers on improving teaching strategies through practices like Indigenous technologies. We also need to think about these Indigenous technological practices to be used as illustration and example in our Namibian textbooks to help learners to understand better. Findings of	subjects and I am giving emphasise on assisting teachers to effectively bringing it into the classroom conducts. If assistance is not given to the teachers, integration may disadvantage teachers, learners and the country at large. In Namibia there so many schools that are not having science laboratories, and hands-on practical activities are not done, teachers do not know what to do fermentation for example, the elders are				can use to treat certain alignments.

	such researches should be shared with all the teachers in the region.	just there at home with the knowledge that is relevant to schools Sciences. Like I have said earlier, perhaps it should start from curriculum developers, subjects advisors, teachers, parents and down up to the learners. Parents can also play their role to do demonstrations, presentation at school and share their knowledge with schools.				

Appendix H: Analytical Framework Concerning the Research Question and Data Gathering Tools

Phases	Research Question Focus Area	Gathering Tools	Analytical Framework
Phase 1: **Mirror data generation**	**RQ1:** Pedagogical insights, towards integration of Indigenous technological practices to surface the contradictions embedded in these pedagogical insights.	Semi-structured and interviews	Mavhunga and Rollnick (2013) PCK/TSPCK components; Curriculum saliency, what is difficult to understand? (Inductive)
Phase 2: **Intervention for Capacity Building and Expansive learning (through series of change laboratory workshops)**	**RQ2**: By co-analysing the curriculum documents to surface the contradictions regarding the integration of indigenous practices embedded in the curriculum documents.	Change laboratory workshop discussions and Document analysis	Engeström (1987) CHAT Activity System; 2nd and 3rd generation triangle diagrams, CHAT components and principles in relation to 3rd generation of CHAT across three Activity Science, Technology, Engineering and Mathematicss; *Teaching AS; Cultural & Community AS*; *professional learning community AS.* (Abduction)
	RQ3: Creating opportunities to be cultural knowledge brokers by involving and exposing them to the practical demonstrations on traditional marula oil extraction by the Indigenous knowledge custodians.	Participatory observation and reflections	
Phase 3: Intervention	**QR4:** Expansive learning rather than how the exemplar lessons looked like. **QR5:** Enactment (PCK/TSPCK) and reflections on the exemplar lessons that were co-developed.	Observation and reflections	Mavhunga and Rollnick (2013) TSPCK components; Curriculum Saliency, Representation and Conceptual Teaching Strategies. It also may enable me to look at the data in the broader/collective picture of teachers' professional competencies in terms of planning and classroom enactment.

			(Abduction)

Ok – I can

Appendix I: TSPCK components for transformation of knowledge (adapted from Mavhunga et al., 2016, pp. 312-313)

Component	**Description**	**Relevancy to my study**
Learners'prior knowledge	Learners' exist knowledge from their previous grades and home background situations, everyday experiences and misconception. Teachers' understanding of the common misconceptions and recommend strategies to confront misconceptions	Assist teachers through CPD and professional learning communities to come up with teaching strategies that acknowledge learners' prior knowledge and correct their misconceptions. In this case teachers I will find out understand and misconception based on Indigenous Technological Practices of marula oil extraction
Curriculum saliency	Identification the bigger ideas and corresponding subordinate in a topic based on sequencing and scaffolding. It has to do with teachers' ability to understand the key ideas of concepts and arrange them in an effective sequence that can be presented to the learners.	Study findings and recommendations to be considered and inform curriculum designers and developers on possible Indigenous technological practices inclusion in science teaching.
Why it is easy or difficult to understand	Specific problematic topics/concepts within particular subject. Teacher's knowledge of the gate-keeping concepts which are difficult to understand but not necessarily to misconception	Teachers to develop competencies on how to handle challenging concepts and apply their TSPCK
Knowledge of representation	Strategies (demonstrations & presentation of community experts, tools; (odjove) that the teacher can use to re-organise subject matters and make it more understandable to the learners.	Develop best teaching & learning strategies as well as teaching and learning support materials for specific concepts.
Conceptual teaching strategies	Special consideration of above four components and other techniques to make subject matters more accessible to the learners. Effective and specific teaching strategies rather than general pedagogy and logistics. Based om my study the professional learning community will have a presentation of a	Develop and expand teaching methodologies.

	community member as a teaching and learning strategies.	

Appendix J1: Change Laboratory Workshop 1

Orientation Narrative

Date: 24 March 2022

Duration 1:24 minutes

Research Question: *What are grade 11 chemistry teachers' pedagogical insights and contradictions towards the integration of Indigenous Technological Practices in science teaching?*

First of all, I would like to thank each and every one and all of us to avail ourselves to participate in this study and to work together. I do understand that it is not easy because all of us are very much engaged but at least for now we have decided to take part in this study. As for today, we are going to have our first session which is "orientation workshop" and I am going to take you through all the processes and procedures that regards to this research. One first thing that I would like to share with is that there is no way we can take part in the research that we do not understand very well. In other words, we need to understand what our research is all about.

Looking at our first slide the title of our research is Exploring the impart of integrating Indigenous Technological Practices in the Namibian Secondary Science teaching: Pedagogical Insights and Expansive Learning Prospects". By saying pedagogical insight, I am referring to the types of professional knowledge that we apply for example Pedagogical Knowledge, Content Knowledge and Pedagogical Content Knowledge. Expansive learning prospectus, I am referring to new ways of developing better teaching strategies because we are all learning and every time we are learning and we are likely to develop expansive learning space. In this way we can improve and learn new ways of doing things.

So in our research we do have a professional learning community which is made up of seven members. we have those that are here. We also have some community experts that in this study are regarded as more knowledgeable others (MKOs). As we are here in our professional learning community, I hope we are going to learn from one another and there is no one is limited to learn. Even more knowledgeable others that can also learn from others. Before we continue there are ice breakers that I would like to share with you. These are some of the life quotes that motivate and influence me to do my everyday work. They are all about our aspiration, our philosophy, our practices as well as our advancement in terms of our professional growth.

- The very first one said:
  "Alone we do little, together we do much" By Helen Keller, (27/06/1880-01/06/1968)
  This lady was an American author, who used to advocate for disabled people, a political activist and lecturer. She lost her sight & hearing at the age of 19 months due to illness. One thing that was more special to her was that she could not see neither hear. This quote inspired me a lot because it advocates for <u>team work.</u> Reflecting to our research here, I cannot do this research alone and thus why I need you as a team to work together.

- "You can do what I cannot do, but I do what you cannot do, together we can do greater things" by Mother Theresa (26/08/1910-05/09/1997).
  Mother Theresa was an Albanian-Indian Roman Catholic nun & missionary who was dedicated in charity to feed, take care and educate the poorest of poor which she even got an International Nobel Awards. To me this means that all of us we have some strengths and weaknesses as well and it inspired me in sense that <u>collaboration</u> is very important and there is no way one can do all the things for herself/himself.

- "Do what you can with what you have where you are by" Theodore Rosevelt, (27/10/1958-06/01/1919). He was an American politician, historian, writes and serves the youngest president of USA in 1901-1909. This quote inspires me in a way that even if there are challenges such as financial implication/crisis and others at least we can do something with what we have where we are. To me this calls for Efficiency, Effectiveness and Contextualisation. For example, where we are or in our context there are certain things that the government can do and yet there are also things in our own capacity that can do to improve our teaching practices. Looking at the title that the President has given to this year 2022 I am drawing from the few concepts that were strengthened and that is "Rethinking", "Renewing"

- "If you always do what you have always done, you will always get what you have always got" By Hemry Ford (30/07/1863-07/04/1947). He was an American Industrialist, Tycon and Founder for Multinational company called Ford Motors and the developers for mass production plant of cars. This is very simple in sense that if you always do things the same way you will get the same results. But if we want to get different results we have to change the strategies. this inspired me that in our practices there is always a room of improvement, innovation, new strategies and new approaches.

These were just some ice breakers that I have shared with you and I hope it inspired somebody here.

Now let us go to the real issue now and that is the research, context, whereby I just tried to pick some points in our broad or National Curriculum of 2016 which advocates for integration of technologies in education to contribute towards knowledge-based society. A knowledge-based society is where knowledge is created and used to improve the people standard of living, so technology is one of the critical aspect that affects quality teaching and learning. Alright, let me share with you some copies for our National Curriculum and grade 11 chemistry syllabus that I have here.

So we are saying, those two documents that I gave you now is our national curriculum (2016) and grade 11 chemistry syllabus. If we look at page 10-14 of our National Curriculum technology is regarded as one of the key learning areas among others like National Sciences, Mathematics and so on. When I saw this, I realised that, we do not talk about it a lot but the fact will always remain that it is a critical aspect of teaching and learning. By critically looking at our National Curriculum, there is no clarity and guidance on possible Indigenous technological practices that can be integrated in teaching, but instead the technology that is integrated in science teaching seems to be dominated by modernised technologies.
The other thing is that there is inadequate and in consistency in counting professional Development (CPD) Programmes for Science teachers are not always aligned to teacher's needs.

In 2011 UNCEF carried out a research for improving quality and equality in the Namibian education, which has revealed that there is the need for improvement in the Namibian teaching as majority of the teachers seem to struggle to use the local examples that would relate the everyday life of the leaners although teachers are expected to contextualise scientific knowledge within their local context.

Some scholars such as Mawere (2011), Seehawer (2018) Semali and Kincheloe (1999) observed and raised their concern that our Indigenous technological ways of knowing seems not to be recognised by our teachers. Hence technology that is integrated in science teaching is modernised. This means that Indigenous technologies in Africa offers interesting possibilities for including alternative forms of cultural activities into teaching and learning practices.

Now let us move to the fourth component which is the grade 10-11 chemistry syllabus. So we will look at the rationale and aims of such syllabus. In other words, what is the purpose of teaching and learning such subjects? According to grade 10-11 chemistry syllabus, the rationale is to promote the learners understanding of physical and biological world around them in terms of local, regional and international level. This means that learners need to acquire skills such as critical thinking, investigating phenomena, experimental & investigating skills in relation to application to daily life. To achieve this technology is needed. Theoretical and practical science aspects to help the learners to acquire abilities and skills that are useful in everyday life and relevant to the study of chemistry. In addition, our science syllabus emphasis the notion of "prior learning progression" which advocates that effective teaching must involve, build on the learners' prior knowledge. Our point from here is to teach our learners to get quality symbols from Namibia Senior Secondary Certificate Ordinary to NSSCAS or to any other opportunities. All these support our research that technology is needed in teaching and learning.

Let us move to the next component which is the: Statement of the problem. So here we are going to look at challenges and problems with our education system specifically in profession development in relation to technological world that prompted this study to be carried out. There are three problems that prompted me to carry out this study. *First problem* is that I observed that there is adequate continuing professional development Programmes for science for science teachers. This is mainly influenced by modernised or in other words Eurocentric technologies which exclude Indigenous Afrocentric technological ways of knowing in science. This means that trainings are few or less and the technologies that is used is just modern for example information communication technology or modern science apparatus or equipment. Our Indigenous technological ways of knowing are not excluded.

The *second problem* is that our National Curriculum for 2016 encourages integration of technology but it does not explicit guide or support teachers on how to implement this. Teachers need support on technology integration. This is what we would like to address with this research.

The *third problem* is that; the way we were trained from the higher learning institutions, inhibits innovation in teaching and learning. This means that teachers were taught or trained in a way to think that technology is all about information technology (IT), digitalisation and the use of any others modern devices to make life easier. With this research we are challenging Perspective of technology.

Shall we proceed to the next component? or perhaps there is a question or any contribution?
Theoretical, Scientist, Nelago, Panduleni: we can proceed.

Me: Alright let us move on and talk about aims and objectives of this study. Our research goal is to explore how to integrate Indigenous Technological Practices of Marula oil extraction in grade 11 chemistry teaching. In order to achieve this goal the following research question will be addressed.

What are grade 11 chemistry teachers' pedagogical insights and contradictions towards the integration of Indigenous Technological Practices in science teaching?

What contradictions regarding the integration of indigenous practices surfaced when grade 11 chemistry teachers co-analysed the curriculum documents and textbooks?

How do the practical demonstrations on traditional marula oil extraction by the Indigenous Knowledge Custodians enable and/or constrain the grade 11 chemistry teachers to become cultural knowledge brokers?
What expansive learning opportunities are created (or not) when the grade 11 chemistry co-developed exemplar lessons that integrate traditional marula oil extraction and other Indigenous technological practices?
How do grade 11 chemistry teachers enact and reflect on the exemplar lessons that integrate traditional marula oil extraction and other Indigenous technological practices in their classrooms?

Now let us move to the next component which the Research Focus and Processes. Our research focus is: Intervention, expansive and transformative case study that is looking at integrating Indigenous technological practices in grade 11 chemistry lessons which is looking at:

a) Tapping from the community cultural heritage expertise of Indigenous technologies through collaboration and community participation to form what we call "community of practices" or "professional learning community"
b) Community technological expertise will be used in this research to support teaching and learning, broaden and expand training or workshops through professional learning communities
c) Six grade11 chemistry teachers and myself will be learning Indigenous technological experimental technigues for marula oil extraction and relate it to topics/concepts such as fractional distillation of oil, separation of mixtures in grade 11 chemistry syllabus page8. We are going to learn these from the

community experts in order to improve our teaching practices and see how best we can integrate Indigenous technologies in our teaching.

Our research will be conducted in four phases and this will determine how the research process will unfold and which data collection methods will be used. Our research will be conducted in the following four phases:
Phase one: Is called *Mirror Data Generation* whereby semi-structured interview will be conducted. This is what we have done already through telephonically interview sessions.

Phase two: Is called *Intervention for Capacity Building and Expansive learning (through series of five change laboratory workshops).* There will be session whereby we will analyse curriculum documents and textbooks. This will be our next session. From there we will another workshop whereby Indigenous Knowledge Custodians from the community will conduct a practical demonstration and teach us how to extract marula oil. On the last workshop we are going to co-develop and teach exemplar lessons whereby classrooms observation, stimulated recall interviews and reflections will be made.

Phase three: Is called *Intervention* and we are going to teach and reflect on exemplar lessons

We move on to the Significance of the study whereby I am going to explain as to why this study is important and what it brings or benefit you as participant, our directorate and our education systems at large.

a) Indigenous technological practices has a potential value to contribute to science teaching to see whether professional learning communities can expand or constraints such integration. It will explore Indigenous technologies of food production and presentation and determine its role in science education.
b) It might provide an opportunity for innovation in teaching and modernisation of traditional technology which may lead to technological Advancement.
c) Indigenised curriculum and Afrocentric approached to science will be promoted.
d) The study may improve technical skills on how to conduct workshops for teachers with community participation.
e) It may capacitate teachers on how to develop Teaching and learning Support Materials grounded on Indigenous technological practices.
f) The study may inform the curriculum developers, implementers and textbook writers ad researchers to explore more in Indigenous technologies and integration if science teaching.

Perhaps I can end here for all of us to come and share together the research expectation. What do you expect from this research? Ok, is there anything to clarify ask or contribute?

Theoretical: Before expectations I would like to ask.

Me: Yes, Sir you can ask.

TA: Please let us go back to the first slide with the research little. When I look at the little it says, exploring the impact of Indigenous technological practices integration in Namibian Secondary Science teaching. The title looks general but here we talk about marula oil extraction.

Theoretical: Yes, the title looks general but because there are many Indigenous technological practices but our research with focus is on Indigenous technological practices of “Odjove” or marula oil although there are many of other practices such as “Oshikundu”, Ombike and so on.

Panduleni: Let me also come in, I think what I am seeing is that Indigenous technological practices, which is Indigenous technological practices, while we only know information communication technology which is modern while Indigenous Technological Practices is Indigenous. This brings me to realise that our Indigenous practice has what we consider as technologies.

Me: Oh! yes, yes.

Panduleni: So the use of "Omushi" that we use for Odjove is technology my making of "oshiyuma" is also technology and also the way for preparing "Oshikundu is also technology.

Me: Yes, and I think there are many technological practices within our communities.

Information Communication Technology

Scientist: For me I have learnt that Indigenous Technological Practices is Indigenous and information communication technology is modern but is more on information and digitalisation, but where do we put this other forms of technology that is not digitalised or indigenised? When we are pounding Mahangu sometimes we use machine is this INDIGENOUS TECHNOLOGICAL PRACTICE or information communication technology?

Me: Let us go back to our statement of problem and look at problem number 2, which talks about our perspective of technology due to the way we were trained. We were not trained in such a way to think that technology can be either modern or Indigenous. This also contributes to the reasons why we are not innovative in our teaching.

Theoretical: I would like to talk about Afrocentric curriculum in sense that our African technological ways of knowing are not recognised. But we have a lot Indigenous technological practices that can be integrated in Science teaching.

Me: Alright, in this research we are not saying that modern technological practices are not good but we want to use it in education complementary with Indigenous technological practices. One interesting thing is that we can use modern technology to enhance Indigenous technologies in Science teaching. What if we go out in our local communities observe and capture certain indigenous practices and use them in the classroom. The two technologies can both work effectively.

Theoretical: I think when our country got independence, things changed. We ignored traditional education and focus only on modern education, but now we have realised that we ignored out things and run to other people culture. This is the reason why our learners are struggling in Science Subjects because we always refer to and use foreign examples that our learners are not familiar with.

Panduleni: Now I do understand why is always a challenge to explain certain concepts to the learners but they do not understand exactly what are you saying.

Me: I picked something when you raised your concern. Let me give you an example someone who is taught about lions that they have not seen or even seen a forest. Do you thing they will really understand what is a lion: Is the same with us, things are there in our communities and what if we make use of what we have and see if it can make our Science teaching interesting?

Scientist: I want to ask; at the beginning you have indicated that our research will explore the impact of integrating Indigenous Technological Practices in Science teaching specifically to marula oil extraction. Now to which curriculum competencies do this linked to? I am trying to see how it is impacting chemistry teaching

Me: Very good, thus why we have the next session of document analysis. For example I have already linked the Indigenous Technological Practices of marula oil to experimental techniques which is also a topic and the skills in grade 11 chemistry syllabus. One may teach this as a theory or practical's. I think there are many skills and topic that we came up with one we analyses curriculum documents in the next sessions.

Scientist: It looks interesting and I think there are so many things like during the marula oil extraction people put hot water that has to with increasing the temperature as well as the rates of reaction. I can see there are a lot of scientific processes involved in this practice of marula oil.

Me: Yes, that is why there is a workshop session as we will go in the community to observe, trained and interact with the community member who is an expert on Indigenous technological practices. So for now let us wait for the workshop and what will emerge, but we need to go with our critical mind in sense that what will happen, how it happens and how we can relate to our chemistry concepts. The other thing is how am I going to help my learners, making them aware that what they have or do at home with their parents is also relevant in their science classrooms.

Nelago: Very interesting and I think we are going to learnt a lot from community expert.
Me: One more last component: Research expectations. What do we expect from this research? Throughout our research activities you will always reflect and see whether your expectations are met or not.

Theoretical: Perhaps I can say that my expectation is to be able use the local readily materials or Indigenous materials to integrate in our teaching.

Scientist: And also to add, we expect to be able to identify different types of Indigenous technological practices in our local communities.

Theoretical: Development of new concepts

Me: What do you mean by that?

Theoretical: I expect that during study, we may come up with some new concepts that we were not aware about.

Panduleni: I am looking forward to unpack this Indigenous technological practices, how it will uniform my teaching and how expansive learning will take place. Expansive learning is the concept that I picked from the title of this research which is quite interesting to me and I would like to learn how it happens.
Scientist: While we are there, the other expectation is to learn some better ways of getting, bringing in or involving the knowledgeable others, community members into education.
Nelago: In just want to say that this marula oil extraction is Oshiwambo culture, what about other culture? Will it not only benefit Oshiwambo-speaking learners? How can we include other tribes? I will really appreciate if we can also learn from other culture.

Panduleni: I agree with you TC, but I would also like us to explore on some other Indigenous ways of extraction of oil such as "omagadhi goongombe"
Me: Yes, I agree with all what you have raised that we need to explore variety of Indigenous technological practices from different tribes. This marula oil is just a model of many Indigenous technological practices that are out there. If we are trained, we are free to go out there in our communities and explore more, we are not limited to one tribe or culture at all. Alright, we got some quite good number of expectations and I think for now we can just do some reflections. How do you want us to reflect? Should we do it once we are done with everything or what do you think?

Nelago: I think we can do it on daily basis, otherwise we will forget some of the things.

Panduleni: For me the most salient aspect is that I have learnt the difference between Indigenous Technological Practices and Information Communication Technology, That Indigenous Technological Practices is Indigenous while ITC is modern and that information communication technology can be used to enhance Indigenous technological practices, like pictures of Indigenous technological practices, like taking pictures of Indigenous technological practices use it in the classroom through video or presentation.

Nelago: Can I also reflect?
Me: Yes, you can.

Nelago: As for me, the most salient aspect for me was that when we talk about technology, the thing was that always come in my mind was equipment that we can use to share information such as computers, cameras and others. But today, I have learnt to differentiate technologies and that technology has not only to do with computers, Cameras and devices. I have leant that some of the indigenous practices in our communities are also technologies and that is all I have internalised today.

Theoretical: But for me I also have learnt something completely new. I was just familiar with IK, pure IK which is Indigenous knowledge, so the concept of Indigenous technological practices was new to me and I have never heard about it before. Making odjove, ombike and others I have been aware about, but I did not think about them in the way of technology. My understanding of these cultural practices was that they are just Indigenous knowledge of making oil, ombike and oshikundu. But then to link these practices technologies was completely out of my mind. But when I attended this workshop, and it is something interesting that I have learnt today, understand, assimilate and accommodate it. It is a new knowledge for me and I am excited about it.

Me: Interesting about new knowledge, and it should be there in terms of conceptual framework, perspectives as well as in many other ways.

Scientist: My reflection is just to say that some of the things that are happening in our immediate environment but to apply that and indigenise our syllabus is the challenge to us teachers. This is perhaps syllabus itself did not even mention about these things. Of course I am aware about oil extraction, odjove but to apply it to teach some of the science concepts, it has been a challenge and I hope this research will capacitate me to be able to integrate Indigenous technological practices in my teaching, I also learnt a new perspective of technology as today but in the past our forefathers have been always involved in simple and intermediate technologies to make their lives easier.

Nelago: I just want to add that to what Theoretical has said, "the use of technology limits our us to think" because, imagine we were only use to talk of only Indigenous knowledge, then we were only used to the concept of Indigenous knowledge, IK but we could not think of practices and technology. My old perspective of IK was just a knowledge but today I have learnt that IK could be also technology.

Me: Alright, from my side, my reflection is that all those quotes that I have shared with you earlier today, were manifested here. I also acknowledged that this research needs involvement of others, further consultations, community experts, different practices from different tribes. I do appreciate the contributions for the camera man who is assisting us to capture the whole session for us. At this note I just want to thank each and every one for this first session.

Scientist: Thank you it was really fruitful

Appendix J2: Change Laboratory Workshop 2

Document Analysis Narrative

Date: 11 April 2022
Duration 1:45 minutes

Research Question:

What contradictions regarding the integration of indigenous practices surfaced when grade 11 chemistry teachers co-analysed the curriculum documents and textbooks?

Me: Good Afternoon colleagues and how are we doing? Welcome to our second session which is our document analysis. Our previous session was based on orientation, and I hope it went well. Perhaps we can do a little bit to reflect on our previous session on how it went, and so on. Who is willing to start reflecting?

Theoretical: Let me start, we looked at the research little which focuses on technological practice of marula oil extraction. We also looked at our prior knowledge of the learners that is connected to Indigenous technological practices in our local communities and it is connected to the teaching of Science in our schools.

Me: Alright, thank you, Sir. Next

Nelago: I think we also got to really familiarise ourselves with the goal of the research, research plan, internalise to research topic and iron out all the misunderstanding that I had towards the research topic.

Panduleni: I was introduced to the concept of *expansive learning*, we also looked at the difference between Indigenous Technological Practices and Information communication Technology.

Me: Alright for today we going to look at analysis of some curriculum documents that we have, for example, our national curriculum, looking what it is says in relation to what we are researching. If we look at page 10 of our national curriculum there are learning key areas of which technology is indicated as one of the key learning areas. Let us look in this document and try to make sense of what is said in relation to what we are researching.

Theoretical: As for me I can see from the National Curriculum that there are two types of technologies which are Information and Communication Technology and Material Technology, which mean that technology is categorised into two groups.

Me: Yes, it is indicated as such.

Panduleni: This is interesting, as I did not expect this, so material is also a technology

Nelago: Me too, I did not expect material to be referred as a technology but on the other side having things or materials like computers is a technology. I am just surprised when I look at these key learning areas, why is the Science not there? Like physics, chemistry and biology?

Theoretical: I think those subject that you have mentioned will fall under the key areas of Natural Sciences and Material Technology when key design things.

Nelago: I am getting it now, but still when we talk about material technology what exactly are we talking about?

Theoretical: The National Curriculum made it clear here on page 10 that material technology is the study for making a product(s) by a process of transformation by the use of tools and this can be done in subjects such as physics, Design and Technology where the learners can have some raw materials, use certain tools and come up with certain products.

Panduleni: Science is covered in almost all the key learning areas mentioned in the National Curriculum.

Scientist: Exactly, is only that it is not explicit shown.

Me: Now it seems that all of us here have seen and agreed that technology is one of our key learning area, and from the previous session which was an orientation we have also indicated that technology should be regarded as critical aspect of teaching and learning. Can we look at what type of technology that we can relate to our Indigenous technological practices? Perhaps we can analyse and find out what is it that our National Curriculum says in relation to our Indigenous technological practices or Indigenous knowledge?

Theoretical: As for me I think that we can relate and link our Indigenous technological practices to material technology that is indicated in our National Curriculum. This is because when we talk about example of marula oil extraction we use material like marula seeds to produce oil, there are processes we follow and that are giving information as to how, when, and why certain things are done in that specific ways.

TE: So we are saying Indigenous technological practices are based on material technology with some elements of information communication technology?

Theoretical: Let come in with information communication technology which stands for information communication technology, I want to ask, is it refer to information itself or devices for information? Is it also regarded to specific persons who process and passes information to the next person or device that can process information?

Me: Let me classify on what our National Curriculum says about information communication technology, Our page 12 on the last paragraph. Could you please read Mr Theoretical?

Theoretical: The term information communication technology comprises of all technology in media used for management of information which indicates finding, evaluating, processing and presenting information. So my point is that if I can extract marula oil, I am generating the information, that I can explain to the learners and share it with them again. Which means that I am passing information at the same time and using materials.

Scientist: From what I am hearing it seems like material technology can also be information communication technology at the same time.

Theoretical: Exactly!

Panduleni: The way I am getting this is that we cannot teach without technology whether it's Information Communication Technology, Indigenous technological practices or material technology we always find examples to make learners understand and those examples are done using materials from environment, right!! Now if we use those materials to teach our learners and I maintain my point that "we cannot teach without technology" it is just always part of teaching in terms of information, materials or Indigenous technological practices. When we teach concepts like distillation, filtration and others we always refer to material technology, things that we have in class like condenser, Indigenous technological practices within our community or ICT.

Me: Yes, thus why from our previous session we have indicated that technology is a critical aspect of teaching and learning. The fact that we are getting here is that technology is one of our key learning areas; it can be either material or information communication technology. Is there anything else that we need to act or classify before we proceed?

Theoretical: Let us go to page 2 for our grade 11 chemistry syllabus, Ms Mika could you please read on the aims of grade 11 chemistry?

Me: Alright! The aim of chemistry grade 11 is that we want to "promote learners understanding of physical and biological world around them". It continues saying that advanced technology is needed in order to go about this. Perhaps we can take it up from here.

Theoretical: It is clearly stated on page 2, last paragraph that "this requires advanced technology and efficient use of equipment's and materials processes. Modern technology is required by the least to solve problems in the society to design realisation and evaluation of activities.

Theoretical: This is clearly indicated that the curriculum mainly focuses on modern and advanced technology to assist the learners to solve problems. But to us we can improvise and use Indigenous technological practices to assist the learners and solve problems.

Me: Perhaps we have to think in this line, how can we use Indigenous technological practices to assist learners and solve problems?

Panduleni: Let us go back to the aim of grade 11 chemistry syllabus, same page 13
There is a use of inventing innovations and improvise.

Theoretical: I am getting it, which is about what we have already in existence if we can apply it in our teaching, it may create an opportunity to the learners to advance to a better level in terms of academic performance,

Nelago: I think this speak well to aim of grade 11 chemistry syllabus bullet one point number one says: "become confidence in technological world" because you know when u bring a computer in classroom, not all the learners are very familiar with this modern technology. But if we bring in Indigenous technologies they know and familiar with from their home, they may feel much more comfortable with it and become confident in technological world.

Me: Alright, now we have analysed what is our National Curriculum and Grade 11 Chemistry curriculum is saying about technology. Can we now continue with analysis and come up with possible examples of Indigenous technological practices that can be integrated in grade 11 chemistry lessons and perhaps how can we effectively have integrated.

Theoretical: Let us go to page 16 of grade 11 chemistry syllabus, topic: "materials" Our Indigenous people use different types of materials in terms of their suitability of properties used, For example, metals and ceramics.

Me: So you are saying there is also technology of materials with our Indigenous technological practices?

Theoretical: Yes, another example is that there is Indigenous technology of using different materials for cooling down our drinks, construction and thatching of our rooms.

Panduleni: Interesting and in Science we talk about properties and suitability.

Me: So our first topic is: "Materials". Let us continue.

Theoretical: On page 25, we can also look at "preparation of salt" where concepts like purification are. I am sure we have some salt pans in our Indigenous communities as I know from our northern part of Namibia there are these pans when Indigenous technology of extracting salt is happening although some people claiming that such does not contain Iodine as an element. But when you look at the way they extract salt has a sophisticated technology as not everyone can extract, there are certain Indigenous experts who have the knowledge on how to extract salt for human consumption and animal consumption. When I was young I use to go with my uncle and that is how I got to know about this where I observed how people use certain material to extracts salt how to separate salt from the sand around other particles in order make it safe for human or animal consumption.

Scientist: As for me I see there is the topic of scientific processes where we can integrate Indigenous technological practices. This can cover a lot of technological indigenous Practices. According to syllabus requirement this topic has mathematic requirement whereby the leaners are expected to acquire skills of knowing numbers, addition subtraction, reciprocity, measurement, finding mean, averages, but there is so much that is happening within our Indigenous technology that can be linked to chemistry topics. You know some of the learners from their youngest ages, they know how to do some of the Indigenous work from home for example building which could be difficult if you do not have mathematic skills on how to dig foundation, measurement and all mathematic skills involved. To me all these are Indigenous technological practices within our environment. In other words, tribes like Oshiwambo, Okavango and others are specialised in Indigenous technology of building and extractions and I think this can be linked to scientific skills in grade 11 chemistry teachings. This is what I can refer to what we call "innovation". One cannot do all this without scientific skills such as mathematical requirement

Me: I got you very well you are saying that most of our Indigenous technological practices constitute scientific skills?

Scientist: Exactly, scientific skills are manifested in almost all indigenous practices and this can be taught throughout all the topics, we cannot teach it alone or separate but rather throughout the whole curriculum until it is done. Indigenous technologies are done Science, Technology, Engineering and Mathematicsatic which means that you cannot just do it anyhow, but you need to plan, being innovative to apply scientific skills.

Nelago: I want to talk about this *omagadhi goontanga* the oil that is extracted the seed s of water melons, whereby first they processed seeds and they later on produce oil. I think this Indigenous technology can be linked to the topic of "particle nature of matter" which is on page 9 specifically to the second bullet that says; describe the state of solid, liquid, gases and particles collision, arrangements and types of motion. We can start there; why do we have to pound the seeds it first?

Scientist: Perhaps for the reactions to go faster.

Nelago: You see another topic is also linked to chemical reactions and all these can be integrated in our science teaching. In the process of pounding the seeds, topics such as physical changes and chemical changes are also coming in.

Scientist: If we look at the whole process of making *omagaghi goontanga* extraction, we can link it to chemical reaction.

Me: So we are saying that page 2, 9 and 21 topics are all related to chemical reactions in relation to indigenous technological practice of making *omagadhi goontauga*?

Nelago : O yes,

Me: It seems like there are many topics in grade 11 chemistry that can be related to many different types of Indigenous technological practices in our local communities.

Theoretical: Yes, there are so many of them

And if we can look at page 27 the topic of metals, whereby we have indigenous technological practice of creating ornaments like knifes spears, hoes, etc.

Panduleni: Yes, we also have the traditional bracelets that we wear made from bronze, silvers, gold, etc. this means that Indigenous technological experts have a way to know that this is a metals, it is malleable that it can be cut into small pieces that can be joined together to create bracelets or necklaces, beads, using a threads. There is technology within all these.

Me: Interesting, and so far I noted that there are quite good numbers of topics in grade 11 chemistry syllabus that we can use to integrate Indigenous technological practices in our teaching much as;

- Types of materials
- Preparation salts
- Scientific processes in relation to construction of rooms, Mathematical requirements and Innovation
- Extraction of omagadhi goontanga
- Metals

Theoretical: Yes, they are a lot even if we go on page 29, the topic of *fractional distillation* of oil on page 34 the topic of *availability and purification of water in Namibia*. So the topic of *hydrocarbon, manufacturing of oil* can be also linked to extraction of "odjove" and omagadhi goontanga "In terms of water purification Indigenous technological practices can be coming in a way that in some areas there is hard water or salty whereby even if you use soap it may not work well. There is Indigenous Technological ways of purify water such as boiling, what else can be use to purify water by using Indigenous technological practices?

Scientist: They filter water with a sand to remove some of the particles of impurities and make it clearer or clean. They also use certain types of grass to filter the water as the water poured through these grass and remove impurities.

Panduleni: The same grass can be also used to filter fresh milk and Marula Juice.

Me: There is also indigenous technological practice of purify water by using wood ashes.

Scientist: How do we call that process of using wood ashes? I think it is *neutralisation*.

Me: Alright, can we proceed to the next part? Now that we can see that there are many Indigenous technological practices that we can integrate in our Science lessons. Now lets us talk marula oil extraction which is the focus for our research. Let us discuss, to which topic within grade 11 chemistry can we relate this? In other words, how can we integrate marula oil instruction in our Chemistry teaching?

Theoretical: I think we can go on page 29 where it talks about fractional distillation of oil, and refining oil.

Nelago: After finishing extracting oil we refine and purify it by means of boiling.

Me: What about the concepts food preservation? I am thinking of something that we need to do when we will visit the More Knowledgeable Ohers who is the Indigenous technological practices expert. We need to ask as to how she will do it and why doing certain things and then we relate it to our science concepts and scientific skills.

Nelago: I was also thinking what Ms. TB was talking about that when marula oil is extracted there is *hydrolysis* that is taken place.

Panduleni: What do you mean by that? Does that make sense when we are adding hot water or cold water on the process of oil extraction?

Scientist: Yes, we hydrolyses and I think the reason why they do that is just to make The reaction goes faster especially if the water is hot.

Nelago: Is it only water that can be used?

Panduleni: Can we not reserved all our questions related to marula oil extraction to the community expert when will she workshop us in the next session?

Me: I agree with you, Ms. Panduleni, we need to go and ask everything in next session. To which other topics can we relate this? What concepts or scientific skills that emerges from this Indigenous Technological Practices of Marula oil extraction?

Scientist: For me the topic of *fractional distillation of oil* coming in.
Nelago: So when we talk about this, I want to know if marula oil extraction will go under *hydrocarbons, organic, inorganic, alkanes or alkenes.*
Me: Something is also coming in my mind now, is Marula oil *saturated or unsaturated?*
Scientist: Can Marula oil catch fire? What about *activation energy*?
Me: I think we can test it and find out.
Theoretical: Let us go and ask the expert next week,
Me: What I see here is that there are a lot of questions that need answers from the community expert; we also need to prepare ourselves so that when we go there we pose some of the question to her. But I picked concepts such as *hydrolysis, purifying* and *refining*, also *physical and chemical changes, and change of states* from solid to liquid and to gases.
Panduleni: Also *reactants* and *products*.
Theoretical: Also *rates of reactions, factors that are affects the rates of reactions*.
Me: Lastly on page 8, the topic of *experimental techniques* which also part of our scientific processes. It says: outline the importance of purity for substances in our everyday life.

Panduleni: Wow! One thing that I learnt about chemistry is that its application is in almost everything that we do in our everyday life.

Me: Exactly, still on page 8 it continues saying that learners should be able to suggest suitable purification techniques given information about substances. What do you think about this? What topics or concepts that are emerging from this perhaps?

Scientist: But Ms. Mika there are also other competencies such as bullet 2, 3 and 4 concepts like *measurement, estimation,* etc.
Me: To what concepts can we relate this?
Nelago: Can we not come up with the concepts map and mind map?

Panduleni: Let us do it after the presentation of the community expert after observing and see the concepts that emerged in the whole process of extraction.

Me: I think it is okay that way because for now we have analysed, we came up with some topics that are related to Indigenous technological practices and the next item is for our community experts to give us a workshop and presentation f or demonstration for the whole process of extracting marula oil. Lastly we can just reflect a little bit just like what we have done for our previous sessions.

Theoretical: Let me start, most of objectives and competencies that we are teaching, in chemistry, the technology is available in our local communities is just that we were not aware about them. It is now our task to integrate Indigenous technological practices in our lessons instead of modern or machinery and scientific apparatus that is lacking in some of our schools.
Me: Thank you, next,
Nelago: For me the most salient aspect is that I got to learn that utensils that we use in our everyday activities at home are material technology and we can use these to drive and become innovative and contribute toward what our curriculum refers to as knowledge-based society, where knowledge is created, transformed and used for innovation to improve quality of lives and that for me it stands out because we cannot just be doing things in life for the sake of just doing them but at least to improve quality of life and academic performance of our learners.

Panduleni: Science is not taught just anyhow so we need to teach it *with consideration, innovation and integration*. In our previous session we taught about technology, for today it was about analysing our National curriculum, whereby I could not understand the concept of technology but today I have learnt that material could be also a form of technology and there is also aspect of media and information that bring about information communication technology When I look in our local environment there are a lot of materials that can be used to teach Science and that is the reason that I came with the statement that says: "*we cannot teach without technology"*. In fact I have learnt and conceptualised a lot from this document analysis.

Scientist: For me is almost like what TC has said that almost everything that we use in our environment starting from writing on the chalkboard, is all about technology but like what TD has said if you could not take part in analysis and discussion like this, you may not realise it. So I think everything is all about technology. I did my study for Master degree in easily accessible materials to teach Science but I did not know that we were doing technology through hands-on practical activities and experiments with my learners. When we looked through these documents I did not know that almost all the topics that we have in grade 11 chemistry are related to many Indigenous technological practices. I have learnt a lot around the concept of technology. Although we have all these documents I was unable on my own to know the types of technologies, so this was really an eye opener for me to know now that even things that we regard as simple could be technology.

Me: My reflection, I do not want to repeat all what was reflected as I agreed with it. I was not expecting us to have a longer list for Indigenous technological practices that we have in our local communities and they are related to skills, competencies and concepts that are taught in grade 11 chemistry lessons. In fact one can say that there a lot of themes, topics and concepts in chemistry that are related to Indigenous technological practices which shows that we can integrate it. I am still learning and I think there is a lot even with this marula oil extraction. I picked lot concepts although we are still going to come up with concept mind map after the next session with the community expert. Lastly is about the textbooks we could not go through because of time but let us do it as an activity for next week to see or analyses how local technological practices are cited by publishers like Living, Oxford, Solid, Namcol, etc.
Finally, I would like to thank each and every one for your time, attendance and contribution, Thank you very much to all of you. We are done for the today.
Theoretical, Nelago, Panduleni: You are welcome!!!!!!

Appendix J3: Change Laboratory Workshop 3

Indigenous Knowledge Custodians Presentation Narrative

Date: 29 April 2022
Duration 1:58 minutes

Research Question:

How do the practical demonstrations on traditional marula oil extraction by the Indigenous Knowledge Custodians enable and/or constrain the grade 11 chemistry teachers to become cultural knowledge brokers?

Me: Good afternoon each and every one? And how are we doing?

Scientist: *Otwa uhaleipo nawa atushe?*

ALL: Yes we are fine

Otwa uhalapo nawa lela! Onawa meme!!

Me: We are here today so that we can be taught and learn our cultural practice of extracting marula oil. We are going to attend the lesson or presentation and see how marula oil is extracted.

Theoretical: *Otweyapo notuli apa nena opo twiilonge omukalo wokuninga odjove, ommaadi eengongo. Otweya kutala nghee haa ningwa sheetwii longe mosha.*

Me: Now let us give the floor to our community experts in marula oil extraction. The floor is yours now. (Scientist: *Omhito ohalwiiyandje paife ngaha kova shivinawa vetu)*.

MEME FUDHENI: *Iyaloo tangi unene komhito ei mwetupa. Apa outnapo omahuku etu aa eli moshimbale omu.*

(Scientist: Thank you very much for the opportunity that is given to us. So we are going to start: Here is our marula nuts ‘’Omahuku’’ in this basket).

MEME FUDHENI: *Otwahala nee okumulonga nghee omaadi eengongo haa ningwa ile okuetwapo*

(Scientist: We are going to teach you on how marula oil is generated and extracted from the marula seeds).

MEME FUDHENI: *Paife nee ohatukatula mo nee omongwa opo uka etemo omulyo komaadi eshi hatu kaa eta po.*

(Scientist: Now we are going to add salt and the reason for adding the salt is to bring in the taste to the oil that we will extract).

MEME FUDHENI: *Paife ohatu ka tanauna nee nokupilulamo opo omongwa uye mumwe nawa nomahuku.*

(Scientist: Then we have to mix to ensure that everything is thoroughly mixed up).

Theoretical: I want to ask, why do we add salt? And why that coarse instead of the refined salt?

(Scientist: *Ondahala kupula, omolwashike tolongifa omongwa womawe?)*

MEME FUDHENI: *Ohatu longifa ashike omongwa womawe, culturally from the salt pan but not the refined one.*

(Scientist: The reason why we use coarse salt is because it is locally available in the villages from the salt pan and we regard it as culturally and Oshiwambo salt but not refined one in the shops).

Panduleni: *Mhn Mh---omongwa womawe ohau nyenyepala diva udule ou wa kweywa?*

(Scientist: Does that coarse salt bring more taste than the refined one or what?)

MEE NDATOOLOMBA: The coarse salt is perfect and it can bring the taste so faster then the refined one

MEME FUDHENI: *Paife ohatukatulamo nee omakala etu Oshiwambo, elalakano, opo omahuku adule okudja omaadi nokuetamo edimba liwa.*

(Scientist: Now we are going to put the charcoal, the lighted one and the main reason why such is to bring in nice smell and to increase the temperature as well for the oil to come out)

Nelago, Panduleni: Ok, is that now the ‘’activation energy’’ or what?

TB: The charcoal is added now.

MEME FUDHENI: *Paife ohatutanauna nee opo omakala a dule okuhwika omahuku aete edimba*

(Scientist: Now the charcoal is heating the marula nuts and we can now experience the smell).

Panduleni: That is ‘’diffusion’’ the smell is coming out.

MEME FUDHENI: *Okudja nee opo ohatu hoololamo omakala adjemo.*

(Scientist: So from there, we don’t keep the charcoal in, you have to take them out because it was just there to bring in the smell as we have experience the smell).

Brave: *Paife ngee ondanyika mo, opena eyooloko naashi kwali eli manga inamu ya omakala?*

(Scientist: So if I smell that marula nuts now, the smell has changed because of charcoal?)

MEE NDATOOLOMBA: It has changed now, the more the charcoal the greater the smell.

Me: What if you did not put those charcoal?

(Scientist: *Ngeenge inotulamo omakala otashi ningi shike mbela?)*

MEE NDATOOLOMBA: There will be no smell in the oil, although you will be able to extract oil, but it will not be much, because charcoal is needed to increase temperature and start melting the marula nuts.

Panduleni: *Ngee kapuna omakala oshike vali hashi dulu okulongifwa?*

(Scientist: In case there is no charcoal, what else can be used?)

MEE NDATOOLOMBA: Is the only thing that you can use for the smell, but for activation energy you can put outside to be exposed by the sunlight for sometimes.

Nelago: *Omutenya ihautulamo edimba nee?*

(Scientist: So exposing it to the direct sunlight cannot bring in the smell?)

TATE SHEEHAMA: *Aaye, the sunlight cannot bring in the smell.*

MEME FUDHENI: *Paife ohatu tula nee omahuku koshini atukufa omushi opo tutwe omahuku.*

(Scientist: Ok, Now we will use the mortar and Pestle to pound and crush the nuts).

MEME FUDHENI: *Shaashi omahapu, omahuku ohatu a tukula omawi avali.*

Scientist: Since the marula nuts is a lot, the mortar does not need to be full it has to be crushed into two halves.

TATE SHEEHAMA: This one is the pestle and the mortar that is used to crushed the nuts.

MEME FUDHENI: *Ohatutameke nee okutwa omahuku.*

(Scientist: Now we are starting the process of crushing and pounding marula nuts).

MEE NDATOOLOMBA: *Paife omahuku otaa tuwa nee opo anyanyauke, nokukala moupambu vashona lela, shaashi ngeenge inaa nyanyauka nawa omaadi itaeyamo. (*The reason for pounding and crushing is to reduce the size of particles so that when the hot water will be added, the process will be easier and faster for oil extraction).

Brave: In other word is to reduce or decrease the surface area. As MEME FUDHENI was busy pounding marula nuts,

TATE SHEEHAMA: The way it looks was as we are pounding it can be called a “magma”

Nelago: *Omolwashike meme tatu eli omutumba? Oshike inafikama?*

(Scientist: Why is it that MEME FUDHENI is pounding while she is seated? Why not pounding while standing?)

MEE NDATOOLOMBA: If she stands, she will apply more pressure and the magma may spill out, the process does not need too much pressure.

MEME FUDHENI: *Ohatutwikile okutwa fiyo shanyanyauka nawa tu dule kuwedako omeva mapyu.* (Scientist: We will continue to pound until particles are reduced, become smaller for us to be able to add hot water).

MEME FUDHENI: *Paife ohatu wedamo nee omeya a lomoka*

(Scientist: Now we are adding luke warm water and the pounding should be faster. Texture is change, becoming more oily, keep on adding a bit of warm water).

TATE SHEEHAMA: For you to extract more it will depend on many things like for how long marula nuts has been kept, if it is too old or kept for so long the amount of oil produced will be less.

TATE SHEEHAMA: Now it is becoming juicy which means that more oil is about to come.

MEME FUDHENI: *Paife omaadi okweya nee*

(Scientist: Now the oil is generated or extracted).

Nelago, Panduleni; Wow the oil is indeed generated, it is even

Scientist: even More!!

MEME FUDHENI: *Paife omaadi ohatuakufamo, she hatwaatile nee mokambiya.*

(Scientist: So now we are pouring the marula oil in the pot).

Theoretical: Now I can only see the oil but where is the water that we have been adding?

MEE NDATOOLOMBA: It got dissolved and it was just used to bring about oil.

Nelago: I heard there are certain myths associated with the extraction of marula oil such as: ‘’Extraction cannot be done by two people’’

TATE SHEEHAMA: We also hear about it but I don’t think it is true because it is a tiring process and there must be a division of labour, especially on the crushing and pounding.

Panduleni: I heard ‘’if marula oil poured away all the people in the house will die’’

MEE NDATOOLOMBA: I think since marula oil is regarded as a precious oil in our culture maybe this was just said to scare people to take good care of it and avoid wasting it.

MEME FUDHENI: *Omaadi eengongo oshinima shafimana unene momufyuululwakalo wetu woshiwambo, nongaashi paife omaadi meefitola a ninga ondilo, ohatu tende ashike eengongo ndee hatuli odjove. Oina noxo oukolelele noitungifi ihapu ei twa pumbwa momalutu etu.*

(Scientist: Marula oil is very precious oil in our culture as Oshiwambo-speaking people. Like how the modern oil in shops became very expensive, and now we will just extract our marula oil instead of buying from the shops, moreover, marula oil is a healthy oil, with vitamins and nutrients that our bodies need to be healthy).

MEME FUDHENI: Opena ou a hala kuyengako kewi litivali?

(Scientist: Is there anyone who would like to try and do extraction for this second portion?)

Nelago: Let me do it.

TATE SHEEHAMA: You are doing it very well. Like I said earlier that the quality and the quantity of oil that will be pounded is affected by many things, also <u>if there are pests or insects in marula nuts, then the oil will be less</u>. It is not good to keep marula nuts for so long. It is better to extract nuts from the seeds and start the process of oil extraction within few days rather than keeping it for so long.

Me: Question to TATE SHEEHAMA you said something about division of labour. How does this happen?

TATE SHEEHAMA: It is the process that needs people to assist each other. Crushing and pounding can be done by everyone, but when the oil is about to come, the extraction and separation of oil from the reside can be only done by a specialised person.

Theoretical: More knowledgeable others are needed in the process of oil extraction

Brave: So if you want more oil you can add more water?

Scientist: *Ngeenge ondahala odjove ihapu onda pumbwa kuwedamo omeya mahapu?*

MEME FUDHENI: *Ngee owa wedamo omeya mahapu unene omaadi itaeya vali. (*Scientist: If you add more water, you won't be able to extract oil)

Scientist: How do you know that you need to add luke warm water?

TATE SHEEHAMA: You know as you start pounding the colour is whitish but when it is ready to add water, it will turn brownish and oily.

Nelago: Why adding luke warm water but not cold water?

TATE SHEEHAMA: Hot water can melt the nuts and help us to extract oil faster. But some people can also do with cold water that will take a very long period of time and I don't think oil will be even more. So hot water is better than cold water.

Panduleni: Let me ask TATE SHEEHAMA, How do you know this marula oil extraction as a male? I thought in some homestead marula oil extraction is for women?

TATE SHEEHAMA: I have learnt this while I was young from my grandmother and I know it very well. It is just a believe and myth that is only for women but everyone can do it even us males like myself.

Scientist: We have more knowledgeable Tate (Father) here which is very interesting that we can talk about gender issues and gender balance here.

TATE SHEEHAMA: Now you can see we are extracting oil for the second time and we *have what we call 'Ezi'* I don't know the word in English.

Me: I think it is called a ''residue''

Me: Before we proceed can we not talk about a residue

Scientist: *Tutongeni nee manga kombinga yedi, oha lilogifwa nee shike*?

MEE NDATOOLOMBA: *Edi ohalilongifwa okuninga osopa yo momunghoka, ohali nyanghaulilwa ashike momeya mashona ove to tulu nee mombiya opo liainge osopa moshivelelwa ngashi ombelela, eeshi, oxuhwa ile ombidi. (*Scientist: The residue is used to make a soup that you can add or put in relish like meat, fish, chicken, spinach and so on).

MEME FUDHENI: *Ngeenge opena ''ezi'' inopumbwa vali uka lande osopa, olo ashike tolongifa, ohalidulu okukutikwa ndee tokala tolilongifa oule wefimbo lile.* (Scientist: If there is this residue, you do not need to buy soups in shops anymore, you can just use it as a soup. A residue can be dried for future use or to be used for a very long period of time).

MEME FUDHENI: *Ohandimuulikile paife nghee osopa, ''omwai'' hauningwa hedi*

(Scientist: I am now going to show and demonstrate how a residue can make a soup.

Otonyanyauka nee edi moupambu vashona ndee toweda mo oumeva etata lokahalasha ngaashi handi ningi ngaha, shamha nee sha lumbakana nawa, ototula nee moshivelelwa shoye).

Scientist: You break the residue in a smaller pieces and you add water of about half a glass, like I am doing now. Once it get dissolved evenly then you add it on the relish.

TATE SHEEHAMA: *Odjove ngeenge oyapwa, ohaitelekwa, ndee ihali tulwa mee freezes*

(Scientist: Once marula oil is extracted, it is cooked or boiled but not to put it in the refrigerator).

Nelago: Why do we need to cook marula oil after extraction?

TATE SHEEHAMA: If it is not cooked it will get rotten within few days. It has to be cooked well by someone who knows and thereafter, it can be kept or used even for more than 2 years.

Panduleni: Very interesting, so it means that it cannot be stored without being cooked, we are learning and to me it seems like there are scientific skills and scientific reasoning being applied here.

MEE NDATOOLOMBA: Now we are moving to the part of cooking marula oil

MEME FUDHENI: *Paife ohatukateleka nee odjove, nomundilo woikuni ndee inau pumbwa kukala uhapu unene, shaashi odjove otailungwina* (Scientist: Now we are cooking the marula oil preferably on fire, but the fire should not be too much otherwise the oil will be burnt and the quality of oil will not be good).

MEME FUDHENI: *Ngeenge nee watula ombiya pediko, oto kala nee topilula opo ita yaalele*

(Scientist: Once you have put the pot on the firewood, you should keep on steering to avoid light residue to be burnt at the bottom of the pot).

Theoretical: How do you know that you know that it is ready and stop cooking the oil?

(Scientist: *Oho mono ngaipi kutya odjove oyapya?)*

MEME FUDHENI: *Shaa yatameke okufuluka, ohakukala etutu litoka kombada, lomeya enya twakala hatuwedamo eshi hatuyenge. Etutu ohaleende nee talishuna pedu, shamha nee lapumo otashiti oyapya.*

TATE SHEEHAMA: *Ngeenge omunhu keshishi okuteleka odjove, ota dulu kwii kufapo inaipya nelee tai kaola ile eilungwinife. Ohaitelekwa kwaava vena eshiivo. (*Scientist: When the oil start to boil, it forms a white foam on top, which is that water that we have been adding during extraction process. As we keep on heating the oil, will start reducing and disappear completely and that will be the sign that it is ready.)

Scientist: If the person does not know how to cook marula oil she/he may remove it on the fire while it is not yet ready and that it will go rotten or to over burn it, cooking marula oil is not for everyone it need skills.

Brave: Look at the white foam that was said by MEME FUDHENI!! My dear these are really experts teaching us as qualified teachers.

Panduleni: Meaning that it is not yet ready

Me: But now you can see that the foam has decreased.

Nelago: Which means that more water has evaporated, but she said that the foam will completely disappear when it will be ready and we remove the pot from the fire.

MEE NDATOOLOMBA: Keep on steering Ms Nelago, you see it is changing, the foam is almost gone which means that only small amount of water is remained.

Theoretical: But the oil is now smelling nice,

Scientist: It is smelling now

MEME FUDHENI: *Paife etutu olapwako nee, yoo nodjove yetu oyapya nee nghaha. Omubiya otaidipo nee nghaha, ngee oyakalapo vali otailungwina ashike.* (Scientist: Now you can see the foam has disappeared which means that the oil is ready and we can now remove the pot from the fire. If we continue and keep it on the fire the oil will be burnt).

Panduleni: Nice smell

MEME FUDHENI: *Odjove yetu oya nee ngaha, otaikala mokambiya okafimbo kashona opo ipole.*

Scientist: Here is our end product which is marula oil, we will keep it in the pot for few minutes to cool down.

Nelago: Science is happening here

Theoretical: The light residue is settling at the bottom of the pot and the clear oil on the top

Panduleni: Look at the layers separating the light residue and the clear oil

Scientist: Concepts like density, residue are engaging here

Me: Very interesting

TATE SHEEHAMA: We have to wait a little bit for the oil to cool down because we will store it in a glass container, otherwise it will break if we pour it in now.

MEME FUDHENI: *Paife ohatuka pungula nee odjove yetu mekende omu, omo taikala. Shee hatukala nee hatukufamo opo twiilongife. Ekende oliwa lidule eeplastic.*

Scientist: Now we are going to store oil in this glass container, whenever we want to use the oil we will take from here. Bottle containers are more suitable than plastic containers.

MEE NDATOOLOMBA: Glass containers are more suitable than the plastic containers because the quality like the smell and taste remain the same even if the oil has been kept for a very long time.

Theoretical: Scientifically said that glass containers are more suitable because they keep the same quality as it cannot compromise the quality of the smell and taste, and therefore the glass containers are more appropriate to store the oil. The oil is now preserved.

TATE SHEEHAMA: Is only that we are in towns or urban areas but claypots can be also used and good as the glass containers.

Brave: I think we are done

Me: Yes we are done, it is just to conclude and do the vote of thanks. Thank you very much to all of us that attended this workshop. A special thanks is going to all our community experts for your willingness to share your expertise with us and to spend your time with us here. We are very thankful and we have learnt a lot from all of you today. Like we have said recently the aim is to improve our science teaching in our schools, we are happy to acknowledge that your expertise and involvement can be used to contribute to effective teaching and learn in our schools thank you very much. We appreciate what you have taught us and we hope we will still work together to improve our education. (Scientist: *Tangi unene kwaamushe ava mwali mwaongala apa nana. Otwapandula unene Kovashiivi nawa vetu vounghulungu wopamifyuuluwakalo molwa ehalo lavo okulopolelafana nashe ounongo wavo wefimbo lavo okukala nashe apa nena. Otwemupandula notwe lihonga shihapu kunye nena. Ongaashi ngoo twapopya nale kutya elalakano letu opo tulongeleni kumwe momapekapeko aa, otwa hala okuhwepopaleka ehongo bunongononi meefikola detu. Otwa hafa notwa tambulako kutya ounongo-weni nekufombinga leni otali dulu okulongifwa mokuhwepopaleka ehongo loilongwa yopaunongononi meefikola detu. Tangi unene).*

TATE SHEEHAMA: We are also thankful that you came to us even here down in our informal settlements to talk to us and spend time with. We never knew if what we know can be appreciated and used in our schools. We are here and we will always willing to share what we know with you. Thank you.

Me: Our session is officially come to an end and will still meet for the next session of co-lession planning of

Appendix J4: Change Laboratory Workshop 4

Co- Lesson Planning/Preparation Narrative

Date: 16 May 2022

Duration: 2hrs: 16 Minutes

Research Question: What expansive learning opportunities are created (or not) when the grade 11 chemistry co-developed exemplar lessons that integrate traditional marula oil extraction and other Indigenous technological practices?

Me: Good afternoon colleagues, welcome back to our fourth session whereby we are going to plan together and come up with the model lesson that we are going to teach this week. Our previous and third session was all about a presentation by community experts whereby we were taught a how to make and extract marula oil. Before we start with our session for today can we please reflect on the previous session, just a short reflection, on how it went, what went wrong, what came out and anything else we may think of?

Nelago: The excitement of the community members was really outstanding, their eagerness or willingness to share their knowledge is a very good thing that I have picked and observed.

Scientist: For me it was about the level of knowledge that the community have regarding the indigenous technological practice of marula oil extraction is of higher level. This was manifested by the way they were teaching us and demonstrating the whole process of marula oil extraction to us. This really helping us to plan and teach chemistry concepts.

Theoretical: As for me at the beginning I had an understanding that will have challenges to teach us since they are not qualified in education, but to my surprise, I am very impressed by the expertise and knowledge that our community members possess. This means that there is science and technology in our communities and I have learnt. Even though they did not use scientific terms they demonstrated some scientific skills and technological skills to us. They understand everything very well and know very well what they were doing.

Brave: You could really see that what we apply or application of their skills for example the crushing of marula nuts, to fastened up the rate of reaction or extraction of the oil. Community experts have good potential to train educators. Although they were not formally trained like us teachers but the way they were teaching us was outstanding and we were able to understand very well.

Me: From my side is that I did not expect the community members to be active and I thought it will be just one expert. I was even surprised to see many people from the community attending even the young ones that are school going they were there. And also other community members that attended seems to have the knowledge of marula oil extraction as some of them were able to share their insight regarding marula oil uses. I was also surprised to have a community expert who is a male as I thought this practice is only done by women but this male was more knowledgeable to teach us. Technological skills and Scientific skills that Mr Theoretical reflected on, in our community and I think it can be used to enrich our professional learning community. From now let us look at the scientific concepts that emerged from community presentation.

Panduleni: There was the concept of residue that was left as the by-product when the oil was extracted from marula nuts.

Scientist: There is also refinery or refining when the women was boiling the oil to make sure that, water was removed and to be only left with oil.

Nelago: The whole process of boiling and refining was done in order to bring about the concept of food preservation.

Scientist: Probably the term materials emerged when the experts were talking about suitability of different materials to store marula oil that was glass container, plastic containers and clay pots.

Theoretical: Also Motor and Pistil as the instruments that were used to crush the marola nuts

Me: Alright, those were some of the concepts that emerge from the presentation and perhaps we can proceed. What lesson can we plan based on all these concepts?

Brave: There are also concepts such as catalyst, inhibitors when the hot water was used, and explanation as to why cold water was said not to be good.

Me: Thank you Mr Brave. Now let us come up with possible lessons at least two. I think we should look at the more appropriate one that can reflect what happened during our community expert's presentation.

Me: Thank you for all the reflective. Now let us continue with our session for today reflecting to our previous session perhaps we can look at the concepts that emerged from the presentation. We need to come up with our concept mind map and this may assist us to plan our lessons property.

Panduleni: When the lady was burning the charcoal in the marula nuts, can be linked to the concept of diffusion.

Nelago: The crushing of nuts to increase surface area.

Scientist: Conversion of state of matter or change of state from solid nuts to liquid oil.

Panduleni: Chemical changes and Physical changes also chemical reactions.

Scientist: The concept of temperature when the charcoal was added as well.

Theoretical: Also Activation of energy, separation of mixtures.

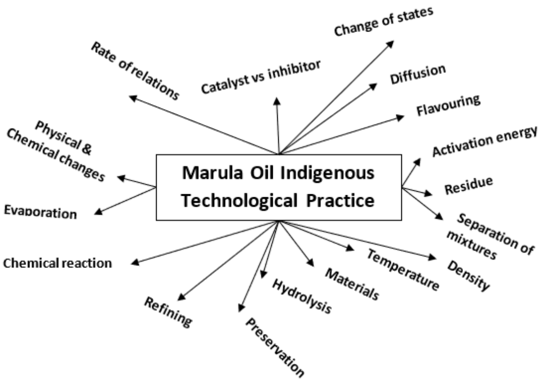
Nelago: The others terms reruns that emerged are densities, when the oil was cooling down and residue settle at the bottom of the container.

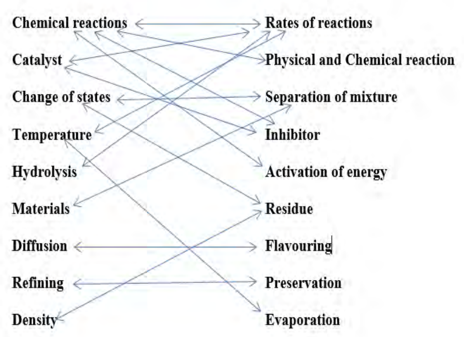
Me: How do we call that process when the women were adding water during extraction process?

Scientist: It is hydrolysis or Reduction?

Brave: There is also evaporation when they were boiling or cooking marula oil

Mind map and concept map





Brave: Let us look at the page 20, grade 11 chemistry syllabus. Under the theme chemical reactions and we can talk about the rates of reactions and even factors that affects the rate of reactions

Me: Yes, it makes sense

Brave: That is 6.4 that talks about factors such as particle size, pressure, collision theory temperature, light intensity and others.

Me: So we are saying 6.4 is more appropriate to link to what happened to the community expert's presentation?

Theoretical, Scientist, Nelago, Panduleni, Brave: Yes

Theoretical: Who will teach the two lessons among us?

Nelago: I think TD and TF can teach the lessons.

Me: Is it fine for the two of you to teach?

Brave, Panduleni: Yes it is ok.

Me: Ok let us proceed, so we are opting for chemical reactions.

Nelago: Yes

Scientist: I think 6.4, which is chemical reactions can be taught with integration of physical and chemical changes which is indicated in 6.2.

Nelago: I agree with that is our first lesson and after the chemical reaction perhaps we can focus on the factors that affects the rates of reactions, collision theory and other things, or what do you think?

Brave: Yes it is fine but how are we going to teach these lesson?

Me: Alright, the idea of teaching the lessons in just to relate and see whether what we have learn from the community presentations can assist us to teach chemistry better. I other words what have we learnt yesterday from the community presentations and how we can use it in our chemistry lessons to assist our learners?

Theoretical: Mhmm Mhmm ….. I think we can even use some pictures on PowerPoint presentation and video clips in the class.

Scientist: Yes, that will be great because we are going to relate what we have learnt yesterday to our chemistry syllabus topics and themes.

TC: How long will one lesson be? I think we will need more time to show pictures, play videos, explain, discussing and ask questions.

TF: Let us plain for double lessons for to be on the safe side.

All : Yes that will be fine.

Scientist: We also need to critically consider the issue of multicultural classrooms that we have, Some leaners might not be familiar with the indigenous technological practice that we are going to introduce, I think they will need enough time to internalise and accommodate the new Indigenous technology.

Me: Alright, can we start framing lesson one. what will be the title for this lesson?

Scientist: I think it will be best to have to our first topic as Experiment Techniques and this is on grade 10-11 syllabus, page 8 starting at 1.4 and bullet one to three whereby the learners are required to name appropriate apparatus, Explain the change of the states, outline the importance of purity for substances.

Nelago: All those learners specific competencies are speaking well to what we have learnt from our community members recently for example naming of appropriate apparatus, We were shown 'motor 'and 'pistil' change of state we have seen solid marula nuts changed to liquid marula oil.

Theoretical: Also importance of purity in substances we have observed community experts boiling the raw marala oil to preserve and refine it. I agree that experimental techniques could be on first lesson.

Brave: Are we all agree with topic one to be experimental techniques?

Scientist, Theoretical, Nelago, Me: Yes

Me: Since we are co-planning the lesson who is going to type on lesson plan while we are discussing?

Nelago: Let me do the typing for our lesson plans and presentation, but I will need assistance fom all of you to make it perfect

Me: Thank you TC and I hope we will assist you.

TE: Before we start with our typing, can we also identify the second topic so that when we will start typing we will just do it once for both the lesson.

Me: I agree with you Scientist.

Scientist: Let me ask before we continue; When the lesson will be taught who will observe those lessons?

Me: Myself plus one or two of us as a critical friend.

Scientist: I would like to observe as well.

Nelago: Me too I want to observe some lessons. I have already started typing the first lesson that we have agreed but we will go through together, I think.

Scientist: That is good, we will go through together, but for now let us talk about the second lesson.

Theoretical: For lesson 2 I think we can go to page 20-21 on our chemistry syllabus 6.4 under chemical reaction or rates of reactions.

Brave: Yes, then we can go with the competencies that says: Materials needed such as marula nuts, salt, motor and pistil. These are all the things we learnt from community members.

Panduleni: There is also a very good competency here that learners will be able to understand chemical reactions. Also to define and explain the terms rates of reactions, catalysts. I am typing these and I think here the learners need either to watch the pictures or videos depicting rates of reactions.

Brave: We will need to have short video clips for certain episodes that shows and relate to specific competencies. For example when the community members were adding warm water, etc. I think learners should watch these video clips for less than 5 minutes after introduction. You see our learners may understand how increased temperature that speed up the rate of reaction by reducing activation emery theoretically but they may not know how this happens practically. Thus why watching a video clips plus explanations from community expects may assist then to understand some of these concepts better.

Me: I agree with you Brave.

Scientist: Can we not have the lesson plan with specific competencies for the learners, activities for both the teachers and the learners, and also the power point presentations with few slides with introduction entire presentation of the lesson and conclusion.

Theoretical: That is what I have suggested earliest and I hope the power point presentations plus video clips will make our lesson interesting and draw attention of our learners.

Me: So first we will finish with the two lesson plans and later we can put those lesson plans in power point preventatives. Who is willing to put on lesson plans into power point presentations?

Scientist: I can assist TC for as to finish it today.

Brave: But when the learners will watch the video the teacher will need to guide the learners pause when necessary to explain certain things and also to monitor how the learners are learning.

Nelago: Yes if that will be good and of agree with you 100%. Since we are still in lesson two, can we go for the second competency?

Theoretical: There as that one for defence an inhibitor. Here we can relate this explanation to what they saw from the video. For example when the community expects were adding warm water to marula nuts instead of cold.

Nelago: We may ask the learners on the role on cold water as inhibitor which can increase the activation energy and that the process of oil extraction may take much longer.

Brave: You know we should encourage learner cantered approach whereby we will ask the learners, provoke their thoughts like why cold water was not used? Factors that affect the rates of reaction such as temperature can be explained.

Me: This is getting more interesting, I am listening and following, In fact, there is a lot from community presentations that we can use in our lessons.

Scientist: There is a lot indeed. I think we can also bring in collision theory or what do you think? Yes it is applicable then we can talk about factors that affect the rates of reactions such as particles, size, which can be seen in the video when the expert were pounding marula nuts to reduce the particles' size.

Nelago: There is also the competencies that say: Learners should be able to identify factors that affect the rate of chemical reaction. Then from the video clips learners can tell based on the video and what they know:

- Particle size
- Concentration
- Pressure
- Temperature
- Catalysts, etc.

Me: What should we give or assess these learners to determine whether they have learnt or not? Or whether what we as teachers learnt from the community experts assisted them or not?

Scientist: Maybe they can consolidate the lesson give them home works or ask them to reflect on the lesson as well. We need to hear from them as well. What is the reason for involving them in lesson observation and there is nothing that we want to hear from them? Lessons should build from lesson one.

Theoretical: You are correct Scientist, let as give then some home works and let than reflect on all the lessons.

Me: Alright, now we can go through together in all the lessons plans and power point presentations.

Nelago, Scientist: Ok

Nelago: We have agreed that one lesson one is titled as experimental techniques: under scientific processes as follows;

- Name appropriate apparatus
- Indicate that mixtures melt and boil over a range of temperature
- Outline the importance of purity in substances in everyday life, e.g. foodstuffs and drugs

Perhaps TC and TB can take us through as they were busy writing the lesson plans and power point presentation for both the two lessons

Nelago: For Lesson 2,

SPECIFIC COMPETENCIES/OBJECTIVES: (Refer to Syllabus) Learners should be able to:

- Explain the meaning of the term rate of reaction
- Define a *catalyst* as a substance that increases the rate of a chemical reaction. (The catalyst participates in the reaction but is chemically unchanged at the end of it, although it may change physically)
- State that a catalyst increases the rate of reaction by reducing the activation energy of a reaction
- Distinguish between chemical and physical changes
- Define an inhibitor as a substance that reduces the rate of a chemical reaction
- Describe, in terms of collision theory, the effects of

- Concentration
-Pressure
- Particle size (surface area)
-Catalysts (including inorganic or organic)
- Temperature
- Light

Scientist: I am going to lead you through all the two lesson plans and power point presentations.

Me: These were the longest session and I would like to thank all of you for your time, focus and your valuable contributions. Really this session proved just like others that we need to work together, to come up put all our ideas together and come up with two lessons that I think they are both speak well to our chemistry syllabus grade 10-11 and what we have learnt from our community members. Our next Activities. Panduleni and Brave are going to teach the lessons, Nelago, Me, Theoretical and Scientist will observe the lessons and after the lessons we will come together once again to do entire reflections on the lessons presentations as well as entire process of intervention. Once again thank you very much for today. We are done.

Brave, Scientist, Nelago, Theoretical: It is our pleasure as well, we are also learning from all those engagements.

Appendix K1: Lesson Plan for Exemplar Lesson 1

Teacher: Panduleni and Brave	**Grade: 11A**	**DATE:08/08/2022**
SUBJECT: Chemistry		
THEME: Scientific Processes TOPIC/SKILLS: Experimental Techniques		
1.LEARNING AND TEACHING SUPPORT MATERIALS (LTSMs)	**Video Clips constitutes the followings:** **Indigenous materials and apparatus needed in the experiments of marula oil extraction:** **Marula nuts, Marula oil, pestle & mortar, salt, warm water**	

1. **SPECIFIC COMPETENCIES/OBJECTIVES:** (Refer to Syllabus) Learners should be able to:
   - **Name appropriate apparatus**
   - **Indicate that mixtures melt and boil over a range of temperatures**
   - **Outline the importance of purity in substances in everyday life, e.g. foodstuffs and drugs**

2. **MONITORING OF HOMEWORK DONE**:

3. **INTRODUCTION:**

   Teachers test the learners' prior knowledge for Indigenous Technological Practice of marula oil extraction. Video clips will be played on Indigenous Technological Practice (ITP) of marula oil extraction for the learners to learn experimental techniques, identify appropriate apparatus used, observe refinery and purification techniques.

Presentation of subject content and learning tasks: Duration: 90 Min

Presentation Specific Competencies/Objectives	**Class Exercises** *(should be relevant to the specific competencies/objectives)*
a) Play the video on the extraction of marula oil. **b)** Ask the learners' to name the appropriate apparatus used in the video **c)** Outline the importance of purity in the substance (marula oil) with regard to preservation **d)** Purification techniques **e)** Concluding the lesson and Assessment	**a)** Learners Watch and take note of the appropriate apparatus, experimental techniques involved. **b)** Learners list apparatus used. **c)** Observation on how marula oil was produced/extracted and refined **d)** Learners identify the purification techniques **e)** Open Discussions: Clarification, questions and answers. **f)** Reflection **g)** Assessment Activities

4. **Assessment Activity given (After the lesson): Homework**
   Apart from Indigenous technology of refining and purifying marula oil "odjove", Think of and research about any other two Indigenous or local technologies in our everyday lives that involves the scientific processes of refining and purifying. **[20 Marks]**

5. **Reflection:**

Appendix K2: Lesson Plan for Exemplar Lesson 2

Teacher: Panduleni and Brave	**Grade: 11A**	**DATE:08/08/2022**
SUBJECT: Chemistry		
THEME: Scientific Processes TOPIC/SKILLS: Experimental Techniques		
1.LEARNING AND TEACHING SUPPORT MATERIALS (LTSMs)	**Video Clips constitutes the followings:** **Indigenous materials and apparatus needed in the experiments of marula oil extraction:** **Marula nuts, Marula oil, pestle & mortar, salt, warm water**	

6. **SPECIFIC COMPETENCIES/OBJECTIVES:** (Refer to Syllabus) Learners should be able to:
   - **Name appropriate apparatus**
   - **Indicate that mixtures melt and boil over a range of temperatures**
   - **Outline the importance of purity in substances in everyday life, e.g. foodstuffs and drugs**

7. **MONITORING OF HOMEWORK DONE**:

8. **INTRODUCTION:**

   Teachers test the learners' prior knowledge for indigenous technological practice of marula oil extraction. Video clips will be played on indigenous technological practice (INDIGENOUS TECHNOLOGICAL PRACTICE) of marula oil extraction for the learners to learn experimental techniques, identify appropriate apparatus used, observe refinery and purification techniques.

Presentation of subject content and learning tasks: Duration: 90 Min

Presentation Specific Competencies/Objectives	**Class Exercises** *(should be relevant to the specific competencies/objectives)*
f) Play the video on the extraction of marula oil. **g)** Ask the learners' to name the appropriate apparatus used in the video **h)** Outline the importance of purity in the substance (marula oil) with regard to preservation **i)** Purification techniques **j)** Concluding the lesson and Assessment	**h)** Learners Watch and take note of the appropriate apparatus, experimental techniques involved. **i)** Learners list apparatus used. **j)** Observation on how marula oil was produced/extracted and refined **k)** Learners identify the purification techniques **l)** Open Discussions: Clarification, questions and answers. **m)** Reflection **n)** Assessment Activities

9. **Assessment Activity given (After the lesson): Homework**
   Apart from Indigenous technology of refining and purifying marula oil "odjove", Think of and research about any other two Indigenous or local technologies in our everyday lives that involves the scientific processes of refining and purifying. **[20 Marks]**

10. Reflection:

Appendix L: Syllabus Learners Specific Objectives

TOPIC	GENERAL OBJECTIVES *Learners will:*	SPECIFIC OBJECTIVES *Learners should be able to:*
6.4 Rate of reaction	• know the factors affecting rate of reaction	• explain the meaning of the term rate of reaction • define a *catalyst* as a substance that increases the rate of a chemical reaction. (The catalyst participates in the reaction but is chemically unchanged at the end of it, although it may change physically) • state that a catalyst increases the rate of reaction by reducing the activation energy of a reaction • define an inhibitor as a substance that reduces the rate of a chemical reaction • describe, in terms of collision theory, the effects of – concentration – pressure – particle size (surface area) – catalysts (including inorganic or organic) – temperature – light on the rate of reactions (**NB**: an increase in temperature causes an increase in collision rate **and** more of the colliding molecules have sufficient energy – activation energy - to react whereas an increase in concentration only causes an increase in collision rate) • state that proteins that catalyse organic reactions are called enzymes • describe the application of the effect of surface area to the danger of explosive combustion with fine powders (e.g. flour mills, coal mines) • describe experiments for the investigation of the effects of given variables on the rate of reaction • interpret data obtained from experiments concerned with rate of reaction
6.5 Reversible reactions	• understand reversible reactions	• describe the idea that some chemical reactions can be reversed by changing the reaction conditions (including the effects of heat on hydrated salts, e.g. hydrated copper(II) sulfate and hydrated cobalt(II) chloride (cross reference to 11.1.1) • define dynamic equilibrium • describe that reversible reactions can reach dynamic equilibrium in a closed system • predict the effect of changing the conditions (concentration, temperature and pressure) on equilibria

TOPIC	GENERAL OBJECTIVES *Learners will:*	SPECIFIC OBJECTIVES *Learners should be able to:*
1.5 Experimental techniques	• understand the principles of experimental technique	• name appropriate apparatus for the measurement of time, temperature, mass and volume, including burettes, pipettes and measuring cylinders • indicate that mixtures melt and boil over a range of temperatures • identify pure substances by distinctive melting and boiling points • outline the importance of purity in substances in everyday life, e.g. foodstuffs and drugs • describe methods of purification by the use of a suitable solvent, filtration, crystallisation, re-crystallisation, paper chromatography of coloured substances and distillation (including use of a fractionating column). (Refer to the fractional distillation of crude oil in section 10.2.1 and products of fermentation in section 10.5) • suggest suitable purification techniques, given information about the substances involved • suggest suitable apparatus, given relevant information, for a variety of simple experiments, including collection of gases and measurements of rates of reaction • outline how paper chromatography techniques can be applied to colourless substances by exposing chromatograms to substances called locating agents (knowledge of specific locating agents is not required) • interpret simple chromatograms including Rf values

Appendix M1A: Lesson 1 Observation Narrative

Duration: Double Lesson (90 Minutes)

Teacher: Panduleni

Theme: Scientific Process

Topic: Experimental Techniques

Grade: 11

Research Question: How do grade 11 chemistry teachers enact and reflect on the exemplar lessons that integrate traditional marula oil extraction and other Indigenous technological practices in their classrooms?

PANDULENI: Good morning class and how are you doing today? Our lesson for today is based on scientific process and experimental techniques. We are going to learn scientific process and experimental techniques by applying and relating this topic to our indigenous Technological Practice of Marula oil extraction which is marula oil that we call in vernacular "omagadhi goongongo"or "odjove".These are the Indigenous names for marula oil and it is an indigenous technological practice.

Marula oil is a very important technological cultural practice commonly practised in the northern part of Namibia by Oshiwambo-speaking people. However, we have other tribes as well that also do extraction of oil. Can I please hear from you on how different culture also extract oil? How do you do it as Nama, Herero, Kavango and any other tribes that I did not mention?

L1: Ms, us Nama we have a!Nara plant that has seeds which can also be used to extract the oil.

PANDULENI: What about Herero tribe? What do you do in your culture to extract oil?

L2: I only know about the oil that is taken from the cows

PANDULENI: Mhh…. Wonderful, you know we have so many plants that are eatable and gives us seeds. Seeds have inner part that is oily and there is a special way that we are going to learn today on how to extract oil. Let us then look at our introduction. It will be better for all of us to bring marula fruits or pictures to the class. I think we do have the marula trees in our community here.

L3: I saw one big marula tree with fruits in our location.

PANDULENI: Very good, please bring along the fruits tomorrow. Let us continue with our introduction

> Marula oil is a Southern African Indigenous oil extracted from the nuts inside the marula trees' seeds. It is pure natural oil commonly used as delicacy in the northern part of Namibia and has been honoured, treated as a symbol of respect for the guests. It is scientifically proven that marula oil is rich in amino acids, vitamins, minerals for good nutrition, health skin and eyes. Marula oil is called "odjove" in Oshiwambo. How do you call it in your language?
>
> So we are going to watch video clips on indigenous technological practice (INDIGENOUS TECHNOLOGICAL PRACTICE) of marula oil extraction from our local community of Okahandja. We would like you to learn some experimental techniques, identify appropriate apparatus used, observe refinery and purification techniques of marula oil.

We go to the next slide and this is coming from our own syllabus and if you look at competencies it says that you need to:

- Identify appropriate apparatus that we use in science.
- Indicate that mixture can melt and boil over a range of temperature. Whatever constituents of a mixture in most cases, they don't boil at once but rather at a wide range of temperatures.
- Lastly we are also expected to apply importance of purity in substances in our everyday lives example in food stuff, we need to understand these things and for today we are going to use and relate our topic to the extraction of marula oil.

> So for now we are going to watch a short video clips on how marula oil is extracted. I want all of you to watch and listen attentively as well as relating the video clips content to our lesson objective and competencies that we talked about earlier. We will be pausing the video when necessary for further explanation. Before we watch the video, I have to let you know that last week we went in our informal settlement of 5 Rand Location whereby we visited some community members who taught us on how to extract marula oil. In fact we have learnt a lot and that is what am going to share with you in this lesson. So you are going to watch how community members and experts were extracting the oil and they were teaching us. Although community members used their vernacular language, translation was also made in English. So let us watch now.

L3: Ms I heard Mr TA asking the lady was not using the fine or refined salt. I did not know about that.

PANDULENI: O yes they do not use the refined salt and you know in the northern part of Namibia we have the salt pan where some people can get this type of coarse salt rather than always buying from the shops. According to the community experts this type of salt is more suitable to use than the refined salt when they extract the oil.

L4: I want to ask do these community members extract marula nuts from the fresh fruits or how?

PANDULENI: marula fruits have juice, first, the juice is extracted, then the seeds are allowed to dry. Inside the seeds there are marula nuts that are also extracted and that is where the oil is coming from. When we will proceed with our lesson tomorrow, I will show you the whole process from the fruits, juice and the oil.

L4: Alright Ms Panduleni, but I think the nuts softer than the seed itself.

PANDULENI: Yes, let us proceed with the video

L5: Ms Panduleni, why are they adding charcoal? charcoal in marula nuts?

PANDULENI: Yes that community member that you are watching in the video and the teacher if I can refer to her because she was teaching us, she put a charcoal in the marula nuts after adding the salt. Why do you think, according to the video?

L5: To activate Ms Panduleni I heard

PANDULENI: Yes that’s true, the charcoal was used as activation energy as well as for flavouring, that smell that comes with the oil. I am telling you, when we were there I experienced the smell.

L4: But I am a bit worried when the woman was just touching that hot charcoal with her hands, was she not scared to be burnt?

PANDULENI: You know when you are an expert you will get used to do certain things that you have to do without any harm. But the issue of adding the charcoal has to do with two main things that we need to take note of:

- ✓ Activation energy, that we learnt in grade 9,10
- ✓ Flavouring

L5: But Ms Panduleni when the community expert was choosing bigger charcoals and leave the smaller once why?

L4: Probably is for more activation energy. I think the bigger one produces more energy.

PANDULENI: Ok. Remember in grade 9 and 10 we have learnt that when the chemical reaction is taking place between reactants, heat energy is needed and that is what we are referring to as activation of energy. What we are watching from this video is a chemical reaction that is taking place, and like we said heat energy is needed and that is why the charcoal was used. Let us continue to watch the video. Let us pause a bit. There was question that was posed to the community experts on whether there was something else that can be used instead of charcoal and the answer was that you can put marula nuts or expose them to the sunlight for heat energy, but this will take longer and sunlight cannot put flavour, so they recommended the use of the charcoal. As we continue to watch the video clip, if you happen to observe something that is not clear to you or you do not understand it please feel free to ask so that we can pause the video.

L4: Ms Panduleni, how do we call that mortar and pistil in Oshiwambo?

PANDULENI: Mortar………”Oshini”

Pestle………….”Omushi”

PANDULENI:What do you think the woman is pounding?

L6: I think the purpose of pounding is to make marula nuts more fine.

PANDULENI: Alright, but when we make the particles of marula nuts morefiner, how do we call that in science? When we grind bigger particles to become smaller what are we trying to say in science?

L7: Ms Panduleni, It has to do with surface area, but there is something I heard that: In some cultures, you cannot pound while seated, is it true?

PANDULENI: Well it all depends with the context and what is being produced. For example when someone is pounding mahangu grains, he/she need to stand to apply more pressure because mahangu grains are harder than marula nuts. Here is marula nuts that am giving to you now to see and feel how it looks like. As you can see, these marula nuts are softer than mahangu, maize meal, nuts and that’s why the lady is pounding while seated because it does not need a lot of pressure to be crushed.

L8: Why the lady is adding warm water?

PANDULENI: There is the question, why do you think so class?

L9: For the oil to come.

PANDULENI: What have you noticed when the lady was adding water?

L10: She was adding a little bit by bit but not pouring much at the same time.

L4 She was using her sense of touch to determine probably whether it was the right temperature for the water.

PANDULENI: Yes, all these are scientific skills that the woman was using.

L11: Why is it that immediately when she adds the warm water, the woman will crush faster than before?

L4: I think is to maintain the temperature together with the friction and make sure that the hotness is kept to bring the oil.

PANDULENI: You can see the oil has come out now and now she will separate the oil from the residue. Here with me I have a residue that you can have a physical look on it now. Let us share it.

L4: Let us watch first Ms Panduleni.

PANDULENI: Ok. That is good and the last part that we are going to watch is refining the oil. As you can see the woman is boiling the marula oil. Why do you think is she doing so?

L14: What was extracted was not just oil but the mixture of oil and water. So she boil to separate the two.

PANDULENI: Correct, we have learnt that mixture can be??

Whole class: Separated.

PANDULENI: Very good and boiling is a method of separation that was used. While the community member is boiling, she kept steering, why and what is the purpose of doing so?

L4: Perhaps she was trying to spread the heat energy throughout the pot.

PANDULENI: Yes, but also to make sure that the sediments are not burnt under the pot. Woow! You can see all the water has evaporated and the woman is now removing the pot from the fire. Once the oil has cool down it is stored or preserved in a special container preferably in a glass or ceramic containers. Here is our refined marula oil in this glass container that you saw in the video. What do you think could have happened if the oil was not refined?

L14: It will be rotten and decompose because of the presence of water and oxygen within the mixture.

L15: Ms Panduleni, We want to see a closely look at how it smells and looks like.

PANDULENI: I am passing the opened glass container to all of you now but please take care of it. You have heard about the beliefs about handling the oil in the video.

L16: What happened to the salt that was added?

PANDULENI: Remember in the video, salt was added for taste, charcoal was added for activation energy and flavouring. So the salt has dissolved within the oil and mostly in the sediment. It is tasty. Alright now we are rounding up our lesson for today. Let us see what we have learnt from the video clips in relation to our syllabus competencies and objectives. Name the appropriate apparatus named in the video?

L17: "Omushi" and "Oshini"

PANDULENI: Correct, in English as well?

Whole class: Mortar and Pestle.

PANDULENI: Here is the mortar, which is used for?

Whole class: Crushing the surface.

PANDULENI: And the Pistil is used for?

Whole class: Crushing the particles.

PANDULENI: Any other apparatus that you have seen in the video representations?

L15: Also the pot to boil and refine the oil.

PANDULENI: O Yes in the laboratory we used modern apparatus such as beakers to heat/boil but the pot is also appropriate apparatus that our community experts used.

PANDULENI: What purification techniques that you have observed in the video presentation?

L4: Evaporation

L18: Also distillation

PANDULENI: What is the importance of purity and refining in the substances such as marula oil? Based on the video what do you think was the purpose of refining marula oil?

Whole class: to separate the mixture of oil and water.

PANDULENI: Very good, what is the other concept behind refining that we talked about?

L19: Preservation

PANDULENI: Wonderful! Yes purity and refining helps us to preserve substances but we have to take note that when we are refining substances, we are removing substances that we do not want and leave the substances pure. Lastly, we are moving to the part of reflection. What have you learnt from the video presentation? You are going to reflect in this papers but you not going to give them back to me now, you will do it at home today and give them back tomorrow. But before we end our lesson, I want to hear from you the essence of the lesson, what did you learnt or not?

L20: Ms Panduleni I have learnt that if this marula oil was not refined, it will go bad.

PANDULENI: Ok anybody else?

L9: I have learnt the methods of separation mixtures marula nuts from the oil.

L4: I have learnt about different apparatus and their uses.

L21: I have learnt that the charcoal that was added was for flavour and activation energy.

PANDULENI: Alright what were reactants in this chemical reaction of marula oil extraction?

Whole class: Marula nuts, salt, and water.

PANDULENI: What was the product?

Whole class: Marula oil

L6: Except from the charcoal I have learnt that sunlight can also work but it will not give the good results because it cannot add the flavour to the oil.

PANDULENI: O, yes, yes...

Alright we are almost at the end of our lesson and I would like to assess what we have learnt and also just to open your mind up to other Indigenous technological practices that you may know, and that we can use to learn science. So what I am asking you to do is as follow: Apart from indigenous technological practice of marula oil think of any two other practices of Indigenous local technology that involve refining and purifying. You will come with this in our next lesson and that is Friday. So the reflection you are giving it tomorrow.

And with that we have come to the end our lesson….

Appendix M1B: Lesson 1 Observation Narrative

Duration: Double Lesson (90 Minutes)
Teacher's Code: BRAVE
Theme: Scientific Process
Topic: Experimental Techniques
Grade: 11

Research Question: How do grade 11 chemistry teachers enact and reflect on the exemplar lessons that integrate traditional marula oil extraction and other Indigenous technological practices in their classrooms?

BRAVE: Good afternoon learners, today we are going to have a very small lesson presentation under the theme of scientific process and the topic will be experimental techniques from our grade 10-11 chemistry syllabus. We are going to link or relate our topic for today to the indigenous technological practice of Marula oil extraction. Like I have said earlier today we are going to learn scientific process and experimental techniques by applying and relating Indigenous Technological Practices of marula oil (odjove) extraction. Is there anyone of you who knows about marula oil (odjove) and how it is extracted?

L1: Sir BRAVE, I know that marula oil comes from marula nuts that are crushed with some heat to produce such oil.

BRAVE: Alright thank you, there is a lot of scientific knowledge in such practice and that is what we are going to learn today. **Our general objective** from grade 10-11 syllabus is that you should be able to: *Understand the principles of experimental techniques*

In order to achieve our objective, we need to master the following **specific competencies** from our grade 10-11 syllabus and that we should be able to:

- *Name appropriate apparatus*
- *Indicate that mixtures melt and boil over a range of temperatures*
- *Outline the importance of purity in substances in everyday life, e.g. foodstuffs*

The following are the **Indigenous materials and apparatus** needed in the experiments of marula oil (odjove) extraction:

- *Marula nuts*
- *Marula oil*
- *Pestle & mortar*
- *Salt*
- *Warm water*

Let us then watch the video presentation

Now that we have come to an end of our video presentation, we are now going to relate the content of the video presentation to our lesson objective and competencies for today. According to the video presentation, what appropriate instruments/apparatus that you have seen in the video?

L2: Motor and Pestle.

BRAVE: Correct and what are the uses of these apparatus?

L3: To crush bigger particles to become smaller.

BRAVE: What were the other instruments\apparatus that we have used?

L4: There was also the electrical kettle that was used for warm water.

BRAVE: What else perhaps?

Whole class: The pot that was used for refining the oil.

L5: Sir! Also the glass container for storing the refined oil.

L6: The spade was used for charcoal.

BRAVE: Ok. The charcoal was used as?

L7: Catalyst

L8: To produce heat energy.

BRAVE: Mhh….. Let us carry on. Let us talk about purification techniques. What are purification techniques that you have observed in the video?

L2: Boiling and Evaporation

BRAVE: Yes, Yes, you have seen during the process of crushing, the community member was adding warm water and when the oil was extracted it was the mixture of water and oil. So boiling and evaporation was used to separate the two. As the woman was boiling the mixture in the pot, all the water evaporated and the oil was left in the pot. Now we need to talk about the importance of purity and refining of substances. What do you think the purpose of refining and purifying marula oil (odjove)?

L9: To give it a longer life cycle

BRAVE: Yes, that means that you are trying to prevent this oil from getting expired within a shorter period of time and that's why the woman have refined and purify it as well. As you see the marula oil in this bottle container here, you do not just want to use it all in one day, but once it is refined it can be stored and used for a longer period of time, even more than a year.We are still on the importance of refining and purifying substances. What else can you say on importance of purifying and refining of substances?

L10: Is just for storage and preservation.

BRAVE: Alright let us move on, now on the general reflection on the video presentation in relation to our topic for scientific process and experimental techniques. What did you learnt from the video presentation?

L2: I have learnt how people in the community can use their own cultural scientific apparatus and use things in the environment to produce something like oil.

LF: Very good, as you can see this motor and this pestle was not manufactured using machines, but it was just made by our local people as their cultural scientific apparatus that they use. So natural resources around us were used, what else have you learnt?

L11: Different apparatus that were used and their uses.

L12: I learnt that there is also a cultural method of extracting oil apart from the modern method of producing oil.

L13: I have learnt that are also certain steps that were used to shorten the process of extraction.

BRAVE: For instance, crushing of marula nuts to increase the surface area and the use of warm water to fasten the process of extraction.

L14: I learnt that diffusion is caused by the moving air because there was a smoke when the charcoal was put on the marula nuts and the smell came out according to the teachers who were present.

L15: I also learnt that there are specific reactions where pressure is not required much because the woman in the video was relaxing and seated while crushing.

BRAVE: Yes she did not apply too much pressure and that’s why she was not even standing. From scientific perspective we have learnt that pressure is increased by height. The higher the woman can lift the mortar, the greater the pressure and the lower the woman is lifting the mortar the less the pressure she is applying when crushing the marula nuts.

L17: I learnt that when the marula nuts are old, you cannot extract more oil, and that’s why extraction should be done while the nuts are new and fresh.

BRAVE: Very good observation, if the nuts are old, than the quantity and the quality of oil is compromised.

L18: I learnt what is left after the oil is extracted is called the ‘magma’ or ‘residue’ and this can also be used to make soup for meat or chicken.

BRAVE: Yes instead of buying soup in the shops you can just use that.

L10: How long does it take for the 'magma' or 'residue' to expire?

BRAVE: The most preferable answer is that it will also depend on the environment around it and the condition around it for example, temperature, insects, moisture, etc. If you dry it, it can even take or last for more than a year and that's why in our tradition, this type of things are kept in a safe place and throughout the year we do not run out of them at all. When the visitors are coming to your house then you can serve them with these.

L6: Sir, I just want to add that odjove is also used to treat cough, you just drink a small spoon the cough will go.

L19: I wanted to see the other processes that are involved before extraction of oil. Why was it not shown in the video?

BRAVE: The process is longer and it was not our target. You know it starts from marula fruits, remove the juices, removal of the shells, extraction of oil. Is not something that can be done in one day. But tomorrow is our next lesson I will show you the other process that are involved before extraction.

Homework:

Apart from Indigenous technology of refining and purifying marula oil "odjove", Think of and research about any other two Indigenous or local technologies in our everyday lives that involves the scientific processes of refining and purifying. [20 Marks]

These type of assessment are very good to you in a way that they can prepare you to improve your research skills and when you will go to universities at least you will be able to produce better research. Apart from that, the video presentation can help you to link the science that we have in our community to the school science.

L19: Why do we only store the marula oil in the bottle container?

BRAVE: We have learnt that different materials have different properties that can play an important role in storage and preservation of substances. In this case a bottle glass is more suitable to store the oil than the plastic container. The last thing that I want to talk about is reflection of the lesson. You will give me or hand in your research project this week Friday.

Appendix M2A: Lesson 2 Observation Narrative

Duration: Double Lesson (90 minutes)
Teachers: Code: PANDULENI
Theme: Chemical Reactions
Topic: Rates of Reactions
Grade: 11

Research Question: What are grade 11 chemistry teachers' pedagogical insights and contradictions towards the integration of Indigenous Technological Practices in science teaching?

PANDULENI: Good morning class and welcome to our second lesson. In our previous lesson, I asked you to bring along the marula fruits, pictures of the marula fruits as well as marula trees. Do you have these things?

Whole class: Yes Ms

PANDULENI: Thank you so much, let me collect the marula fruits and the pictures for both the fruits and the tree. Alright, this is how the marula fruits look like. You can see that the fruits are slightly different; some look greenish which means that they are not yet ripens. Some look yellowish which means that they are ready or ripen to be harvested. When the fruit is green it appears to be harder but when it becomes yellowish it becomes softer and juicy, when it is ripening the is then extracted and the seed remained, dried for sometimes or some weeks with in the seeds, there are nuts that are also extracted and the nuts are the one that you saw yesterday in the video. When the community members were extracting the marula oil. Let us also look at the pictures that you have brought. This is how the trees are looking like. I am sure there are different species and I am sure you have learnt this in biology. Today we are going to build from our yesterday lesson of scientific processes and experimental techniques. Based on that, today we are going to learn more about the rates of reactions in terms of rates of reaction, Catalyst, physical changes, chemical, changes, inhibitors and collision theory.

Don't forget that we are learning all these by relating and linking our topic to Indigenous, Technological. Practice of marula oil extraction that we have watched yesterday in video presentation. So once again like what I have said ealier we are just building from what we have learnt yesterday. Thank you once again for the fruits and the pictures that you have brought for now let us look and learn from the PowerPoint presentation that I prepared for you for today lesson; let us see how marula tree and fruits look like. During the extraction of marula seeds, there is a common and important juice that we call omagongo. You can see the juice is extracted during the rainy season. By woman omagongo can be fermented and become soft alcoholic can be fermented and become soft alcoholic practitioner drunk for orders but as per societal beliefs, it more regarded to be taken by Males/Man book at how it is served in traditional cups and serve the visitors. Let us also look at commercialised marula products as you can see marula cream wine that is sold in the shops, pure organic marula oil that is also sold in the shops to apply on the skin and the hair. Apart from that it can also sold as a pure oil to put on our food as you have seen in the video yesterday.

Yesterday you requested me to show the processes that are involved from the fruits up to the nuts and this is what I am showing you now. Overal, just look at how the grandmother is busy with the processes of extracting marula nuts from the marula seeds. So marula nuts are raw materials that we need to extract the oil. I hope this has helped you to understand different processes that are involved in marula oil extraction.

Whole class: Yes Ms

PANDULENI: Alright, now let as look at our general and specific competencies and objectives in our chemistry grade 10-11 syllabus. We are going to active these lesson objectives by using the same video that we watched yesterday and what we are learning today. Here are the basic competencies and objection, Plus teaching and learning support materials.

SPECIFIC COMPETENCIES/OBJECTIVES: (Refer to your Syllabus) is that you should be able to:

- Explain the meaning of the term rate of reaction
- Define a *catalyst* as a substance that increases the rate of a chemical reaction. (The catalyst participates in the reaction but is chemically unchanged at the end of it, although it may change physically)
- State that a catalyst increases'[the rate of reaction by reducing the activation energy of a reaction
- Distinguish between chemical and physical changes
- Define an inhibitor as a substance that reduces the rate of a chemical reaction
- Describe, in terms of collision theory, the effects of:

- Concentration

-Pressure

- Particle size (surface area)

-Catalysts (including inorganic or organic)

- Temperature

- Light

The following are Teaching and Learning Support Materials that we are going to use:

- Video Clips constitutes the followings: Indigenous materials and apparatus needed in the experiments of marula oil extraction
- Marula nuts
- Pestle & mortar
- Salt
- Warm water
- Marula Oil

Alright let us proceed with the lesson; we want to talk about rates of reaction.

How do you understand the term rates of reaction?

L1: It is how fast or how slow the reaction can take place.

PANDULENI: Thank you L1, based on yesterday video presentation what was done by the community experts for the reaction to go fast?

L2: We have added heat energy in the form of warm water.

PANDULENI: Very good L2, then we move to the concept of catalyst. Anybody who would like to explain what catalyst is all about?

L3: Is a substance that speed up the rates of the reactions

PANDULENI: O, yes a catalyst is a substance that speeds up the rates of reaction. From the video presentation you have seen that the community experts used warm water to increase the temperature. Warm water was used to provide increase the rate of reaction. Like we have said that a catalyst is any substance that increases the rate of chemical reaction. A catalyst participates in a chemical reaction, but it is chemically unchanged at the end of reaction although it may change physically. Who want to explain to us this statement about what catalyst is all about based on yesterday presentation?

L4: When the women poured warm water during the process of pounding marula nuts, the water was still present as a mixture of oil and water

PANDULENI: Ok, How do we know that warm water that we are saying is a catalyst was not changed?

L5: Ms, during the process of refining and purification the water evaporated.

PANDULENI: Yes, you are correct and you have seen that there was a foam on top of the mixture and when all the water has evaporated the foam disappeared. Let us proceed, we are saying that catalyst increase the rate of reaction by reducing the activation energy for the reaction.

Now we are going to talk about inhibitors. What is an inhibitor?

L2: Substance that slows down the rate of reaction.

PANDULENI: From the video presentation, what sort of condition that you think the community expert may have avoid as it may reduce or inhibit the rate of reaction?

L2: They were not adding a lot of water at a time.

L1: Ms, This one is tough, maybe after boiling they allow the oil to cool down before pouring in the glass container.

PANDULENI: She avoided the use of the cold water as it can slow down the rate of reaction.

Lastly let us talk about collision theory and the factors that affect the rate of reaction. When the community experts were adding water, they were not just adding or pouring large volume of water at once, they were doing it a bit by bit, This was just to make sure that the concentration of the oil is not compromised or too diluted. Let us watch for few minutes to link to more factors that affects the rates of reactions.

The women were pounding while she was seated instead of standing to make sure that the pressure was not too much. Imagine if she was to stand and pounding, perhaps some particles of marula nuts could have spilt out.

What do you think was the purpose of pounding marula nuts at first place?

L6: To reduce the size of marula nuts.

L2: To make the marula

PANDULENI: Very good, nuts more, finer so that when the woman adds warm water it can mix up nicely and faster, call that in

L7: She is increasing the surface area

PANDULENI: Very good, the marula nuts are a little bit bigger but when we are crushing then to become finer, we are increasing the surface area, allowing the particles of warm water to come in contact with marula nuts as much as possible. When the particles are bigger, the rate of reaction can be slow and therefore we cut into smaller pieces. When the woman was pounding, the particles were becoming more, finer and smaller, creating large surface area for more particles to be exposed by warm water. Let us also talk about physical and chemical changes, Now from the video presentation, at what point have you observed that it was physical changes that took place or chemical changes? Now what I would like you to do to distinguish between physical changes and chemical changes in relation to marula oil extraction video presentation.

L8: When the women started to pound marula nuts it changed from solid to oil and it is a physical change

L2: No Ms Panduleni it cannot be a physical change because the products that are formed are totally differ from the reactants. First there was only nuts and finally oil was formed and it cannot be changed back to nuts.

PANDULENI: O,yes L2, any other example?

L9: During the process of extraction, water was added to generate the oil but when the oil was refined and boiled the water disappeared in during evaporation as a gas and this is a physical change.

PANDULENI: Thank you very much

L10: When the women added the charcoal to the marula nuts and mix it with the nuts to bring the flavours, later she removed the charcoal with her hands to separate the two and this was a physical change

PANDULENI: Yes, another example?

L11: When the particles of marula nuts were crushed, they became smaller or fines but now I don’t know if it is a physical or chemical change Ms Panduleni

PANDULENI: That one is a physical change because the properties of the particle did not change, it does not matter whether they are big or small. Another one?

L5: When the charcoal was added for the favour, there was a smell or a flavour and was a chemical change Another one?

L8: The nuts were more of the white but the residue and oil that was formed was more of brownish and I think this was a chemical change.

PANDULENI: Fantastic, are we really getting to know and differentiate physical and chemical changes?

Whole class: Yes Ms

PANDULENI:Now what we are highlighting the factor those affect the rates of chemical reactions that we just talked about concentration, pressure, particles size (surface area), catalysts, temperature and the light. Did we talked about the light? When we watched the video we can all agree that all these factor that affects the rates of reaction were observed except the light if I may say.

L12: No Ms, all the factors were observed including the light. I can remember someone asked and the women said that if we do not have the charcoal to activate we can put nuts on the sun but it will take longer.

PANDULENI: Yes, it is true, I do remember also. Do we see that this indigenous technological practice is really enriching us in the learning of chemistry? So a lot of science is happening in our communities.

L13: Ms Panduleni, I want to ask, why didn't they use very hot water but they used warm water?

L4: From my point of view is that if you use hot water it may speed up the rate of reaction in such a way that the reaction will be too fast and you won't get the amount of oil that you wanted to extract.

PANDULENI: Yes if it was in biology we can say that too hot water may denature the enzemes.so with this marula oil extraction we can say that community members applied experimental techniques to describe collision theory. Now what have you learnt from the video presentation and this lesson?

L13: I learnt better on factors that affects the rates of chemical reaction

L4: I have learnt that in everyday things that are happening in our community there is science that we can learn in the class like what we are doing now.

PANDULENI: Woow, I like that, indeed sciences is around us and also scientific apparatus are also used in our communities

Nelago: It is very much exciting to see things that we do at home being featured in our syllabuses, in our text book, although they are not explicitly coming out, I am happy that we can relate to them. It tells us that also that we should not undermine the science at home, and whatever we learnt in the classroom it is also found and we can still learnt more about it in or everyday life.

PANDULENI: Thank you Ms Nelago, not let us look at practical exercise;

a) In terms of collision theory, describe any other three Indigenous technologies (apart from marula oil extraction) which involves catalyst that increases the rate of reaction by reducing the activation energy of a reaction. [9]

b) Give two practical examples and outline the importance of catalyst in chemical reactions [6] We have up to Friday this week to hand in this activity. Thank you very much, tangi unene, bye dankie, mpandu, mpandu, okuhe

Appendix M2B: Lesson 2 Observation Narrative

Duration: Double Lesson (90 minutes)
Teachers Code: BRAVE
Theme: Chemical Reactions
Topic: Rates of reactions
Grade: 11

Research Question: How do grade 11 chemistry teachers enact and reflect on the exemplar lessons that integrate traditional marula oil extraction and other Indigenous technological practices in their classrooms?

BRAVE: Good morning class and how are you today?

Whole class: Good morning sir!

BRAVE: Our lesson will continue and I hope you remember about the video presentation from our community members. Today we are going to learn about chemical reaction and the rate of reactions by applying and relating Indigenous Technological Practices of marula oil (odjove) extraction that we talked about yesterday

Whole class: Yes sir!

BRAVE: Last time we talked about scientific process and experimental techniques. For today we are going to talk about chemical reaction and the rates of reactions. We are still applying and relating to our Indigenous Technological Practices of marula oil extraction. As we already talked about video presentation, we will continue with our lesson. Before we start the lesson let us talk about the background of this marula oil once again.

Marula oil is a Southern African Indigenous oil extracted from the nuts inside the marula trees' seeds. It is pure natural oil commonly used as delicacy in the northern part of Namibia and has been honoured, treated as a symbol of respect for the guests. It is scientifically proven that marula oil is rich in amino acids, vitamins, minerals for good nutrition, health skin and eyes. Marula oil is called "odjove" in Oshiwambo. How do you call it in your language? So we are going to watch video clips once again on indigenous technological practice (INDIGENOUS TECHNOLOGICAL PRACTICE) of marula oil extraction from our local community of Okahandja. We would like you to learn more about the rate of reaction, *catalyst*, chemical reaction, chemical, physical changes, inhibitor and collision theory. Today we are going to learn about the rate of reactions, catalysts, inhibitors, chemical reaction, physical reaction, application of collision theory.

BRAVE: In the last lesson you asked me to show you the process involved in the marula oil extraction. So in this slid, you can see marula tree and marula fruits. This is the tree were the marula fruits are produced. These trees grow natural and the fruits look greenish and when they turn yellowish it means that they are ready or ripen and they fall off on their own. When they fall off women gather to extract the juice from the fruits. When they are removing the first layer of the marula fruits, the juice come out collected in the special container. Once the juice is extracted, it is kept for one to three days to ferment. The juice can be fermented in two categories: the soft (non-alcoholic) one normally for the children and the strong one which is alcoholic to be consumed by the elders. Marula products can be commercialised like what you can see in the slide that I display. You can see Amarula cream juice that is sold in the supermarkets, sheeben and bars. There is also commercialised marula oil that we buy in the shops for food consumption or for the hair or the skin.

After all once you have removed the juice, the seed is dried for some weeks. Within the seeds, there are nuts that contain the oil. The outside layer for the seed is hard and women used instruments such as axe, pestle and special extractors. Finally marula nuts are extracted and this is what we need to extract the oil. I hope you now have the detailed background of marula oil.

Whole class: Yes sir!

BRAVE: Now let us look at our specific competencies/objectives from our chemistry grade 11syllabus and that by the end of this lesson, you should be able to:

- Explain the meaning of the term rate of reaction
- Define a *catalyst* as a substance that increases the rate of a chemical reaction. (The catalyst participates in the reaction but is chemically unchanged at the end of it, although it may change physically)
- Distinguish between chemical and physical changes
- State that a catalyst increases the rate of reaction by reducing the activation energy of a reaction
- Define an inhibitor as a substance that reduces the rate of a chemical reaction
- Describe, in terms of collision theory, the effects of Concentration, Pressure, Particle size (surface area), Catalysts (including inorganic or organic), Temperature and Light

Now we are starting with the rate of reaction. But before we start let us look at the video presentation for few minutes once again. Ok. Now that we have watched the video presentation once again, relate to it and explain: What is the meaning of the rate of reaction?

L1: It is how faster or how slower the reaction can take place.

BRAVE: Yes you are correct; it is how fast or how slow the chemical reaction or physical reaction can take place for the products to be formed. Let us proceed with the concept of catalysts. We have said that the catalyst is a substance that increases the rate of chemical reaction. A catalyst participates in a chemical reaction but it is chemically uncharged at the end of reaction although it may change physically. A catalyst increases the rate of rate reaction by reducing the activation energy of a reaction. Remember that activation energy is the minimum amount of energy that is needed for the reaction to take place. Now in the process of marula extraction that you have observed, what catalyst was used and what evidence can you share that it has increased the rate of chemical reaction?

L2: Sir, Luke warm water was used and when it was added it immediately changed colour to brownish and oily.

BRAVE: O, yes warm water was a catalyst as we have seen that once warm water was added, the mixture started generating oil. The evidence is the colour change and the oil that started to be formed. We are moving on with the concept of inhibitors. These are substances that reduce the arte of a chemical reaction. From the video clips, what sort(s) of conditions that you think the community experts may avoid as it could have reduced/inhibit the rate of reaction?

L3: Sir, cold water.

BRAVE: Sir they avoided using the cold water, because it could have reduced the rate of reaction. Yes if they could have cold water, it may generate the oil in very low quantity and even in a longer period of time. So we are sating cold water was avoided and it have served as an inhibitor in that extraction process. We are moving on to the concept in relation to the video presentation for the community members. From the video presentation what were chemical changes and physical changes that you have observed.

L4: Chemical change is a chemical reaction in which a new substance is completely formed.

BRAVE: Yes, New substances are formed and they are irreversible, and what about the physical changes?

L5: Physical changes are reversible and no new substances are formed.

BRAVE: Ok, but question still not answered, based on the video presentation, what were physical changes and chemical changes that you have observed?

L6: A chemical change was observed when the oil was formed and this oil cannot change back to the marula nuts that started the reaction.

BRAVE: Very good, oil was produced and it could not be changed back to marula nuts.

L4: When the community members added the charcoal and mix it with the marula nuts and then later it was separated with her own hands. That was a physical change.

BRAVE: O, yes.

L4: When she added salt into marula nuts was a physical change.

L8: When she boiled the oil, the water started to evaporate, removed from the oil completely and this is a chemical change.

BRAVE: But boiling is a physical change. Now we are moving on and we would like to apply experimental techniques marula oil that you have learnt from the video presentation to describe collusion theory in relation to the following factors:

- ❖ Concentration
- ❖ Pressure
- ❖ Particle size (surface area)
- ❖ Catalysts
- ❖ Temperature
- ❖ Light

All these factors were observed in the video presentation but I will only give you an example of the first one and that is concentration, then you do the rest. You have seen that the experts were adding water and they were not just adding any amount of water, they were adding a little bit by bit. If they could have added huge amount of water at a time this could have compromised the quality of the oil that could have produced. So they made sure that the concentration of water is under control to extract move oil.

Now we are moving to the next factor which is pressure, who can tell us based from the video presentation where pressure was involved and how it was applied?

L2: When the woman was crushing the marula nuts, she was seated and she applied less pressure

BRAVE: Very true she was seated to make sure that she apply less pressure. Remember that pressure increases with the height. If she could have been pounding while standing, she could have applied more pressure and that some of the mixture could be spilt out. The higher, the more the pressure, so the community experts controlled that. Let us move to the next factory which is he particle size

L9: The size of particle was reduced when the lady was crushing to increase the area of the surface.

BRAVE:Yes, the crushing made it possible for the particles to be more fine and smaller and the surface area was increased and also to increase the rate of reaction. The catalyst we already talked about it and what was the catalyst once again?

Whole class: Warm water.

BRAVE: Let us talk about temperature as the factor.

L10: The temperature was controlled through Luke warm water that was added to the mixture.

BRAVE: Yes, the light was also mentioned video presentations that if you do not have the charcoals you can expose the nuts to the sunlight for activation energy but it will take much longer as compared to the use of the charcoal.

BRAVE: Now let us round up and explain the collision theory:

- The higher the concentration, the faster the rate of reaction. If the concentration is too much, the reaction will be very fast that's why they did not add too much water so that the concentration remain high for them to extract marula oil at a faster rate

- What about pressure

L11: The lower the height, the lesser the pressure and the higher the height, the more the pressure.

BRAVE: Very good, we can link this to our physics, Pressure = Force/Area. Remember you apply force our certain amount of area, when do you think pressure supposed to increase? It is when the area is small or when the area is big?

T12: When the force and the area is bigger the area smaller. That is the reason the motor should not be very big to decrease the pressure.

BRAVE: What effects does the particles size have on, the rate of reaction?

L13: When the particle size is bigger, they decrease the surface area and when they are smaller they increase the surface area

BRAVE: Thanks you T13, and how all what you have said affect the rate of reaction

L14: The large the particle size, the slower the rate of reaction and the smaller the particle size, the factor the rate of reaction.

BRAVE: Yes tis why the community experts crushed the marula nuts to reduce and make particle size smaller and fine. In this way the rate of reaction was increased. What about temperature?

L7: When we increase the temperature, the faster the reaction the temperature, the fasts the reaction will be.

BRAVE: Let us move to the general reflections. What did you learnt from the video presentations in relation to own today lesson

L3:I learnt on how to extract marula oil from marula nuts

L10: I learnt that collision theory is very true that when you increase temperature, the rate of reaction increase as well. I saw this when the women added the water on the crushed marula nuts, immediately the oil was formed.

BRAVE: Yes next what have you learnt?

L15: The catalyst increased the rate of reaction

L2: I learnt more about physical changes and chemical change

L8: Particles size, that the larges the particle size, the smaller the surface areas and slower the rate of reaction.

L3: I learnt that during the extraction of marula oil, both physical changes and chemical changes took places.

BRAVE: I have learnt that when the oil was extracted it was refined in order to refine, purify and pressure the oil for future use and storage. Without refining the oil, it will expire within few days.

L4: Cow milk and butter

L16: Mahangu

L17: Extraction of ombike from palm fruits

BRAVE: Very good, next

L19; Sunflowers oil

BRAVE: This practical assessment you will do it for the whole of this week and also your reflection so next week Friday you will hand in these two items and that is the practical assessment and the lesson reflection.

c) In terms of collision theory, describe any other three Indigenous technologies (apart from marula oil extraction) which involves catalyst that increases the rate of reaction by reducing the activation energy of a reaction. [9]

d) Give two practical examples and outline the importance of catalyst in chemical reactions [6]

We have up to Friday this week to hand in this activity. Thank you very much!

We have come to the end of the lesson and I would like to thank all of you, thank and have a nice day

Appendix N: Collated Teachers Reflections

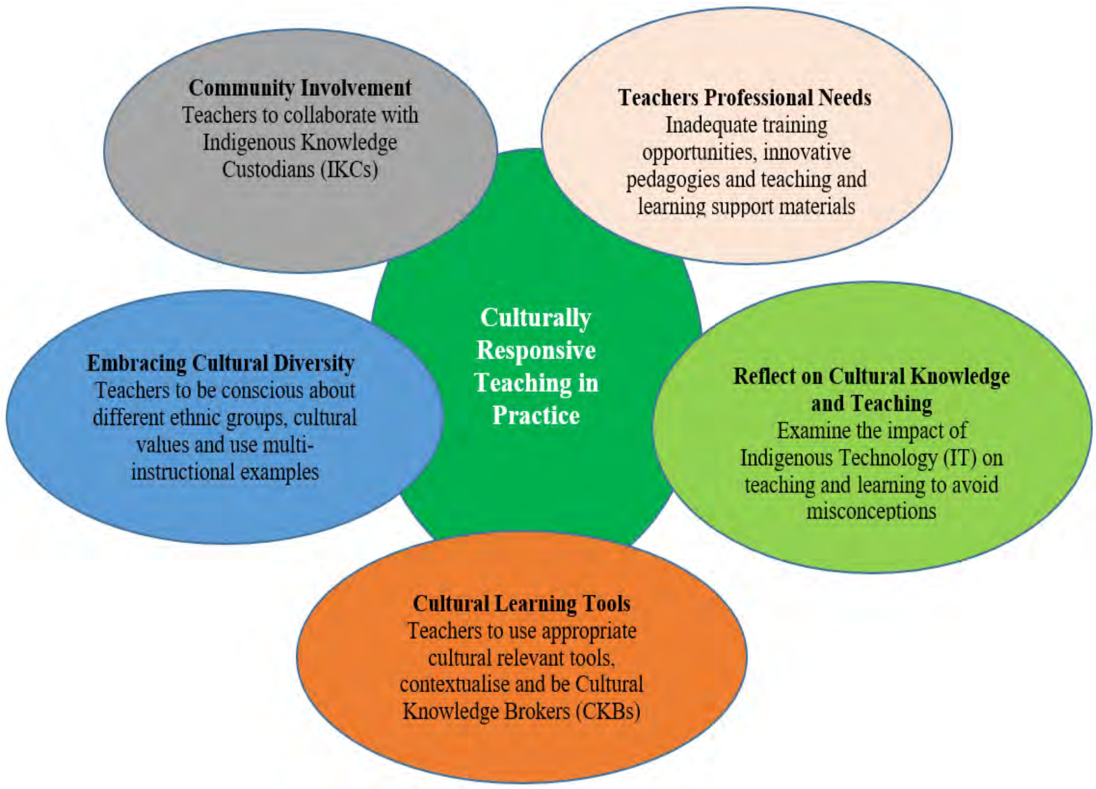
Participants Responses / **Questions**	**Theoretical**	**Scientist**	**Nelago**	**Panduleni**	**Brave**
1. What have you learnt from these lessons?	There are Indigenous knowledge that are scientific and Indigenous technological practices can be used to teach chemical reactions and it can be integrated in science teaching	The use of Indigenous technological practices in teaching is the way to go. I was so touched by how the lessons were just going on, how learners were asking questions which I did not expect. We really need to think about bringing the use of Indigenous technological practices in the education Science, Technology, Engineering and Mathematics	I thought I knew everything about marula oil extraction, but blending it into the chemistry content felt like epitome of teaching methods. I also learnt more about the concepts that emerged from marula oil extraction	Indigenous technological practices can be used to enhance learners participation, engagement and understanding as it capture their full attention	It is very possible to teach the topics of chemistry even if you do not have all the supplied materials. Indigenous technological practices make it possible and the lesson was very interesting
2. In general have you the integration of Indigenous technological practices in these lessons useful to you and your learners or not? Explain why.	Yes because learners could understand Indigenous knowledge in relation to Chemical reactions, physical changes, chemical changes and catalysts	Yes it has scaffold the learners, as some had no understanding of factors that affects the rate of reactions, but during the lessons they were asking many meaningful questions, meaning that their understanding and interest was stimulated	It was very useful because learners got to link everyday experiences and concepts to what they are taught in their chemistry lessons	Learners from different cultures were all engaging and identify the scientific reasoning behind how okuyenga is done	Yes because the scientific processes and chemical reactions could be easily explained easily with Indigenous materials and video presentation

3. Which aspect(s) of the lessons did you find most helpful to teach these lessons?	Watching the video that shows appropriate apparatus that were used to teach experimental techniques	When the learners watched the video presentation of the oil being extracted, It was helpful because learners were able to link the scientific concepts to the process itself. I have learnt that using the video clips from the community can make my lessons more interesting	The aspect of refining substances in our everyday lives, method of purification, appropriate techniques and the use of hot water to increase the rate of reaction came out very strongly. If cold water was to be used it could have acted as inhibitor	Increasing the surface areas by crushing and grinding marula nuts as well as identifying catalyst and inhibitors	Factors that affects the rate of reaction and collision theory
4. How did you view the lessons were they successful or not? Explain why	They were successful because learners were able to relate Indigenous technological practices to scientific concepts like purity of substances, experimental techniques and factors that affect the chemical reactions	Very successful because learners had to listen to the teachers explaining and at the same time watch the process from the video. Learning was just made easier	It was very successful because learners really engaged in the lesson and they were interested in knowing more	Very successful because it yielded maximum interaction between teachers and the leaners. Learners asked more questions more than the usual lessons. When leaners reflected, the really showed understanding	Successful because lesson objectives were all mastered

5. Was there any aspect(s) about these lessons that you did not like? Explain why	No	Not really	Not content related but some of the learners could not hear very well due to poor quality sound from the speakers	No, I enjoyed the lessons	No
6. What are your views on integrating material technology and information technology in the lessons?	It will be very interesting	Integrating material technology is the best as it really makes teaching and learning easier, meaningful and it saves time	Interesting, I did not know there is something called material technology, although, it is in the curriculum documents	Both the two types of technologies need to be used in collaboration. There is no material technology without information technology. If they are used in an integration, I feel is more effective and it save time	It may help teaching and learning process
7. If we happen to enact another Indigenous technological practices lessons on which area(s) do you think we need to improve?	More teachers to be trained by community members on how to integrate Indigenous technologies. We need to critical examine the impact of IK on teaching and learning	More videos presentation presentations from the community are required. To avoid misconception, we need to rehearse or have the mini-lesson before the actual lesson presentation	We need more time on preparation and include more different cultural practices	The community should be made friendly to the making more videos. This means few people to be selected so that interaction is much each. Too many people get excited. We should work with our Indigenous Knowledge Custodians to train us and provide us with more cultural tools. We need to watch the video together to pick out some possible misconception that can hinder teaching and thereafter, peer teaching to help us to identify any	Integration of Indigenous technologies to be done on other subjects like physics, biology and others

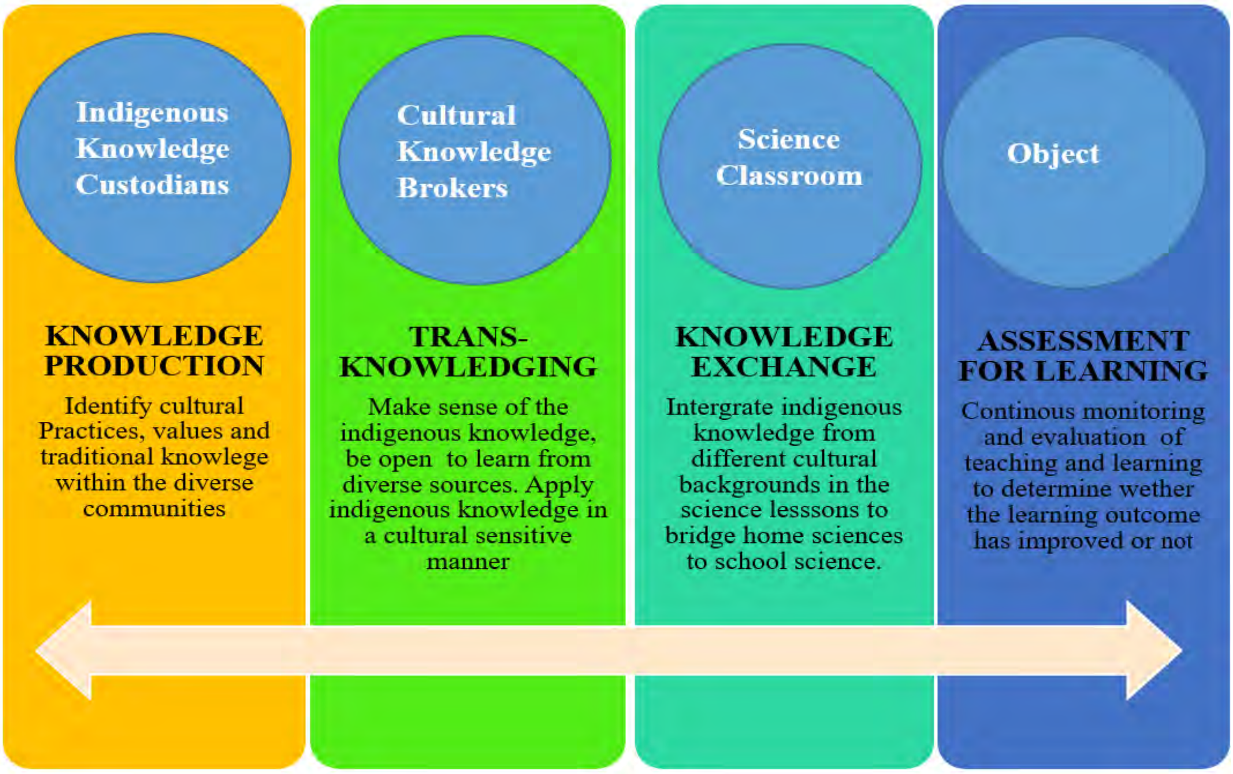
				possible misconception that can arise	
8. How do you feel about Ms Mika and community experts working with you, engaging in professional activities within professional learning communities?	So good because we were linked to community members who are more knowledgeable and this assisted us to teach chemistry concepts	Feeling very well, those types of practices are mostly needed because it makes teachers work easier and enjoyable especially when you interacting with more knowledgeable ones	It is a good experience and felt the spirit of Ubuntu among us and very professional at the same time	It was very helpful as it really showed me how Indigenous technological practices could be integrated and was very good for my professional development as we could link document to practice	Proud, because there are lot of things that were done related to things learnt in the syllabus
9. How does the integration of Indigenous technologies of marula oil extraction may impact (or not) your learners' scientific concept sense making?	Leaners gained interest and link their prior knowledge to science concepts	It is conceptualised teaching that enhance critical thinking amongst the community and the learners	The integration enhances conceptual understanding and this could be seen from active participation of the learners	Make sense because learners could link scientific concepts to their indigenous practices	Enabled me as the teacher to teach science concepts easier

Appendix O: Cultural Responsive Teaching Reflective Tool (Mika, 2024)



Element	**Description**	**Relevance to the Study**
Community involvement	Teachers and communities need to collaborate and share cultural knowledge that impact the classroom environment.	To promote Cultural Knowledge Brokerage Both-Ways of Knowing and Two-Eyed-Seeing
Teachers' Professional needs	Teachers' professional needs are characterised by lack of teaching and learning support materials, lack of relevant teaching pedagogies and trainings.	Working with the Indigenous Knowledge Custodians and Cultural Knowledge Brokers enabled professional development that is cultural responsive
Embracing cultural diversity	Teachers understanding and consideration of multicultural classrooms.	Ability for the teachers to bridge the gaps between the learners' cultural knowledge and the and the school science
Cultural learning tools	These are cultural resources that science teachers use in science teaching.	Teachers need to be Cultural Knowledge Brokers who can use the tools that are based on the learners' background and promote the voice of Indigenous Knowledge Custodians
Reflection on cultural knowledge and teaching	Critical examination of teaching and learning to improve the quality of the lesson enactment.	Teachers to critically examine the impact of IK on teaching and learning to avoid misconception

Appendix P: Cultural Brokering Framework for Science Teaching and Learning (Mika, 2024)



Component	**Description**	**Relevance to the study**
Knowledge Production	Indigenous knowledge custodians are the producers of cultural knowledge. This knowledge includes cultural practices, values and traditional knowledge within diverse communities.	Teachers to work in collaboration with Indigenous knowledge custodians and identify cultural knowledge that is relevant in science teaching and learning integration.
Trans-Knowledging	Cultural knowledge brokers are expected to translate and scrutinise the knowledge from the Indigenous Knowledge Custodians and make it accessible and useful to a diverse cultural group.	Teachers as cultural knowledge brokers should make sense of Indigenous knowledge and apply it to teaching and learning in a culturally sensitive manner.
Knowledge Exchange	Teachers as cultural knowledge brokers are expected to use what Coleman et al. (2021) referred to as transknowledging pedagogy in their science lessons.	Teachers should use different cultural examples, code-switching and translation to assist the learners in concept meaning making and sense making.
Assessment for Learning	The object of cultural brokering in science teaching and learning is to improve the learning outcome. This needs to be assessed.	Teachers to continuously monitor and evaluate teaching and learning of lessons that integrate Indigenous knowledge by means of assessment of learning.

Appendix Q: Participants Written Consents for their Faces not to be Covered

To Whom it may Concern

To the Researcher(s) of *Integration of Indigenous Technologies in Teaching Science*

I, Scientist a research Participant is hereby confirm that I give my full consent for my face to be visible in all images and videos included in the research findings chapters of the thesis. I do not wish for my face to be hidden.

I take pride in my participation in this research and acknowledge my presence as an affirmation of Ubuntu and African cultural identity. I have no objections to being seen in video clips and pictures used for this academic work.

Yours

....

Participant: Scientist

Consent Letter For Research Conducted
Name: Nelago

To you Ms Rauha Mika

As an African scholar who holds the principles of Ubuntu in high regard, I, Nelago proudly give my consent for my image and likeness to be presented in the research findings chapters of the thesis. I was a participant for the study researched about integration of Indigenous Technologies in teaching grade 11Chemistry concepts in 2022.

I believe that knowledge and heritage should be shared openly and honestly. In this spirit, I affirm that I have no issue with my face being seen in pictures and videos included in the research. My participation in this study is a mark of pride, and I am so happy.

With my Regards

Nelago

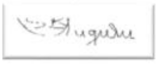
Consent Letter

To Whom It May Concern

I, Theoretical, hereby grant my full consent to the researcher of the study for research conducted on integration of Indigenous Technologies in Teaching Science the year 2022 to use my images and videos without covering my face in any way. I understand that these visual materials are presented in the research findings chapters of the thesis.

As a proud advocate of Ubuntu and African cultural values, I believe that my identity should be fully represented. I do not object to my images being seen in video clips and pictures within the research documentation.

Sincerely



Mr Theoretical
Research Participant

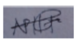
From: Panduleni
Research Participant

Dear Ms Mika

I am honored to have been a part of the research on Integration of Cultural Technologies in Teaching Science that was conducted in March 2022. With great pride and confidence, I hereby grant permission for my images and videos to be used in the research presentation without any modifications on my face.

I believe it is important for my identity to remain visible in the presentation of this research. I take no issue with being seen in videos and pictures. I am happy for the opportunity I had to contribute to the knowledge and cultural heritage shared in this study.

With my full consent and appreciation, I thank you



Panduleni

Brave
Okahandja
03 March 2025

To the Research Team,

I, Brave, grant permission for my face to be openly displayed in the images and videos presented in the research findings of Ms R. Mika' Research. I was one of her participants.

I believe that education is a shared journey, and knowledge should be embraced with visibility and integrity. Therefore, I do not wish for my face to be blurred or covered. My contribution to this research is a testament to my cultural pride, and I welcome its open presentation.

With gratitude and full consent

Brave

Appendix R: Explanation Letter for Happiness Participation in the Research

Happiness
Okahandja
Namibia

Attention to: Ethics Committee
Rhodes University

Subject: Explanation of Participation in the Research Study

Dear Ethics Committee Members

I am writing to formally provide an explanation regarding my participation in the educational research study conducted in the year 2022.The research was about integrating Indigenous and cultural technologies in teaching Chemistry lessons.

I participated in Phase One of the study, specifically in the semi-structured interviews. During this phase, I engaged fully and contributed my insights as per the research objectives. However, as the study progressed to Phase Two, particularly prior to the orientation workshop, I encountered an unforeseen family-related circumstances beyond my control. Due to these personal matters, I was unable to attend the workshops and regrettably, I could not continue with the successive phases of the research.

Despite my inability to proceed further, I remained interested in the research and fully acknowledge its importance. I hereby grant full permission for my interview data collected during Phase One to be used in the research analysis as per the original research objectives.

I appreciate your understanding of my situation and your consideration of this explanation. Should you require any further information or clarification, please do not hesitate to contact me.

Sincerely,

…………………………………

Happiness
Research Participant