EMPOWERING GRADE 10 TEACHERS TO BECOME CULTURAL KNOWLEDGE BROKERS WHEN TEACHING CHEMISTRY IN NAMIBIAN SCHOOLS

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ABSTRACT

The integration of Indigenous Knowledge (IK) in science teaching remains a challenge for most science teachers in Namibian schools. It is against this background that this study used the indigenous technologies of preserving *Mahangu*, pounding *Mahangu*, and making *Oshikundu* as examples of how chemistry lessons can be contextualised, made relevant, and accessible to learners. This study addresses the existing gap in the literature by actively involving chemistry teachers with Indigenous Knowledge Custodians (IKCs) in practical demonstrations. Previous studies have not taken the step of engaging teachers directly with these custodians to learn about the preservation of *Mahangu*, the process of pounding *Mahangu*, and the making of *Oshikundu*. A qualitative case study research design was employed and underpinned by an indigenous research paradigm. Five chemistry teachers, two IKCs, and a critical friend voluntarily participated in this study. Data was generated from practical demonstrations, participatory observation, and journal reflections. Concepts from Vygotsky's socio-cultural theory were employed as theoretical lenses to analyse the data. The findings of this study revealed that the chemistry teachers were able to identify and learn some chemistry-related concepts during the practical demonstrations by the IKCs. One implication of this study is that continuing professional development is imperative for chemistry teachers. We thus recommend that chemistry teachers tap into the cultural heritage of IKCs to become cultural knowledge brokers who can make science relatable and comprehensible to learners.

Keywords: Chemistry; scientific knowledge, Indigenous Knowledge, Indigenous Knowledge Custodians, indigenous research paradigm, socio-cultural theory

INTRODUCTION

Indigenous Knowledge (IK) is embedded in the cultural practices of Indigenous peoples. It has been passed on from one generation to the next orally, and through observing and engaging in traditional practices. It is, thus, the body of knowledge that belongs to certain communities but has evolved (Klein, 2011; Mhakure and Mushaikwa, 2014; Shizha, 2016). This hands-on approach was intended to contextualise and bridge the gap between Western scientific concepts and indigenous practices. By doing so, the study sought to enhance the integration of culturally relevant knowledge into the science curriculum, fostering a deeper understanding and appreciation of both Indigenous and Western scientific knowledge among chemistry teachers, and it was hoped that, ultimately, the learners would be the beneficiaries.

Essentially, learners are exposed to practical indigenous practices that are done daily in their homes or communities. Yet, when scientific knowledge is introduced in the science classroom, learners become disoriented and experience what Le Grange (2007) refers to as cognitive dissonance. According to Le Grange (2007), science is not relevant to the learners' everyday lives unless it is linked to their experiences (Gwekwerere, 2016). Against this caveat, this study contends that science teachers need to act as cultural knowledge brokers so that learners can traverse between scientific knowledge and IK to avoid cognitive dissonance. For instance, the first author was exposed to different indigenous practices during his youth, such as the making of *Ombike,* which were sadly not integrated into science teaching and learning at school. Yet, science concepts can be enhanced using these indigenous practices. One way to achieve this is for science teachers to engage community members, herein referred to as IKCs, in science teaching to unearth or surface the scientific explanations embedded in the cultural activities they do daily.

Thus, in this article, we present, analyse, and discuss data generated from tapping into the cultural heritage of Indigenous people through practical demonstration and observation on the preservation of [1]*Mahangu*, pounding of *Mahangu* using a mortar and pestle, making of *Oshikundu*, and participants' reflections. The data was geared to provide answers to the following research question: *How do Grade 10 chemistry teachers interact, participate, and learn (or not) when participating in these indigenous practices?*

LITERATURE REVIEW

Africanisation of the science curriculum

The Namibian science curriculum does not explicitly guide science teachers on how to indigenise the curriculum during science lessons. Instead, the science curriculum is too Eurocentric and does not connect to the environment or context where the learners are coming from. As a result, in under-resourced rural schools in Namibia it is difficult for science teachers to teach scientific processes that require practical demonstrations. In this regard, Boisselle (2016) articulates that decolonising science and science education might be possible through practices that are primarily contextually respectful and responsive. Concurring, Sayed, Motala and Hoffman (2017) affirm that decolonising of science curricula allows the educators to expose student teachers to IK that is inclusive in science classrooms. Decolonising the science curriculum helps teachers work with community members to teach science. It also allows science teachers to engage

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[1] *Mahangu* are pearl millets mostly grown in the Northern and Northeastern parts of Namibia as a major source of food (Hashondili, 2020)

in professional learning communities (PLCs), enabling them to integrate IK into their science lessons. It is against this backdrop that Mukwambo, Ngcoza and Chikunda (2014) and other scholars call for Africanisation of the school science curriculum. Hence, decolonisation of the science curriculum should start with the universities through integrating IK of Indigenous peoples (Le Grange, 2020; Le Grange, Du Preez, Ramrathan and Blignaut, 2020; Mutanho, 2021).

Africanisation of the science curriculum allows teachers to use learners' life experiences to explain science concepts authentically and meaningfully during science learning and teaching. This can be done through integrating IK in science lessons. Arguably, IK is becoming more universal nowadays because of the interaction between people from diverse socio-cultural backgrounds (Mavuru and Ramnarain, 2017), but it still has its roots in the specific culture where it originated. In this regard, Dziva, Mpofu and Kusure (2011) contend that IK is not static, but it evolves and changes as it develops. Furthermore, it is influenced by both internal and external circumstances and interaction with other knowledge systems. IK is nonetheless a body of knowledge belonging to certain communities (Klein, 2011; Mapara, 2009; Mhakure and Mushaikwa, 2014). According to Dziva et al. (2011), IK is an all-inclusive and holistic knowledge that covers technologies and practices that have been and are still used by Indigenous and local people for existence, survival, and adaptation in a variety of environments. It thus has the potential to be used in the form of hands-on practical activities, which can enable teachers and learners to visualise science.

Hands-on practical activities and visualisation

Chemistry engages learners' minds, hands, and language skills through hands-on practical activities (Asheela, Ngcoza and Sewry, 2021; Shinana, Ngcoza and Mavhunga, 2021), enhancing their understanding through simple experiments related to their interests (Kidman, 2011). Learners retain information best when they can see, touch, and discuss it. Chemistry teachers can transform Western scientific contexts in classrooms by carefully integrating IK. Moreover, hands-on practical activities in science encourage analytical and critical skills, fostering an interest in the subject (Ottander and Grelsson, 2006). Teaching science without practical activities is likened to a body without a soul (Millar, 2009), emphasising that science education naturally involves showing as well as telling. Visualisation, defined as transforming data into visual representations to facilitate cognitive processes (Chen, Floridi and Borgo, 2013), helps learners grasp concepts, especially in resource-limited schools. This study uses the IKCs' cultural heritage of *Mahangu* preservation, flour production, and *Oshikundu* making to visualise chemistry topics like reaction rates. While visualisation is prominent in mathematics, using cultural artefacts in chemistry, like *Oshikundu* making, can help learners to understand processes better. Arcavi (2003) notes that visual representations have been used for information and communication since ancient times, and visualisation involves creating, interpreting, and reflecting on images to enhance concept understanding. Using *Mahangu* processes to symbolise reaction rates in factories aids visualisation during site visits, with Siseho (2013) advocating for visual aids to enhance understanding.

Cultural knowledge brokers

Cultural knowledge brokers play a crucial role in bridging the gap between different cultural backgrounds, facilitating understanding, and promoting inclusivity (Aikenhead and Jegede, 1999; Wyatt, de Dousa and Mendenhall, 2017). These individuals possess in-depth knowledge of multiple cultures and use this expertise to navigate cultural differences, ensuring effective communication and collaboration. Their responsibilities include translating cultural norms, values, and practices, fostering trust, advocating for inclusion, and educating others about cultural competence (Cooper, Denner and Lopez, 1999; Wyatt et al., 2017).

The role of cultural knowledge brokers is particularly significant in diverse educational settings. In schools, for instance, cultural knowledge brokers help learners understand and integrate cultural knowledge into their teaching methods, enhancing learners' engagement and learning outcomes (Wyatt et al., 2017). As cultural knowledge brokers, teachers should foster the creation, sharing, and use of IK (Meyer, 2010). This entails guiding how knowledge is produced in science classrooms and demonstrating how the dissemination of such knowledge can enable learners to navigate between their lived experiences and scientific worldviews. Science teachers, in their role as cultural knowledge brokers, should comprehend both the methods and the significance of integrating IK into science education (Meyer, 2010).

The effectiveness of cultural knowledge brokers is supported by various frameworks and theories, such as the socio-cultural theory framework. This theory emphasises the importance of context in learning and teaching. Moreover, science teachers need to adapt their teaching strategies to the specific content and cultural context of their lessons. Teachers can thus create more inclusive and culturally relevant environments, ultimately benefiting both individuals and communities (Marshall, 2023), enabling them to see science with both eyes.

Two-eyed-seeing in teaching chemistry

The concept of 'two-eyed seeing', as described by Hatcher, Bartlett, Marshall and Marshall (2009), entails integrating IK with Western science to enhance the understanding and teaching of scientific concepts. This research used this approach to bridge the gap between IK and Western science (WS) in the context of chemistry education. By integrating Indigenous ways of knowing, the chemistry teachers were better able to understand the different IK levels in the community. Hatcher et al. (2009) emphasise the importance of viewing science from both perspectives, IK and WS, to benefit learners in science classrooms.

Seehawer and Breidlid (2021) further highlight the necessity of dialogue between these knowledge systems. Engaging Indigenous elders in the research provided a transformative and authentic learning experience, operating within indigenous and transformative research paradigms. The collaborative efforts between chemistry teachers and IKCs facilitated co-learning and mutual benefits, as detailed by Hatcher et al. (2009) and Onwu and Mufundirwa (2020). This collaboration fostered a deeper understanding and appreciation of both knowledge systems.

Drawing from Korthagen's (2017) work, the research acknowledges that learning occurs at multiple levels, involving cognitive, emotional, and motivational dimensions. The practical demonstrations, such as making *Oshikundu*, allowed chemistry teachers to experience different learning modalities and contextualise scientific knowledge. This improved their ability to teach chemistry using culturally relevant examples. The IKCs' support revealed significant shifts in the teachers' knowledge and practices, highlighting the value of integrating Western Knowledge Systems.

Preservation of Mahangu

Mahangu, one of the staple foods in northern Namibia, is essential to the diets of the Northern Communal Areas, particularly in the North Central Regions, Kavango, and the Western part of Caprivi, where it is cultivated under rain-fed conditions (Mallet and Du Plessis, 2001). In Namibia, pearl millet, also known as Pennisetum glaucum, bulrush millet, cattail millet, and candle millet, is commonly referred to as *Mahangu*, a crop predominantly grown in the northern regions (Mallet and Du Plessis, 2001). It is crucial to note that pearl millet should not be mistaken for other millets like finger millet (Eleusine coracana), foxtail millet (Setaria italica), common or proso millet (Panicum miliaceum), and fonio (Digitaria exilis), which are not cultivated in Namibia (Mallet and Du Plessis, 2001). There is a lack of recent research on the preservation of *Mahangu*, but Indigenous communities possess a wealth of knowledge on food preservation methods, including drying, fermentation, germination, and soaking (Asogwa, Okoye and Oni, 2017).

These indigenous methods, such as sun drying, are vital for *Mahangu* preservation, often shaped by cultural beliefs and practices. The process begins after ploughing, when *Mahangu* is harvested and sun-dried at a designated place called [2]*Omutala*, one of the oldest preservation methods predating Western influence (Asogwa et al., 2017). Harvested heads of *Mahangu* are initially placed in large [3]*Oshimbale* containers for drying before being threshed by community members, typically women, who often sing to signal neighbours to join them in the task (Mallet and Du Plessis, 2001). Ensuring timely harvesting prevents spoilage from birds, pests, and insects. Threshing and winnowing, the latter using wind to separate grains, are usually carried out by women but can involve men and children (Mallet and Du Plessis, 2001). Post-threshing, *Mahangu* grains are stored in traditional *Okaanda* granaries, made from woven branches and plastered with a mixture of hill soil and cattle dung to protect against pests. This intricate process, maintained by community expertise, underscores the significant role of IK in preserving *Mahangu* (Asogwa et al., 2017; Mallet and Du Plessis, 2001).

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[2] *Omutala* - place where *Mahangu* is sundried

[3] *Oshimbale* - the traditional plate made from palm leaves

Rates of reactions

Rates of reactions should be taught by describing collision theory, the effects of *concentration, pressure, particle size (surface area), catalysts (including inorganic or organic), temperature* and *light.* These factors that affect the rate of reactions are like those observed in the practical activities that were used to be done by community members when making *Oshikundu*. Learners are familiar with the way *Oshikundu* is prepared at home. Therefore, engaging them in daily practical activities done at home to teach factors affecting the rate of reaction can enhance their conceptual understanding. Most Westernised textbooks seem to ignore the use of locally available materials that are commonly available in the communities where learners come from. For instance, a common example in chemistry textbooks when teaching particle sizes is shown below (Surface area).

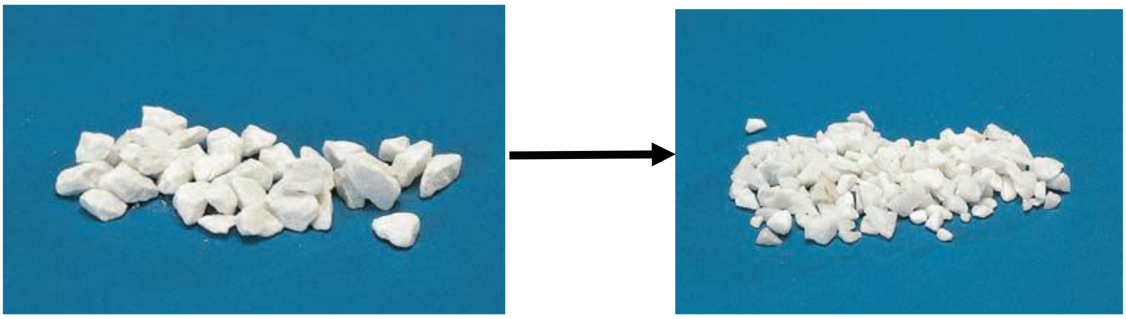

Figure 1: Shows large chips and small chips used in Westernised chemistry textbooks, p. 163

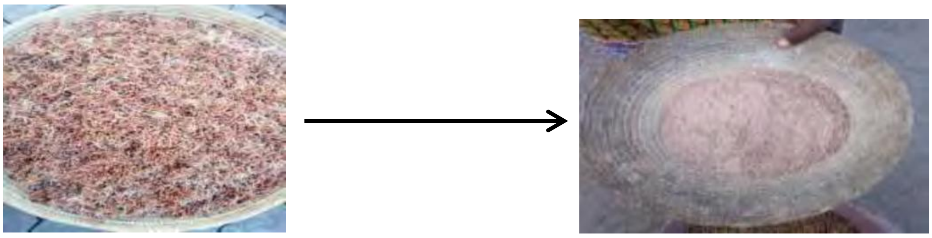

Figure 2: Mahangu pounded into flour to increase surface area

Figures 1 and 2 illustrate that increasing the surface area by breaking large chips into smaller pieces makes the reaction faster by increasing the collision between reactants. The two figures represent different knowledge systems. Figure 1 does not support the learners' understanding that they have gained from home. The use of *Mahangu* grains and flour might replace the use of chips that are not locally available in most secondary schools. The use of marble chips is practised more in Western countries that are developed; in Africa, we need to use African epistemology. Thus, the use of locally available resources/materials that can replace Westernised materials needs to be maximised in hands-on practical activities (Asheela et al., 2021).

THEORETICAL FRAMEWORK

The theoretical framework for this research is based on Vygotsky's (1978) socio-cultural theory (SCT). This theory highlights the importance of culture and beliefs in learning, which influence how learners acquire knowledge. Vygotsky (1978) illustrates these ideas through concepts such as culture, learning, social interactions, mediation of learning, and the zone of proximal development. These concepts served as lenses to analyse the data. Vygotsky (1978) asserts that human learning is inherently social, involving a process by which children grow into the intellectual life of those around them. This theory posits that human activities occur in cultural contexts and are mediated by language and other symbolic systems (John-Steiner and Mahn, 1996). Mediation is the key to understanding how human mental functioning is tied to cultural, institutional, and historical settings, which shape and provide the cultural tools mastered by individuals to form this functioning. Vygotsky's theory promotes gradual changes through social contact and language, which evolve with development. He believed that learners construct their own knowledge through interactions with others (Blake and Pope, 2008).

Teaching acids and bases in the Namibian context

Teaching acids and bases using IK in Namibian schools involves integrating local materials and traditional practices into science education. For instance, teachers can use substances like *Oshikundu* (a traditional drink made from *Mahangu* flour and sorghum) and *Omutoko* (wood ash) to demonstrate acidic and alkaline properties. This approach not only makes the lessons more relatable and engaging for learners but also helps preserve and promote IK. According to Simasiku and Ngcoza (2024), using these local substances in chemistry lessons can enhance learners' sense-making of scientific concepts by connecting them to their everyday experiences.

The integration of IK into science education aligns with the SCT (Vygotsky, 1978), which emphasises the importance of context in learning. By using familiar materials and practices, teachers can create a more inclusive and culturally relevant learning environment. This method also supports the Pedagogical Content Knowledge (PCK) (Shulman, 1986) framework, which highlights the need for teachers to adapt their instructional strategies to the specific content and context of their lessons. As noted by Abah, Mashebe and Denuga (2015), this approach can lead to improved learner engagement. Moreover, involving IKCs in the teaching process can provide valuable insights and foster a sense of community and collaboration. This co-learning approach not only benefits learners but also helps teachers develop a deeper appreciation for IK in their teaching. Aikenhead and Jegede (1999) emphasise that cross-cultural science education can be a powerful tool for bridging different ways of knowing, using two-eyed-seeing in teaching.

METHODOLOGY

Research paradigm

In this study, the indigenous research paradigm was used to describe the real phenomena surrounding the PLCs of chemistry teachers when mobilising indigenous practices in the integration of IK in science classrooms or lessons. We worked with the IKCs to explain to chemistry teachers how *Mahangu* is preserved, how they make *Mahangu* flour, and how they make *Oshikundu,* and this has all three aspects (past-present-future). Ubuntu comprises philosophical values such as the nature of social reality (ontology), ways of knowing (epistemology), and ethics and value systems (axiology) (Seehawer, 2018). This helped us to be engaged during the practical demonstration and ask further questions to the IKCs. This research helped us have an interest in and value the knowledge of community members and conduct this research in a manner that helps everyone freely contribute their knowledge. *Ubuntu* refers to an ontology and way of living that has significant differences from those of Western paradigms (Keane, 2008). Thus, this paradigm acknowledges the relationship between the researcher and the participants.

Research design

This study employed a qualitative case study design to empower chemistry cultural knowledge brokers in teaching chemistry in the secondary school curriculum in Namibia. By focusing on in-depth exploration through practical demonstration and reflective journals, this approach facilitated a comprehensive understanding of teachers' experiences. Workshops introduced teachers to the integration of IK, for example, the process of making *Oshikundu*, bridging it with Western knowledge (Asheela et al., 2021).

This study involved five chemistry teachers and two IKCs who did the practical demonstrations of pounding *Mahangu* to make flour and the preparation of *Oshikundu*. The chemistry teachers were from two secondary schools and one combined school in the Endola circuit, Ohangwena region. Consistent with the Ubuntu perspective, participants chose to use their names that are known by everyone, indicating that they are proud of the knowledge they contributed to this research. The names of the chemistry teachers were Michael, Sebron, Ndeshi, Shipefi, and Tala. The IKCs were [4]Mee Mukwaluvala and Mee Mukwamhani.

Data-generating methods

Data for this paper were generated from practical demonstration, participatory observation and reflections of the participants.

Practical demonstration and participatory observation

Practical demonstration and participatory observation took place at the houses of the IKCs. The 1st visit focused on the IKCs explaining the preservation of *Mahangu*, the pounding of *Mahangu* to make flour using a mortar and pestle, and the preparation of *Oshikundu*. Mee Mukwaluvala and Mee Mukwamhani

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[4] Mee stands for female person in Oshiwambo culture in Namibia and is used to portray respect to the person

explained to the teachers the ingredients used, why such ingredients were used and what apparatuses are used in making *Oshikundu*. The purpose of the 2nd visit was to observe the rate of reaction process, test the gas released with lime water and with a glowing splinter, and test for *Oshikundu* as an acid or base. Chemistry teachers were allowed to ask questions for the community members to answer.

Reflections of participants

Reflection is an important step for qualitative researchers to address imperfections in data analysis (Roller and Lavrakes, 2015). The chemistry teachers worked in groups of two and came up with mind maps that resulted in concept maps during the reflective workshop. They used their reflection journals to help them with concepts that emerged during the practical demonstration from the IKCs. Chemistry teachers could use all the concepts that emerged during practical demonstrations.

Data analysis

The generated data was colour-coded to generate sub-themes and themes. Walker and Myrick (2006) define coding as conceptualising data by a constant comparison of incidents with incidents, and incidents with concepts. Coding is the process of reading carefully through transcribed data, line by line, and dividing it into meaningful analytical units (Creswell, Ebersohn, Eloff, Ferreira, Ivankova, Jansen, Nieuwenhuis, Pietersen and Plano Clark, 2016). Coding includes marking the segments of data with symbols, descriptive words or unique identifying names (Creswell et al., 2016). Data were analysed using thematic data analysis, and themes emerged from the data.

FINDINGS AND DISCUSSIONS

The findings revealed that teachers acquired knowledge after the practical demonstrations by the IKCs.

Theme 1: Chemistry teachers and IKCs' social interactions

Analysing the excerpts from the interaction between the chemistry teachers and IKCs helped them to have a cohesive interaction that allowed them to understand the science concepts embedded in their indigenous practices. For instance, Tala and Ndeshi engaged Mee Mukwaluvala and Mee Mukwamhani:

> Tala: *Meekulu otamu dulu okuya mutu kwafele, Omolwashike Oshikundu inashi pya? (Meekulu, you can come help us here. Why is this Oshikundu not ready?)*
> Mee Mukwamhani: *Oshaya <u>Ongudo</u> ile inashi tulwa sha? (Did we add Ongudo or not?)*
> Tala: *Shimwe osha tulwa Ongudo, shimwe inashi yasha, ashike eshi nge toshi late oshafa shapya, oshili ngoo ngaho… (We put Ongudo in the other one, we did not put in the other one, but this one, if you look at it, it's like it's ready, it's just like that...)*

> Ndeshi: *Oshafa ngoo ngeno opo tashi tameke nee okupya (It is like it has started to ferment).*
>
> Mee Mukwamhani: *Oshaya* ehete *ile inashiya? (Did we put ehete or did we not?)*
>
> Ndeshi: *Ahawe inashiya (No, we did not put it).*
>
> Mee Mukwamhani: *Itashipi shashi inashi ya ehete. (It cannot ferment because we did not put ehete in).*
>
> Tala: *Ehete lovene oshike naana moshikundu? Oha li etamo naana shike moshikundu? Efatululo olo unene twa hala (Ehete itself, what is it in Oshikundu? It brings what in Oshikundu? Explanation is what we want to hear).*
>
> Mee Mukwamhani: *Ehete olo hali pifa Oshikundu, olo onafi yoshikundu, olo onafi yomalondu (Ehete allows Oshikundu to ferment, the onafi/residues/dregs of Oshikundu and onafi/residues of Omalondu)*

From this vignette, it could be surmised that these teachers engaged Mee Mukwaluvala and Mee Mukwamhani to further explain their IK of making *Oshikundu*. This resonates with Vygotsky's (1978) SCT on social interaction and language used as cultural tools to make learning meaningful. The social interactions allowed the teachers to have a better understanding of the process involved in making *Oshikundu*.

Analysing the responses from Mee Mukwamhani, before making the final answer, she asked about [5]*Ongudo* and [6]*ehete,* as these two play a vital role in allowing *Oshikundu* to ferment. *Oshikundu* cannot be fermented without *Ongudo* and *ehete*, even though the IKCs could not further explain the roles of *Ongudo* and *ehete* in making *Oshikundu* ferment. This made teachers understand that *Ongudo* is rich in carbohydrates (activation energy) and *ehete* has active microorganisms that feed on *Ongudo* to make *Oshikundu* ready and release CO_2. Mavhunga and Kibirige (2018) and Seehawer (2018) indicate that teachers integrate IK in science lessons when they have been in peer-learning communities, and they further challenge that a lack of training might hinder the integration of IK in science lessons. For example, the preservation of *Mahangu* yielded scientific knowledge of why Indigenous people sundry their harvest before threshing them and later storing them. Sun drying increases the lifespan of the seeds. Sun drying also helps the chaff and the grain be separated easily. It is difficult to separate chaff and *Mahangu* grains that are not completely dry.

The practical demonstrations helped chemistry teachers' knowledge as they discovered new knowledge that was useful in chemistry classrooms. Teachers

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[5] *Ongudo* is a dormant catalyst

[6] *Ehete* is an active catalyst/dregs

tested *Oshikundu* to see whether it was acidic or basic/alkaline. This was new knowledge to some participants, as they had not thought of using *Oshikundu* to test for acids and bases. Participants engaged with each other and learnt that *Oshikundu* was an acid after testing it with litmus paper (both blue and red), as noted from their discussions in this vignette below:

> *Sebron: This is a blue litmus paper. If it remains blue, it's alkaline. If it turns red, then it is an acid.*
> *Shipefi: Turning red, it's an acid.*
> *Tala: Tashi ti Oshikundu oshina oacid.*
> *Shipefi: Yes, it's acidic.*
> *Me: Take the other one and repeat the test.*
> *Ndeshi: Repeat the experiment.*
> *Tala: To prove it.*
> *Shipefi: Put the red one again. Do not remove it, it will remain red, it will remain red.*
> *Tala: So Oshikundu is an acid.*

Interestingly, it is evident from this vignette that Tala was not aware that *Oshikundu* became acidic when left to ferment over a long period, but this was discovered during the hands-on practical activity (Asheela et al., 2021). Active engagement of participants helped the teachers to learn from each other and learn the science that is embedded in cultural practices. Drawing from Vygotsky's (1978) SCT, learning is integration into the community of practices, in which social interaction plays a role in acquiring knowledge. The chemistry teachers were engaged in social interaction using language to learn from the IKCs and each other. Working with IKCs helped teachers view and understand the curriculum that supports the integration of IK in science teaching. This curriculum is intended to allow teachers to use the IK within learners' intermediate environments that are relevant to the topics that are taught in science classrooms. For example, in this study, *Oshikundu* can be used to teach the topics in Table 1 as illustrated by participants.

Table 1: Shows the relevance between Westernised science and IK

Western topics	**Local examples**
Experimental techniques	*Okuxwa, Okuyela* and *Okufifwa* are practical examples that are used to separate the mixture by Indigenous people.
Rates of reactions	The stages involved in preparing *Oshikundu* allow teachers to use those examples when teaching the factors affecting the rate of reactions. For example, temperature, particle size, concentrations and catalysts could be taught.
Acid and Bases	*Oshikundu* was tested for its acidity and alkalinity to determine whether it

Western topics	**Local examples**
	was an acid or a base. Using litmus paper (blue and red), the blue litmus paper turned red, and the red litmus paper remained red. This result shows that *Oshikundu* is an acid. The sour taste of *Oshikundu* is also a good example of a characteristic of an acid.
The mole concept	The flour proportion when making *Oshikundu* is a good example to introduce mole concepts.

Integrating IK into the chemistry classroom will help teachers use relevant resources that are common in the local environment. The examples above are relevant when making *Oshikundu*.

Theme 2: Hands-on practical activities influence learning

The IKCs followed these instructions to make *Oshikundu*:

- Fine *Mahangu* flour that is properly sieved must be used.
- Sorghum seeds need to undergo germination to increase their nutritional level.
- Warm water must be used to cook *Mahangu* flour, and thereafter, cold water has to be added before *Ongudo* and *ehete* are added, to avoid denaturing the enzymes.
- *Ongudo* is added first before *ehete,* not vice versa.
- *Ongudo* has big particles that will later turn into *ehete.*
- *Oshikundu* is not tightly closed to allow the gas (CO_2) released during fermentation to escape from the containers.

This research drew on Asheela et al.’s (2021) study, in which they used easily accessible resources to conduct hands-on practical activities in the science classroom, to unearth the scientific knowledge embedded in the local process of making Oshikundu. Easily accessible resources helped the chemistry teachers learn and re-contextualise the knowledge they gained during hands-on practical activities. For instance, Mee Mukwaluvala and Mee Mukwamhani used easily available resources to conduct practical demonstrations for chemistry teachers to observe and participate in the brewing of *Oshikundu*. Asheela et al. (2021) introduced predict-explain-explore-observe-explain in practical activities in science classrooms. Shinana et al. (2021:1) used the “principles of classroom inquiry together with the model of inquiry-based science instruction, predict-explain-explore-observe-explain, were used to scaffold teachers towards the PCK for inquiry-based teaching”.

During practical demonstrations and participatory observation, teachers were unable to predict the initial steps in PEEOE introduced by Asheela et al. (2021) and Shinana et al. (2021). These demonstrations allowed chemistry teachers to collaborate with expert community members on activities such as preserving Mahangu, pounding Mahangu to make flour, and preparing *Oshikundu*. These cultural activities facilitated teachers' learning and integration of new knowledge. Typically, science teachers associate practical work with laboratory settings. However, in this research, the practical demonstration took place outdoors and within the community, far from the school environment. This out-of-school context enhanced teachers' conceptual understanding and improved their pedagogical strategies. For instance, using Oshikundu to collect carbon dioxide (CO_2) for testing with limewater encouraged teachers to move beyond textbook-based understanding and explore their surrounding environment when teaching science concepts. Figure 3 illustrates the results of the experiments conducted.

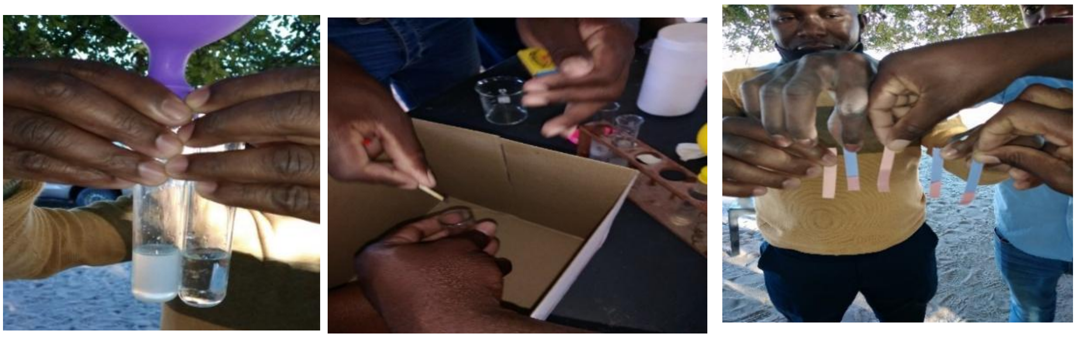

Figure 3: Hands-on practical activities

The table below shows the reaction of *Oshikundu* with *Ongudo* and *ehete*. *Oshikundu* was placed in three different containers with different ingredients to observe the reaction rate of each container.

Table 2: The results of the experiments

Test made	**Results**
Oshikundu with no Ongudo and ehete	*No reaction took place*
Oshikundu with Ongudo (dormant enzymes)	*No reaction took place*
Oshikundu with Ongudo (dormant enyzmes) and ehete (active enzymes)	*The balloon inflated with* CO_2 *and bubbles could be observed*
Carbon dioxide tested with lime water	*Lime water turned milky*
Carbon dioxide tested with a glowing splinter	*Glowing splinter went off*
Oshikundu tested for acidity and alkalinity	• *Red litmus paper remained red* • *Blue litmus paper turned red*

As tabulated, it was discovered that the *ehete* is the catalyst that has active enzymes that digest the carbohydrates present in *Ongudo*. *Ongudo* itself has dormant enzymes that need time to activate and digest the carbohydrates in *Ongudo*. The relations between Westernised science and indigenous technologies in chemistry teaching were evident during practical activities. The chemistry teachers linked the practical activities on factors affecting the rate of reaction to the practical activities done during the *Oshikundu* preparation process.

IK can be used to teach different topics in chemistry, as illustrated in Table 3 below. *Oshikundu* could be used to teach the topic concerning Westernised science.

Table 3: Co-existing knowledge between Westernised science and IK

Factors that affect the rate of reactions	**Community members' experiences**
Catalyst/Enzymes	They add *Ongudo* and *ehete* to *Oshikundu* and other alcohols
Temperature	They boil the water for preparing *Oshikundu,* and if they want *Oshikundu* to be ready in a short time, they put it in the sunlight
Pressure	The container where *Oshikundu* is prepared is not tightly sealed; they let the air escape
Particle size/surface area	They pound *Mahangu* and *Sorghum* grains to increase the surface area

Table 3 summarises how the factors affecting the rate of reactions could be taught using IK that is familiar to the learners.

Language used as a cultural tool in mediating learning

Chemistry teachers reflected on how they acquired knowledge during practical demonstrations using language and cultural tools:

> *Sebron: My interaction with Indigenous Knowledge Custodians helped me to understand the science behind preparing Oshikundu, and it helped me to know that engaging parents' experience in our science education will really help them to understand the concepts better than just using knowledge from the textbook (Western knowledge). I also learnt that real science starts from home and that learners are born with the knowledge; they just need to be boosted.*
>
> *Ndeshi: Asking questions for further explanation. I also did some of the work, like Okutwa (pounding), and Okufifa (sieving) of Mahangu during the preparation of the flour. During this practical, I also took part in the preparation of Mahangu flour; that is, pounding. I learnt a lot through asking questions as to why a certain aspect is to be done and how. Taking part in this activity enriched me as a chemistry teacher because I will simply apply this knowledge and integrate it into my lessons.*

The excerpts from two chemistry teachers illustrate the activities they did during the practical demonstrations. Sebron, on his part, acquired knowledge and gained new skills as he was less knowledgeable about *Okutwa, Okufifa* and other activities. Learning was nurtured through using Vygotsky's (1978) concept of social interaction between chemistry teachers and the IKCs. Language plays a big role during social interactions, and the language used was *Oshikwanyama* (local language). New terminologies emerged during practical demonstrations, of which teachers were not aware. Mee Mukwaluvala, Mee Mukwamhani, and the chemistry teachers were actively interacting with each other, as language was not a barrier to them. This allowed teachers to cross-fertilise the knowledge that emerged from the local language into Westernised science. Language played a role in allowing community members to mediate the practical demonstration that was carried out. IK is embedded in the language and the culture of the people. The local language was used to give the community members the freedom to express themselves easily without being intimidated by the language used. This allowed community members to be more vocal and not to be undermined by the teachers if English was used during practical demonstrations.

It was evident that teachers paid more attention during practical demonstrations and participatory observation for them to grasp new science concepts/content from the activities. Mee Mukwaluvala, Mee Mukwamhani, and the chemistry teachers' engagement were observed, and questions were asked for further clarification. One interesting aspect observed was the respect between chemistry teachers and IKCs; when one talked, the others listened and asked questions or explained further. This was because the language used accommodated everyone, and they were eager to learn from the IKCs about the scientific knowledge embedded in the preservation of *Mahangu*, the pounding of *Mahangu* to make flour, and the making of *Oshikundu*.

Ma (2008) finds that discussions allow learners and teachers to be engaged, listen, think, and read more to be able to give their thoughts on the topic. Lemke (1990) claims that learners pay more attention when a local language is used in a science classroom than an unfamiliar scientific language. Mee Mukwaluvala, Mee Mukwamhani, and the chemistry teachers worked together in harmony because a familiar language was used. Probyn (2009) clarified that the mother tongue might help learners to understand the concepts. Language played a role when IKCs explained the process happening in the local communities.

CONCLUSION AND RECOMMENDATIONS

The findings that emerged from our visits to the IKCs' houses and the practical demonstrations that were done revealed that scientific knowledge is embedded in the activities that are done in the local communities. We need to bring it from context to content, and that can only be achieved when science teachers understand the role of community members in science lessons. We further recommend that science teachers be involved in PLC for them to be aware of the IK the community members are using daily. We suggest that the number of chemistry teachers needs to be increased for them to be aware of how

Westernised science could be contextualised to integrate IK. Science teachers need to be cultural knowledge brokers who can integrate IK in their lessons.

Workshops need to be planned for Grade 10 and 11 chemistry teachers in the region to undergo a similar process. The two IKCs and five chemistry teachers will be resourceful during the workshops as they are knowledgeable in how Westernised science could be contextualised. The PLC needs to be enhanced, and teachers need to start valuing the knowledge from the local community in their chemistry teaching. A PLC should cover all possible content that has IK in it for the teachers to be able to unpack the knowledge embedded in local science. The use of artefacts from the local community in science classrooms should be encouraged, and chemistry teachers need to be aware of the value they add in enhancing learners' understanding.

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