Understanding Heat Energy Conservation: Using Traditional Brick Making in a Grade 7 Natural Sciences Class in a Rural School

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By

Lindiwe Priscilla Godlo

Supervisor: Prof Kenneth Mlungisi Ngcoza

Co-supervisor: Dr Chrispen Mutanho

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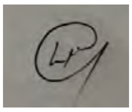
Declaration of Originality

I Lindiwe Priscilla Godlo (17G6603) declare that this thesis has not been submitted for a degree in any other university apart from Rhodes University and I declare that it is my work, written in my own original words. It has only been submitted for the master's degree at Rhodes University. Where I have cited the words or ideas of other researchers, these have been acknowledged using complete references according to the Departmental guidelines.

Signature:  Date: January 2024

Dedication

I dedicate this study to the Lord and Saviour of my life, Jesus Christ. His word in Phillipians 4:13 kept on assuring me that I can do all things through Him who gives me strength. He is the reason I kept sound wisdom and discretion and walked safely in my research journey against all odds. Secondly. I cannot forget my late grandmother, Ellen 'Manqana' (clan name) Nxesi. Her cultural wisdom, knowledge and skills inspired me to conduct this study. May you continue to rest in peace *'gogo induku wayibeka ebandla*' (you guided me to become the woman I am today, who value her cultural background despite my religious affiliation).

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Abstract

Learners seemed to experience cognitive dissonance on the topic of the conservation of heat energy. My assumption is that this might be due to cognitive dissonance or conflict that learners seem to experience in science classrooms. This means the way science teachers teach science does not form part of learners' contexts and hence has no relevance to them. To ameliorate this dilemma, the South African Curriculum and Assessment Policy Statement (CAPS) document requires teachers to integrate indigenous knowledge into science teaching and learning but does not provide explicit methods on how to do it. It is against this backdrop that this study explored how the use of traditional brick making method can support learners to make sense of the topic of conservation of heat energy.

Underpinned by the interpretivist and Indigenous research paradigms, a qualitative case study design was employed. Twenty-four Grade 7 Natural Sciences learners, four indigenous knowledge custodians (IKCs) (who were all women), and a critical friend participated in this study. Data sets were generated through several methods: learner group activity; participatory and lesson observations; a sharing circle; and learners' reflective journals. Vygotsky's Sociocultural Theory and Ogunniyi's Contiguity Argumentative Theory were used as theoretical lenses to analyse data.

The findings revealed that during the demonstration by the IKCs, learners were able to identify science concepts related to the conservation of heat energy which means they understood the science concept. Learners' argumentation and sense-making of the aforementioned topic and related concepts greatly improved. Based on the research findings, I thus recommend that teachers should tap into IKCs' cultural heritage to contextualise and make science relevant and more meaningful to learners.

Keywords: Natural Sciences, conservation of heat energy, indigenous knowledge, Ubuntu, sociocultural theory.

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Abbreviations and/or Acronyms

CAPS: Curriculum and Assessment Policy Statement

CAT: Contiguity Argumentation Theory

DAIM: Dialogical Argumentation Instructional Model

DBE: Department of Basic Education

IKCs: Indigenous Knowledge Custodians

IK: Indigenous Knowledge

LJR: Learner Journal Reflections

MKO: More Knowledgeable Other

PASER: Pan African Science Education Research

SCI: Sharing Circles Interviews

SCT: Sociocultural Theory

TIMSS: Trends in International Mathematics and Science Study

TMESD: Transformative Model of Education for Sustainable Development

WS: Westernised Science

ZPD: Zone of Proximal Development

CHAPTER ONE: SITUATING THE STUDY

1.1 Introduction

In this chapter I situate my research study whose focus was on exploring how mobilising the traditional brickmaking process could support Grade 7 Natural Sciences learners in a rural school to make sense of the topic of conservation of heat energy and related concepts. The study was conducted in the O.R. Tambo Coastal District in the Eastern Cape, South Africa. In the quest for better teaching strategies that can be used to decolonise and transform the science curriculum, I explored learners 'perspectives on the integration of indigenous knowledge (IK) in science teaching and learning in my honour's mini-thesis. The findings of the study revealed that learners were interested in seeing their IK integrated into science. This triggered my interest to find practical strategies that could help me integrate learners 'IK in my science teaching.

Therefore, in this chapter, I start by outlining the background of the study. Next, I describe my personal life experience in terms of IK and science, followed by statement of the problem and the significance of the study. The research goal and research questions that guided this study are also provided. Then, I outline the conceptual and theoretical frameworks that informed this study followed by a thesis outline. Lastly, this chapter ends with the chapter summary.

1.2 Context of the Study

Learners perform poorly in science as they seem to consider it abstract, difficult and boring. More so, the observation that our learners perform poorly in science is evident in one of the findings of Trends in International Mathematics and Science Study (TIMSS) 2019, where only 36% of science learners had acquired the basic scientific knowledge and skills in Grade 9 (Reddy et al., 2022). Moreover, the findings showed that only a small percentage of learners reached the advanced international benchmarks which meant that many countries educate their learners to minimum proficiency and as a result, more than 90% reached the low benchmark. This was evident in the findings in the fourth grade which revealed that 92% of learners who reached the low benchmark had a limited understanding of scientific concepts.

In addition, TIMSS 2019 at Grade 9 (Mullis et al., 2019), revealed that of 39 countries that participated, South Africa attained the lowest scores in science. Essentially, this means learners' poor performance in Grade 12 in science can be attributed to the above-mentioned findings. However, my criticism of the TIMSS is that it does not factor in learners' sociocultural background as espoused by scholars such Mavuru and Ramnarain (2020). Instead, its findings are generalised to all South African learners.

In my 20 years of teaching Natural Sciences, I have noted with concern that learners seem not to find science interesting as they consider it abstract. In particular, the concept of conservation of heat energy has been a challenge to both learners and me. Another contributing factor to this problem is the misconception among learners that emerges because energy is a concept that is used in daily life in a manner that is incompatible with science. For instance, when someone is tired, they would say I have run out of energy. This makes the concept of energy abstract and it is considered one of the concepts challenging the learning of the concept of conservation of heat energy.

More so, the misconceptions that emerge among learners are decontextualised from their life experiences because of how energy is taught. Furthermore, the science content that I have been teaching has been driven by the prescribed curriculum where I would rush to finish the content coverage in the prescribed time for examination purposes without giving learners an opportunity to explore for themselves and make meaning of the concepts learnt. Hence, learners find themselves living in two worlds: they see no link between what is taught at school (Westernised science) and what they are taught or experienced at home or in the community. As a result, they do not perform well in science. My assumption is that this could be due in part to how I teach science as learners struggle to make connections between what is taught in class and their everyday life experiences (Gwekerere, 2016). That is, learners find it difficult to cross over from home or community to school (Aikenhead & Jegede, 1999) and hence experience cognitive dissonance or conflict (Le Grange, 2007).

In addition, when I analysed the South African CAPS document and one of the textbooks that I use to teach Natural Sciences, I found that while the CAPS document explicitly requires integration of IK in science learning and teaching, it hardly contains any specified IK and available materials. Also, the textbook that I analysed is silent on the integration of IK in science in most topics and instead uses examples that are not connected to the learners ' sociocultural backgrounds (Mavuru & Ramnarain, 2020).

It is for this reason that there are national and international policy drives for the integration of learners 'IK in science teaching and learning. These arise from the belief that what is taught in science should form part of the contexts of learners and have relevance for them (Aikenhead & Jegede, 1999; Gwekerere, 2016). In addition, Mayana (2020) believes that one of the reasons for the call to mobilise Indigenous technologies in science teaching is to help learners make sense of some of the concepts taught. Consequently, in the context of transforming and indigenising the science curriculum, integrating IK into science teaching and learning is the most appropriate way (Handayani et al., 2018).

Henceforth, teachers need to recognise that IK and Western Science (WS) can harmonise and work together instead of treating them as two different systems of knowledge. This resonates with Le Grange et al.'s (2020) study which postulates that decolonising the curriculum does not involve destroying all that is westernised but placing it on an equal footing with other ways of knowing such as IK. For example, in the energy and change strand on the topic of conservation of heat energy, the CAPS document requires learners to understand that insulating materials slow down heat transfer, both heat loss and heat gain. This means that heat energy can be conserved using insulating materials that minimise heat loss in winter and heat gain in summer.

At home, for instance, learners live in huts made of mud bricks. So, they need to understand the type of soil used to make the mud bricks and why it is used. They understand that mud does not conduct heat but instead keeps their homes warm in winter and cool in summer. This experience can help them identify science concepts that emerge from their local knowledge of using mud bricks and henceforth contextualise classroom science. In this way understanding scientific concepts such as heat transfer, conservation, insulation, heat gain and heat loss using local knowledge might be easier and clearer as it will be grounded in learners 'local knowledge, experiences and sociocultural background (Mavuru & Ramnarain, 2020.)

It is against this backdrop that in this formative interventionist study, I mobilised the Indigenous technology of brickmaking to support a Grade 7 Natural Sciences class in a rural school to make sense of the topic of conservation of heat energy. The study is based on the belief that learners 'IK, which is part of their sociocultural background, might stimulate interest in learning and make science relevant (Gwekwerere, 2016; Mavuru & Ramnarain, 2020). Integration of IK is also seen as imperative for cultural revitalisation as reiterated by scholars such as Cocks et al. (2012) and Smith (1999). Furthermore, such a study has never been done in this topic in South Africa and this is one of the reasons I decided to explore how mobilising traditional method of brickmaking can support my learners to make sense of the topic above.

1.3 My Life Experiences – Crossing the River

In this study, I use the metaphor of crossing the river instead of border crossing as espoused by Aikenhead and Jegede (1999). This was so because in the context of this study, we do not cross borders, but instead, we cross rivers that do not even have bridges.

I grew up in the rural areas of Matatiele, which was then in KwaZulu Natal province but is now in the Eastern Cape province, South Africa. I grew up as a young girl in a cultural home doing all the household chores done at home, helping my mother. One of the household chores I used to do was making a fire to warm the hut in which we lived and to cook food. I also helped my mother smear the floors with cow dung which served as our floor polish.

During my primary school years, going to school was a struggle as we had to cross a huge river that stood between home and school. Sometimes it would rain while we were at school and the river would flood. On these days, parents would come and help us cross the river. Once we arrived at the river, we would stand there trying to figure out ways to navigate it. As we were crossing the river with our parents holding our hands, we would use our feet to feel the stones at the bottom of the river so that we did not trip and get washed away because the river was flowing fast. The reason for feeling the stones with our feet was to make sure of our footing before taking the next step because we did not know how deep the water was. So, we needed to feel the stones carefully, move slowly to cross the river, and step forward in this unfamiliar river. The only thing we knew was that every step we took was right as we were crossing this unfamiliar river assisted by our parents.

When I arrived at the school where I teach I noticed that some of my learners go through the same experience that I went through as a child: they cross the river every day from home to school and then back again. On rainy days we call their parents to fetch them so that they can help them cross this river.

Seeing the struggle that my learners face in trying to make sense of some of the science concepts in class reminded me of my experiences of crossing the river, hence the metaphor of crossing the river. The experiences of crossing the river from home to school, then back again, relate to the kind of struggle that our learners experience as they try to negotiate meaning across IK and WS (Langehoven et al., 2012). Notably, I refer to WS as Westernised science since science is embedded with Indigenous practices.

Every day of the week our learners cross from home culture to school culture and then back again. This is echoed by Seehawer (2021) who argues that for learners, navigating between different knowledge systems is a daily reality. So, the river crossing metaphor in this study was deemed relevant in that crossing the river is like coming across a situation that one needs to explore without any guide and for me, this was a daily reality.

Therefore, the goal of the study was to explore a new strategy that has never been there (Kozaner, 2021), in this case using traditional brickmaking to mediate learning about the conservation of heat energy to support learners to make sense of the topic. In my experiences of crossing the river, the floor of the river full of stones that we felt with our feet represents the unfamiliar science concepts that learners encounter at school and the murkiness of the river represents the uncertainty that our learners experience as they try to make sense of these science concepts by connecting them with their lived experiences (Gwekwerere, 2016).

For example, none of my experiences of the activities that I performed at home – such as using cow dung which is an insulator – were connected to the science I learnt at school. To me, an insulator was an unfamiliar concept that I never linked to cow dung. In essence, this revealed tensions or contradictions that existed between our lived experiences and what was taught at school. We had to cope with the colonial agenda where our Indigenous ways of knowing were denigrated and suppressed (Ogunniyi, 2007a) by colonisation. This experience is beautifully captured in Simpson's (2014, p.6) quote that:

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

In this way, situating this study in my life experiences of crossing the river was trying to show the significance of involving community elders in the education of their children as this connects learning to the communities, improves the quality of education and promotes educational equity, inclusiveness, social justice and cultural sensitivity (Haimene, 2023; Kozaner, 2021).

Figure 1.1: The Umngeni River that I used to cross when going to school

1.4 My Positionality and Reflexivity in the Study

Salinas and Kozano (2017) note that positionality is a form of sharing personal narratives as they relate to one's own social identities, personal biases, beliefs and values. Concurring, Holmes (2020) describes positionality as the researcher's worldview and the position they adopt about the research task at hand. Accordingly, Holmes (2020) avers that positionality can influence both how the research is conducted and its results. In light of this, it is necessary for a qualitative researcher to declare their positionality (Mutanho, 2021).

In this regard, I conducted the study in my own classroom as a Grade 7 Natural Sciences teacher who has been teaching the subject for 20 years and as a master's student. I was aware that power dynamics might arise due to my position as my learners' teacher and that learners might regard me as more knowledgeable (Vygotsky, 1978). Moreover, no participants were coerced into participating in the study but instead were selected and took part on a voluntary basis. In particular, the fact that I was a married woman who is respected in the community had the potential to make participants feel obliged to participate in this study. I made it clear that they were free to withdraw at any time although in my culture this is regarded as disrespectful and insensitive towards people's feelings.

My learners were positioned as co-researchers in the study and Gingqi (the other science teacher) was positioned as a critical friend. Learners were asked to get information from their homes on building a fire and the stories told when sitting around the fire at home. It was hoped that they might relate this information to science learned at school, thus enable border crossing (Aikenhead & Jegede, 1999). However, in the context of this study, and as mentioned that earlier, I preferred to use the metaphor of river crossing because we do not cross borders instead, we cross rivers. When my learners come to school, they cross the Mpendle river and they struggle to cross it when it is raining; hence the use of this metaphor in the study to depict the challenges faced by our learners as they try to negotiate the two worldviews, that is IK and WS. We visited the brickmaking site to observe the practical demonstration of traditional brickmaking by the indigenous knowledge custodians (IKCs) who were regarded as more knowledgeable in the field of traditional brickmaking. This positioned me as a co-learner during this process.

Coming from a different ethnic group from that of my participants – they were of the Mpondo ethnic group and I am from the amaHlubi ethnic group with different dialects – made me less knowledgeable about their Indigenous practices when it comes to their traditional method of brickmaking. This had the potential of causing some disagreements between us. Therefore, I did not impose my dialect on my participants, instead, I positioned myself as a co-learner where we learned each other's dialects, a form of mutual respect for each other's culture as reiterated by the Ubuntu perspective (Seehawer, 2018).

Holmes (2020) posits that researchers need to acknowledge personal positions that have the potential to influence the study. Therefore, I was aware that obvious and conscious bias might be evident. To address this, I explained to my participants that the intention of this interventionist study was to get an in-depth understanding of how best to integrate IK into my science lessons by using Indigenous practices in their surroundings without influencing them with my own Indigenous practices. I strove to be as neutral as possible, as Holmes (2020) cautions that researchers should aim to achieve neutrality.

To respond to positionality, researchers are encouraged to be reflexive. This is seen as necessary to ensure the accuracy and trustworthiness of the qualitative research (Soedirgo & Glas, 2020). In trying to understand the influence of my positionality in this study, I continually reflected throughout the research process and this helped me to deal with biases.

Reflexivity involves examining one's own judgements, practices and beliefs during the data collection process. Accordingly, Holmes (2020) believes that reflexivity is a concept that researchers should acknowledge, and they should disclose their dispositions towards their research seeking to understand their influence on it. Holmes (2020) also believes that reflexivity influences positionality. Taking counsel from this, I had pre-conceived experience in terms of how I learned and taught science, experiences where what was learned and taught in class did not relate to real-life experiences such as integrating local IK into science (see Section 1.3). I was aware that this might have an influence on what I was investigating.

As part of reflexivity in this study, to level power dynamics between the participants and myself, I used their clan names. This is in resonance with Birhane et al.'s (2022) study which states that reflexivity as part of the participatory process is an important element for improving trust between the researcher and the participants. This helped both the [1]IKCs and the learners to recognise that their culture is valued and appreciated at school. Also, when selecting the participants in the study, gender balance was considered. Moreover, during the presentations and focus group interviews (sharing circle), the mother tongue (isiXhosa) of the participants was used so that they would understand better. However, this was translated into English by Gingqi, my critical friend so that both languages could be learned, a phenomenon known as translanguaging (Mapfumo, 2024). During the interview, when the participants seemed not to understand the questions as was evident in their responses, I rephrased them. Lastly, for those learners who seemed to dominate the interview while others felt marginalised, I found a way to deal with that without offending them.

1.5 Statement of the Problem

Learners seem to find science boring, unimaginative and one of the most difficult subjects with its abstract concepts that are difficult to understand. As such, they perform poorly in science as evidenced in the TIMSS 2019 findings. I assume that learners 'displeasure with science might be caused by teachers 'lack of variation in teaching strategies. We tend to use teaching methods that are in contrast to the Indigenous ways of learning that include but are not limited to, learning situated in natural environments, experiential learning and collaborative learning

[1] In this study, I refer to the community elders as indigenous knowledge custodians since they are knowledgeable about the cultural heritage of brick making.

(Budiastra et al., 2021). Also noteworthy is the fact that as teachers we are good at eliciting learners' prior knowledge, but our limitation is that we do not use this knowledge to plan our lessons. Furthermore, there is a misconception that we always think that prior knowledge comes at the beginning of the lesson as something that has been taught in the previous lesson or grade and yet prior knowledge can come from home in the form of learners' IK.

The Curriculum Assessment and Policy Statement (CAPS) document requires teachers to appreciate learners' IK (Ogunniyi, 2007a) or Indigenous technologies (Emeagwali & Shizha, 2016; Shinana et al., 2021) in their science teaching but it fails to show explicitly how this should be done during science lessons. Yet, the assumption is that the integration of IK in science teaching might help learners understand that science is relevant to their everyday lives (Gwekerere, 2016) and is not restricted to what is learnt in class. This might also enable them to see the connection between science and society and ultimately be able to apply science in their everyday lives.

This is important because learners seem to struggle to understand science concepts when their local knowledge is ignored in their learning. Learners are also unable to connect what they learn in class with their existing local knowledge (Aikenhead & Jegede, 1999). For example, in the context of my study, they could not link the concept of conduction with cooking with fire at home, which is their prior everyday experience as reiterated by Kuhlane (2011). I assume that learners lack the understanding of science concepts because as a science teacher, I fail to use examples from their everyday life experiences. Furthermore, the textbooks use examples unfamiliar to the learners 'contexts. In addition, although studies have been conducted to find ways that might help teachers integrate IK in science, literature has shown that not much research has been done to develop strategies that might assist teachers to integrate IK in their science lessons (Mkosi et al., 2023). It is against this background that this study sought to explore mobilising the Indigenous technology of brickmaking to support a Grade 7 Natural Sciences class in a rural school to make sense of the topic of conservation of heat energy.

1.6 Purpose and Significance of My Study

The purpose of this formative interventionist study was to use the Indigenous technology of brickmaking to support a Grade 7 Natural Sciences class in a rural school to make sense of the topic of the conservation of heat energy. Essentially, the study strived to make science accessible, clearer and more relevant to learners by integrating learners 'existing knowledge into science learning. It was hoped that this might help learners cross this huge river that seems to stand in their way of moving from everyday life experience to school science. Moreover, that this might, in turn, help them develop an interest in science and value, respect and appreciate their IK.

Furthermore, the study might make science relevant and accessible to learners by using easily accessible cultural resources (Asheela et al., 2021; Shinana et al., 2021) such as the Indigenous technology of brickmaking when making sense of the topic of the conservation of heat energy. I was also hoping that developing an exemplar lesson that integrated learners 'IK in mediating learning on the topic of the conservation of heat energy might help me improve my own teaching practice. In addition, the findings of the study might make other teachers appreciate the importance of involving IKCs in imparting their cultural knowledge, wisdom and skills which could be integrated into science lessons (Klein, 2011; Lavallee, 2009; Mateus & Ngcoza, 2019). In turn, this might help enrich the mediation of learning. Lastly, similar to Mashoko's (2022) study, the overarching rationale for this study was to decolonise the science curriculum through the integration of IK of brickmaking on the topic of the conservation of heat energy and through recognising learners 'prior knowledge of fire making.

1.7 Research Goal and Research Questions

The main goal of this study was to explore how mobilising the Indigenous technology of brickmaking could support Grade 7 Natural Sciences learners in a rural school to make sense of the topic of the conservation of heat energy.

To achieve the goal, the following research questions were addressed:

1. How do Grade 7 Natural Sciences learners experience learning about the conservation of heat energy?
2. How do Grade 7 Natural Sciences learners interact, argue and participate during a presentation by the indigenous knowledge custodians on the traditional way of brickmaking?
3. How do Grade 7 Natural Sciences learners 'sense-making shift (or not) as a result of the practical demonstration of the Indigenous technology of brickmaking by indigenous knowledge custodians?

1.8 Theoretical Frameworks

A theoretical framework provides a possible explanation for why things happen and is used as a way of broadly framing the study (Bertram & Christiansen, 2020).

In this study, I explored the relevance of Vygotsky's (1978) sociocultural theory in the integration of local knowledge in science. Hence, the theory was used as the theoretical framework. The theory was deemed appropriate to the proposed study in that its central focus is that human activities take place in a cultural context (such as the local brickmaking site in this study) mediated by language (isiXhosa) to achieve the goal of learning. This is what the study aimed to do as learners interacted with the IKCs sharing their cultural knowledge of brickmaking using language to explain. Also, to supplement Vygotsky's sociocultural theory, Ogunniyi's (2007a) Contiguity Argumentation Theory (CAT) was used to understand learners ' views on learning the topic of conservation of heat energy. The theories were used as an analytical framework. Lastly, the study discussed how the two theories complemented each other.

1.8.1 Vygotsky's sociocultural theory

This study was informed and guided by Vygotsky's (1978) sociocultural theory because he recognises the need for cultural, cognitive and border crossing in learning (Aikenhead & Jegede, 1999). Central to the theory is that cognitive development occurs in a social context.

Essentially, in Vygotsky's (1978) sociocultural theory, language plays a critical role in learning. In addition, he avers that learning precedes development (Mayana, 2020; Scott, 2016). Within Vygotsky's sociocultural theory, I used the following tenets: the mediation of learning, culture and language, social interactions, the zone of proximal development (ZPD) and double stimulation.

1.8.1.1 Mediation of learning

Vygotsky (1978) posits that human activities take place in cultural contexts, mediated by language and other symbol systems to achieve the goal of learning. He believes that learning as a mediated process is social in origin and becomes individual as a result of linguistically mediated interaction between the child and more experienced members of society such as parents, teachers and peers (Stott, 2016). For Vygotsky (1978), language and culture play a central part in learning because he believes that children develop independently of stages as a result of interactions.

1.8.1.2 Culture and language

Vygotsky (1978) gave great significance to culture and the stories that people tell and saw language as the supreme cultural and cognitive tool. In addition, he posits that language is the carrier of culture as it conveys all the information about culture, in both verbal and written forms. During social interactions, community elders shared their wisdom and materials from their culture.

1.8.1.3 Social interaction

To Vygotsky (1978), social interaction is the basis of learning and development. He avers that knowledge is constructed in dynamic interactions between people and their social environment. Concurring, Shabani (2016) accentuates that, based on the theory, the origin of knowledge should not be sought in the mind but should be constructed through social interactions. Essentially, social interactions play a role in the learner's ZPD.

1.8.1.4 Zone of proximal development

The ZPD is the distance between the actual development level as determined through independent problem solving and the level of potential development as determined through problem solving under the guidance of a MKO as an adult or more capable learners (Vygotsky, 1978). To understand how individuals make deliberate actions when faced with a conflicting situation, the principle of double stimulation was introduced.

1.8.1.5 Double stimulation

Sannino (2015) describes double stimulation as a method to study mental functions with the help of two kinds of stimuli. It is one of Vygotsky's principles that is key to understanding how individuals take a deliberate action in situations where they are faced with uncertainty and cognitive conflict (Morselli, 2019) such as negotiating meaning across IK and WS (Langehoven et al., 2012) in the context of this study. To augment Vygotsky's (1978) sociocultural theory, Ogunniyi's (2007a) CAT was used as an analytical framework.

1.8.2 Ogunniyi's CAT

Ogunniyi (2007a) argues that the CAT considers the fact that learners have different worldviews concerning science such as IK and WS (Langehoven et al., 2012). That is, Ogunniyi (2007) claims that CAT happens when two different knowledge systems such as IK and WS co-exist and can only be possible through cognitive shifts to accommodate each other (Nuntsu, 2020).

Ogunniyi (2007a) posits that as learners try to negotiate meanings across the two different systems of knowledge, that is, IK and WS, their minds keep shifting back and forth through five cognitive ideas: the dominant idea – where an idea becomes dominant if it is most adaptable in a given context; a suppressed idea – where an idea becomes suppressed in the face of more valid, predictive, empirically testable evidence; an assimilated idea – where a less powerful idea might be assimilated into a powerful one in terms of persuasiveness or adaptability of the dominant idea to a given context; an emergent idea – where there is no prior knowledge a new one has to be developed; and finally equipollent ideas where two competing ideas exert equal intellectual force on a learner. Based on this understanding, the theory was employed as an analytical framework for the study.

In my view, the two theories complement each other. For example, when there are social interactions, there are discussions and arguments; Vygotsky does not promote arguments but Ogunniyi does. In the context of the study, argumentation enabled learners to communicate knowledge through social interactions. Argumentation also helped them to engage with the social construction of scientific and IK ideas (Govender, 2016). Moreover, categories in CAT helped me to understand learners' views on learning the topic of conservation of heat energy and were used to analyse ideas that emerged from learners during social interactions as suggested by Vygotsky (1978).

1.9 Key Concepts

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

1.9.1 Argumentation

Argumentation involves discussions where learners generate arguments by justifying several claims, explanations and viewpoints. It promotes learners 'critical thinking and understanding of science concepts through elaborating and exchanging each other's opinions (Sengul et al., 2020).

1.9.2 Attitudes

In this study, learners 'attitudes refer to their feeling of pleasure or active interest in science learning and out-of-school learning (Agunbiade et al., 2017)

1.9.3 Cultural knowledge brokers

In this study, this refers to people who facilitate learners 'movement from home or community culture to school culture (Wyatt et al., 2017)

1.9.4 Double stimulation

This is a Vygotskian perspective which is described as a method of studying mental functions with the help of two stimuli (Sannino, 2015; Morselli, 2019; Engestrom, 2020).

1.9.5 Indigenous knowledge

An existing body of knowledge commonly known within a community that covers technologies and practices that have been developed and are still used by local people (Department of Basic Education [DBE], 2011; Onwu & Mufundirwa, 2020)

1.9.6 Out-of-school learning

Learning that takes place in the environment outside the school building but during school hours and within the scope of the curriculum (Kozaner, 2021)

1.9.7 Sense-making

Odden and Russ (2018) define sense-making as a process of building an explanation to resolve an observed conflict of knowledge.

1.9.8 Social interactions

To Vygotsky (1978), social interactions refer to the way people act and relate with each other and he believes that this is where learning and development occurs.

1.9.9 Ubuntu

Ubuntu is the quality of being human including sharing, caring, respect and compassion ensuring a happy and communal life in the spirit of family (Muwanga-Zake, 2010; Chilisa, 2012; Seehawer, 2023).

1.10 Thesis Outline

The study was conducted at Ubuntu Primary School (pseudonym) in the O.R. Tambo Coastal District in the Eastern Cape. It consists of the following seven chapters:

Chapter one

This chapter outlined the background of the study followed by my life experiences that situated the study, and then the researchers' positionality and reflexivity. The statement of the problem and the significance of the study were also provided which involved amongst others, making us as teachers better teachers who acknowledge the sociocultural background of learners by using easily accessible resources from the community to help them make sense of the science concepts that seem abstract to them. The research goal and research questions that guided the research study were also provided. Finally, the theoretical and conceptual frameworks that framed the study were briefly discussed.

Chapter two

In this chapter, literature related to this study is reviewed, namely, a brief overview of the topic of the conservation of heat energy, type of soil, learners ’prior knowledge in science classrooms, IK, the benefits and challenges of integrating local IK in science, hands-on practical activity and visualisation, out-of-school context and role of IKCs in science teaching and learning, Indigenous technology of brickmaking and sense-making.

Chapter three

This chapter explores the relevance of Vygotsky’s (1978) sociocultural theory in the integration of local knowledge in science. Hence, the theory was used as a theoretical framework as discussed in this chapter. To supplement Vygotsky’s sociocultural theory, Ogunniyi’s (2007a) CAT expanded by the Dialogical Argumentation Instructional Model (DAIM) was also used as an analytical framework. This provided an analytical lens to examine how the construction of knowledge took place during a presentation by the ICKs. The reason for expanding CAT with DAIM included the fact that CAT forms the basis of DAIM which is a pedagogical strategy (methodology) that creates discussion spaces within the classroom aligned with the learning objectives (Fakudze, 2021). Complementing Vygotsky’s sociocultural theory was further motivated in part by the belief that the theory does not emphasise the importance of arguments which help learners to make sense of the learning process. Lastly, in this chapter, I also discuss how the theories complement each other.

Chapter four

In this chapter, I discuss the research methodology used in conducting this study. I also outline the research goal and research questions of the study. Paradigms informing the study as well as the research design employed were discussed. Two research paradigms complemented each other in the study, namely the interpretive paradigm and the Indigenous research paradigm focusing on an Ubuntu perspective. A qualitative case study research design was employed. The methodological frameworks DAIM and TMESD, the research site, sampling and participants, researcher positionality, reflexivity, data-gathering tools and the research process were discussed. Lastly, data analysis, validation, trustworthiness and ethical considerations were discussed.

Chapter five

In this chapter, I present, analyse and discuss data from learners ’group activities and the four IKCs’ presentations. The main aim of the chapter was to answer the first and second research questions of this study. I also used my observations during the participatory observation to check whether learners’ sense-making of the topic of conservation of heat energy shifted or not as they interacted with the IKCs. It became evident that IK could be used to teach scientific concepts that seem abstract to learners as the learners were arguing amongst each other on the kind of science concepts that emerged from the practical demonstrations.

Chapter six

In this chapter I analyse, present and discuss the data generated from the lesson observation, sharing circles interviews and learners ’journal reflections. These data generation methods were used to answer research question three.

Chapter seven

Here I present a summary of my findings and provide some recommendations. I also suggest areas of future research, the limitations of my study as well as my personal reflections. The chapter closes with an overall conclusion to the study.

1.11 Chapter Summary

The chapter started by outlining the background of the study, followed by my personal experiences, researchers' positionality and reflexivity. The statement of the problem and significance of the study were also provided. Then, the research goal and research questions that guided the study were outlined. Finally, the conceptual and theoretical frameworks that framed this study were briefly discussed.

CHAPTER TWO: LITERATURE SYNTHESIS

2.1 Introduction

According to Creswell and Creswell (2018), a literature review shares with the reader the findings of other studies that are closely related to the current study. Every piece of research relates to the larger ongoing dialogue in literature by filling in the gaps and extending research that has been previously done (Bertram & Christiansen, 2020; Creswell & Creswell, 2018). The main goal of this study was to explore how mobilising the Indigenous technology of brickmaking can support a Grade 7 Natural Sciences class in a rural school to make sense of the topic of the conservation of heat energy. The study strived to make science accessible, clearer and more relevant to learners by integrating learners 'existing knowledge in science learning. This was done to try to help learners cross this huge river that seems to stand in their way of moving from everyday life experience to school science (Aikenhead & Jegede, 1999) and *vice versa*. As mentioned earlier, Aikenhead and Jegede (1999) metaphorically refer to this phenomenon as border crossing. However, we have no borders where we live and instead, we cross rivers.

In this chapter, I discuss literature related to this study presenting a brief overview of the conservation of heat energy and building materials used, learners 'prior knowledge in science classrooms, IK, the benefits and challenges of integrating IK in science, hands-on practical activity and visualisation, out-of-school contexts and the role of IKCs in science teaching and learning, the Indigenous technology of brickmaking, argumentation and sense-making.

2.2 Teaching the Concept of Conservation of Heat Energy

The conservation of heat energy is one of the topics in the energy and change strand in the Grade 7 Natural Sciences syllabus. The conservation of energy is a concept that cannot be explained without first discussing the concept of energy. As a form of energy, heat (thermal energy) is conserved, that is, it cannot be created or destroyed. It can, however, be transferred from one object to another through a temperature difference between them. Heat is a form of energy and as such, is subject to the principle of conservation.

The CAPS (DBE, 2011) requires Grade 7 Natural Sciences teachers to teach the conservation of heat energy. The CAPS (DBE, 2011), explains heat as the transfer of energy by *conduction*, *convection* and *radiation*. Often, we want this heat energy to be transferred for heating such as making a fire (see Figure 2.1 below).

Figure 2.1: Cooking with fire

At times we also want to prevent heat energy transfer. For example, in winter we need to minimise heat loss from the house so that it stays warm. On the other hand, in summer we minimise heat gain to keep the house cool. To restrict heat transfers we use insulating materials. These insulating materials are either worn by us as in the case of woollen jerseys and blankets or applied to our buildings to keep them warm or cool, for example, in rural areas houses have thatched roofs (see Figure 2.2 below).

Figure 2.2: Thatched roof hut

Based on this, scholars such as Deshmukh et al. (2017) argue that insulation is one of the essential requirements for the conservation of heat energy in general. Accordingly, these scholars underscore that a thermal insulator is a poor conductor of heat with very low heat (thermal) conductivity. Concurring, Aditiya (2017) avers that all insulating materials serve the same purpose: to reduce the rate of heat loss or gain, thus conserving heat energy.

This also resonates with CAPS (DBE, 2011) which stipulates that learners should be taught that Indigenous homes in South Africa make use of insulating materials to be energy efficient in our climate. Moreover, CAPS (DBE, 2011) adds that homes and other buildings need to minimise heat loss in winter and heat gain in summer. This can be done by using proper insulation as it keeps conditions in the buildings comfortable and saves electricity. For instance, we use appliances in buildings for cooling and heating such as heaters and air conditioners, but when we feel warm or cool enough we switch them off. This causes a reversal in the flow of heat, and the temperature once again becomes uncomfortable. So, to conserve heat energy, using insulating materials is the best (DBE, 2011). Olughu (2021) concurs that adding insulation materials to buildings reduces heating and cooling energy needs while maintaining a comfortable temperature within the building.

Furthermore, in support of the belief that conserving heat energy using heat insulators as part of the building materials is one of the best means (Abu-Jdayil et al., 2019), the DBE (2011) underscores that Indigenous people of South Africa have many ways of insulating their homes. They use materials that are available locally and have physical properties that make them energy efficient and suit the climate such as small windows or no windows at all, thatching grass, wood and clay. For example, thatching grass is often used as a roofing material (as shown in Figure 2.2 above) in traditional homes because it is an excellent thermal insulator, and it helps to keep homes warm in winter and cool in summer. Also, the roofs extend beyond the houses to create an overhang that helps to shade the walls in summer while the winter sun can still reach under the overhang. Aditiya et al. (2017) seem to agree that effective insulation conserves energy and consequently requires less energy consumption for cooling in summer and less heat for keeping homes warm in winter.

Moreover, South African traditional homes are designed such that walls are made of clay or mud bricks and covered with thick clay or mud (see Figure 2.2 above) because it is a poor conductor of heat, so it prevents heat loss in winter and heat gain in summer (DBE, 2011). Concurring, Handayani et al. (2019) point out that one of the physical properties of clay is that it is an insulator.

To sum up, according to the literature, the primary aim of using insulating materials is to prevent or minimise thermal energy loss or gain for the conservation of energy. This also helps in several ways including saving energy and reduction in greenhouse gases in the environment (Deshmukh et al., 2019). Understanding the type of soil used to make traditional bricks might help learners make sense of how the bricks conserve heat energy.

Handayani et al. (2019) assert that soil characteristics that affect thermal (heat) conductivity are total porosity and soil pore size distribution. For this author clay possesses these characteristics and as such, it retains heat flowing from high temperatures to low temperatures. The effect of clay is to block the flow of heat, clay being a poor conductor of heat. In light of the above, Wilson (2021) agrees that clay bricks act as excellent insulating materials and can conserve heat as they have low thermal conductivity. It is against this backdrop that the study sought to mobilise the Indigenous technology of clay brickmaking to support Grade 7 Natural Sciences learners to make sense of the conservation of heat energy. Indeed, valuing learners ' prior knowledge when teaching science could enhance their interest in learning science.

2.3 Learners' Prior Knowledge

Van Lloyd Diaz (2017) states that the concept of prior knowledge has its origins in different learning theories, principles and philosophies. One of the theories is the theory of constructivism, which states that knowledge is constructed through active learning in which learners actively create meaning by constructing and reconstructing ideas about reality. Prior knowledge can be learners 'local IK that they bring to school from home or their community. Ahied (2020) defines prior knowledge as knowledge that is already known by learners. He believes that learners are easily motivated to learn when they can connect new concepts to their prior knowledge. It can also be knowledge that learners have gained from previous grades. Similarly, Kuhlane (2011) agrees that learners come to school with different understandings and knowledge bases gained from different experiences that could help them inform new ideas during learning processes.

In this regard, Binder et al. (2019) argue that learners with higher prior knowledge about a topic understand and remember the subject matter better and perform better in examinations. In support of this, Dong et al. (2020), posit that learners with more prior knowledge may have more working memory capacity available to process their current task. It is recognised, however, that prior knowledge could be in the form of Local Knowledge or IK.

2.4 What is IK?

Kibirige and Van Rooyen (2006) describe IK as a legacy of knowledge and skills unique to a particular Indigenous culture which encompasses wisdom that has been developed and passed on over generations. Similarly, Onwu and Mufundirwa (2020) define IK as an existing body of knowledge commonly known within a community that includes Indigenous technologies and practices that have been used and are still used by local people. This resonates with the context of the study in that, although South African huts are built using the same materials such as clay or mud bricks, their designs are different depending on the particular Indigenous culture; for example, a Zulu hut is different from a Ndebele hut. Concurring, Mavuru and Ramnarain (2020) define IK as the knowledge and skills possessed by people living in a particular geographical area which enables them to use their natural environment fully and obtain benefits from it. For example, in the context of the study, the South African Indigenous huts are built from materials that are locally available such as thatching grass, wood and clay or mud bricks as they are excellent thermal insulators as mentioned earlier.

Similarly, the CAPS document defines IK as knowledge that communities have held, used or are still using and is passed on through generations. For instance, in this study, [2]IKCs passed on their knowledge, wisdom and skills of traditional brickmaking to learners as they demonstrated the method to them. Although this was done to help learners make sense of the topic, in the long run, they will possess the skill of traditional brickmaking and be able to make their own bricks and pass on the skill to future generations. Handayani et al. (2018) refer to this as cultural sustainability.

Onwu and Mufundirwa (2020) bemoan the fact that IK is neither a uniform concept across all Indigenous people nor an exclusive preserve of the Indigenous people. Rather, it is a diverse body of knowledge spread throughout different people in many different spheres. As such there are several Indigenous epistemologies as evidenced in the traditional brickmaking industry. Indigenous people across the globe have their own methods of traditional brickmaking. For example, in places like Turkey, Sudan, India and South Africa, Indigenous people use different materials for brick firing, such as coal, wood and macadamia nuts. In some places in South

[2] Indigenous Knowledge Custodians are called custodians because of the kind of knowledge they possess. They pass on IK as it was passed on to them by their forefathers or ancestors.

Africa and Turkey they collect agricultural waste mixed with coal to burn their bricks (Amyikaiye et al., 2021).

2.5 Benefits of Integrating IK in Science Teaching and Learning

It is important to acknowledge that in the world there are many ways of knowing (Hatcher et al., 2009) and that the postcolonial agenda requires us to swim against the stream in trying to cross the huge river that seems to stand on our way of accessing these different ways of knowing. This means moving from everyday life experiences to school science, known as border crossing (Aikenhead & Jegede, 1999). Therefore, there is a need to train teachers who are aware that a school is a place where learners bring their IK which becomes their way of knowing (Handayani et al., 2018; Taber, 2020). However, Taber (2020) cautions that crossing from learners 'local knowledge to science does not mean disrupting their ways of knowing science knowledge. Instead, it is about acknowledging that the different ways of knowing can work together in a complementary manner.

Considering the above, Glasson et al. (2010) assert that teachers have long recognised the importance of learners 'worldviews in science learning as they struggle to explain WS concepts exclusively in English, which is not their home language. However, they are not aware of the teaching strategies that will help them integrate IK with science. It is against this background that some scholars suggest that if IK could be integrated into science curricula it has the potential to provide familiar contexts within which to learn scientific concepts and help learners to recognise its value (Baquete et al., 2016). In this regard, Budiastra et al. (2021) believe that learners' success in learning science, depends on their effectiveness to cross over from a culture of everyday life to the culture of science.

In support of this, Mavuru and Ramnarain (2020) assert that integrating learners 'cultural norms and values into science lessons and class activities could facilitate learner performance since learners will be engaged in familiar activities. In addition, Mhakure and Otulaja (2017) posit that the rationale for integrating IK in science to identify valuable Indigenous wisdom which might have been lost through colonisation, with the aim of engaging this knowledge to improve the daily lives of all South Africans. These scholars assert that success in learning science will depend on how learners effectively move from IK to WS, similar to the border crossing between the two worldviews (Aikenhead & Jegede, 1999).

Similarly, Handayani et al. (2018) underscore that the aim of integrating the two knowledge systems is to provide a new perspective on learning science and to make science relevant to learners and this might motivate them to learn science when they see that their culture is valued in science classrooms. To these scholars, integrating IK in science provides learners with an opportunity to make sense of science concepts that seem abstract to them. As a result, learners realise that science is not foreign to their existing knowledge and they feel included and their culture appreciated in science classrooms (Mavuru & Ramnaraain, 2020). Furthermore, Onwu and Mufundirwa (2020) assert that the use of familiar local technologies and practices from the community as real contexts has the potential to stimulate interest and curiosity.

On the other hand, some proponents of IK such as Handayani et al. (2018), Kibirige and Van Rooyen (2006), Mhakure and Otulaja (2017), Mukwambo et al. (2014) and Ogunniyi (2007a) warn that it is not always necessary to cross over to learn science; instead the two knowledge systems, that is, IK and WS, can work together in a complementary manner. That is, the goal should be to place the two forms of knowledge side by side, identify commonalities and deal with the differences cautiously to avoid being offensive to Indigenous learners (Ogunniyi, 2018; Seehawer & Breidlid, 2021). Therefore, teachers need to recognise that the two knowledge systems can work together and hence there is a need to find strategies for how to integrate the two worldviews in science teaching and learning.

Concurring, Hatcher et al. (2009), through their 'two-eyed-seeing 'approach and Michie et al. (2023) through their 'two-ways-thinking' approach, posit that the approaches intentionally and respectfully bring together our different ways of knowing. These authors emphasise that the approaches seek to avoid knowledge domination and assimilation (Handayani et al., 2018; Ogunniyi, 2007a) by recognising the best from both IK and WS. Essentially, the 'two-eyed seeing 'approach (Hatcher et al., 2009) seems to support the learning of science through seeing from one eye with the strength of Indigenous ways of knowing and from the other eye with the strength of Western ways of knowing. This means finding a common ground between the two worldviews and respecting them while remaining cognisant of their differences. Le Grange (2007) believes that this could help address cognitive dissonance among learners.

Mavuru and Ramnarain (2020), concur that the focus of integrating the two knowledge systems should be on finding ways of using both knowledge systems to equip learners with knowledge and skills that clearly define the applicability of such acquisition in real-life situations. Onwu and Mufundirwa (2020) agree that this is about understanding how Indigenous technologies and science co-exist, where they share commonalities and how they can be beneficially used to facilitate relevant, meaningful and authentic learning. Notwithstanding these ideals, there are some challenges associated with the integration of IK in science teaching and learning.

2.6 Challenges in Integrating IK in Science Teaching and Learning

There seem to be challenges encountered when trying to integrate IK into science as there have been no clear methods on how to do it. Literature has shown that research has not been done to develop strategies that assist teachers in IK integration in science lessons (Mkosi et al., 2023). In support of this, Mavuru and Ramnarain (2020) noted with concern that the integration of IK in science has been a challenge to teachers as there has been no specific directive on how IK should be implemented.

In this regard, Glasson et al. (2010) maintain that teachers struggle to explain science concepts in English as they do not have explicit teaching strategies that can help them integrate IK in science. In addition, literature has revealed that teachers face many challenges when trying to integrate IK in science, such as limited or lack of resources or infrastructure, lack of adequate training to integrate IK in science and teachers feeling lazy or reluctant to integrate IK into science (Budiastra et al., 2021).

At the other end of the spectrum, there are counterarguments against the integration of IK in science. For instance, scholars such as Cobern and Loving (2001) and Hodson (2009) warn that we should be careful to accord IK equal status to Western science: instead, the two should be kept separate because if IK is integrated with WS, it will be absorbed. These scholars argue that IK and WS are different ways of knowing. To Cobern and Loving (2001), for instance, a good scientific explanation will always be universal even if we integrate IK as scientific and broaden what is taught in science.

Similarly, Southerland (2000) claims that accepting some form of multicultural education does not require a rejection of the universal conception of science. Notably, Hodson (2009) also cautions that differences between the two forms of knowledge should be acknowledged and celebrated instead of trying to force all other forms of knowledge as science. Furthermore, Hodson (2009) avers that for a form of knowledge to be classified as science it needs to meet some criteria for judging whether it is science or not. Moreover, Webb (2013) cautions that integrating IK into science may place teachers in a dilemma in which science and IK may collide and in learners' personal beliefs about nature that may be personally valuable but not science. Lastly, one of the findings of a research conducted by Horsthemke and Schafer (2007) revealed that learners themselves rejected the integration of IK in science learning viewing it as irrelevant, outdated and culturally alienating.

Notably, some proponents of IK integration in science teaching such as Ogunniyi (2007a), Afonso-Nhalevilo (2013), Keane et al. (2016), Mhakure and Otulaja (2017) and Mukwambo et al. (2014) caution against romanticising IK. In this regard, these scholars suggest that any misconceptions that come with IK should be corrected.

However, from the experiences of conducting this study, I have noted with concern that some of the issues highlighted by the opponents of IK integration into science were challenged by learners. For instance, my learners appreciated the strategy of IK integration into the teaching and learning of the conservation of heat energy. They were motivated to learn the topic when they saw that it was related to their everyday life knowledge. They appreciated the fact that their IK had a place in the science classroom. As such, they were able to connect their IK with WS and made sense of the concepts related to the topic.

Moreover, through argumentation as they interacted with each other, the IKCs and the researcher, they reached an equivalent cognitive state in their reasoning, in that they could notice that the two ways of knowing could work together (Ogunniyi, 2007a). This was evident as they identified science concepts that emerged from the presentation and in their performance in the end-of-the-term assessment. This supported the belief by some of the proponents of IK integration into science, that the use of familiar local technologies (such as the brickmaking process) from the community (local brickmaking site) as real contexts has the potential to stimulate learners 'interest and hence making sense of science concepts (Mavuru & Ramnarain, 2020; Onwu & Mufundirwa, 2020).

2.7 Hands-on Practical Activities and Visualisation

For learning to be effective, active participation is necessary in learning activities and making connections to real life through hands-on practical learning (Kozaner, 2021). Mavuru and Dudu (2021) define practical work as any teaching and learning activity that involves learners observing and manipulating real objects. Asheela et al. (2021) similarly argue that for learners to be able to relate science to real life at home (Gwekwerere, 2016), they should be exposed to purposeful hands-on and minds-on practical activities. However, as a word of caution, some scholars bemoan the fact that hands-on practical activities are usually of a recipe approach

(Hodson, 1990). Therefore, they advise that when using hands-on practical activities, the focus should be more on sense-making and conceptual understanding. For these scholars, sense-making helps to make science concepts understandable. At the other end of the spectrum, conceptual understanding helps learners to make meaningful connections between science concepts as they are encouraged to predict, explain, explore, observe and explain. This approach helps both teachers and learners to make predictions before doing the practical activity (Asheela et al., 2021; Shinana et al., 2021).

In the context of my study this approach was relevant in that learners were given an opportunity to explore their existing local knowledge to improve their conceptual understanding (Mavhunga & Rollnick, 2013), relate it to science and construct new knowledge in the process. For instance, during group activities, learners were able to relate their existing knowledge of building a fire to science by identifying science concepts connected to fire such as heat transfer. As a result, their sense-making improved hence science concepts related to the topic of conservation of heat energy were understood. Literature also encourages the use of easily accessible resources (Asheela et al., 2021) to bridge the gap between home or community and school, hence the use of traditional brickmaking in the study to make sense of concepts related to the conservation of heat energy. This supports the suggestion made by Mavuru and Ramnarain (2020) that learners feel comfortable when using materials from their community in learning science and it becomes less abstract.

Moreover, it should be recognised that hands-on practical activities are a form of visual presentation. Bobek et al. (2016) posit that visual representations promote learners' understanding as they illustrate and explain concepts. However, Evagora et al. (2015) caution that, when using visual representation, the emphasis should not only be on conceptual understanding but should lead to knowledge production. In light of the above, in the study IKCs' presentations made room for visual presentations to support learners in learning the concept of conservation of heat energy while in the process they constructed new knowledge. Therefore, demonstrating the Indigenous technology of brickmaking served as part of hands-on practical activity and visualisation.

In search of ways to make learning effective and permanent, the presentations by IKCs took place in an out-of-school context (Kozaner, 2021). Learners were taken to a local clay brickmaking site outside the school environment.

2.8 Out-of-school Context and the Role of IKCs

Integrating IK in science is one of the strategies this study advocates. This applies also in areas where learning activities take place which are no longer limited to classroom settings (Kozaner, 2021). Kozaner (2021) argues that out-of-school learning needs to be promoted. This author defines out-of-school learning as the education that takes place in institutions and environments outside the school building but during school hours and within the scope of the curriculum.

In the context of this study, learners were taken to a local traditional clay brickmaking site to observe how clay bricks were made and how heat energy was conserved in the process. Extending on Mavuru and Ramnarain's (2020) seminal work, Rajal et al. (2021) assert that in a sociocultural context, learning should be viewed as connected to diverse contexts as this disrupts the taken-for-granted status of school learning. This author believes that when learners are involved in an out-of-school learning context, they observe natural conditions and learn from them and they find it easy to understand lessons presented to them by, for instance, IKCs. However, the primary focus should not be only on community elders' expertise but learners should be allowed to bring in their expertise and interests in the learning of science (Rajala et al., 2021).

Since I positioned myself as a cultural knowledge broker (Wyatt et al., 2017) in this study, I engaged IKCs in the study to help learners cross over from home or community culture to school culture and vice versa. Community elders as the custodians of our culture are an important part of this research because of the IK and wisdom they impart. They carry traditional teachings, ceremonies and the stories of our relations as explained by Lavallee (2009). According to Viscogliosi et al. (2020), in Indigenous contexts someone is recognised as an elder by other community members based not necessarily on age but on wisdom, skills and knowledge. For these scholars, benefits from elders 'social participation include enhancing education. Essentially, IKCs as holders or depositories of cultural heritage provide an excellent example of how learning takes place in a social context.

In the context of this study, therefore, the wisdom, values, skills and knowledge of IKCs when demonstrating the Indigenous technology of clay brickmaking were shared in trying to support learners to make sense of the concept of the conservation of heat energy, thus enhancing education. In hindsight, it is clear that the IKCs 'demonstration of traditional brickmaking gave *voice* to the relevance and importance of their knowledge in the teaching and learning of science (Glasson et al., 2010). As learners observed, argued and participated during the presentation by the IKCs, they understood and made connections between concepts that emerged and were able to make sense of the the conservation of heat energy and related concepts in the process.

2.9 The Indigenous Technology of Brickmaking

Literature has shown that contextualised and relevant science teaching and learning can be achieved by integrating learners' local IK. This emanates from the belief that scientific concepts taught outside learners 'sociocultural backgrounds may not be useful in their lives no matter how they seem to understand them (Mavuru & Ramnarain, 2020). Concurring, Onwu and Mufundirwa (2020) assert that using familiar local technologies and practices of the community accessible to learners is likely to stimulate interest and curiosity in learning science concepts.

In light of the above, in this study, the Indigenous technology of brickmaking was used to support learners in a rural school to make sense of the conservation of heat energy and related concepts. The study sought to explore how the traditional brickmaking process can be used as an accessible learning resource to mediate learning of the conservation of heat energy. I thus discuss the steps involved in the Indigenous technology of brickmaking.

In the traditional brickmaking process in the O.R. Tambo Coastal District in the Eastern Cape where the study was conducted, five major stages of brickmaking were observed. This is in accordance with the IKCs involved in the study, as shown in Figure 2.3 below.

Figure 2.3: Showing the steps in the process of traditional brickmaking (adapted from Amyikaiye et al., 2021, p. 7)

2.9.1 Excavation

This is the first step in the brickmaking process involving manual mining of the soil suitable for brickmaking. This involves removing the topsoil using tools like shovels, fork spades and wheelbarrows (Figure 2.4a). According to the IKCs, this is normally done by men. They use any available soil within the area regardless of its quality if it is sandy soil and clay soil to produce raw material (Bossard, 2022). Topsoil is dug using spades, pick heads and fork spades and is gathered in a heap (Figure 2.4b).

2.9.2 Preparation

This comes after excavation. The soil that has been gathered in a heap is then sieved to remove larger particles. This is done using a sieve made of wire mesh (Figure 2.4c). After being sieved, the soil is then mixed with the remains of burnt coal that was used for firing the kiln and has been previously sieved. Water that is used in the mix is accessed manually from the nearby river using buckets. Water is then poured into the heap of the mixture of soil and ashes from coal, stirred and shovelled continuously to promote the penetration of water into the mixture (Figure 2.4d). The mixture is then left overnight so that the materials can mix properly. As described in Amyikaiye et al.'s (2021) study, the mixture is left overnight to enhance the softening of lumps covered with a plastic sheet to prevent evaporation from taking place. The brickmakers (*abafolumu*[3]) then knead the prepared mud using their bare hands to break lumps. They, then use the spade to transfer the mixture to the wooden brick mould that has six compartments and opens at the top (Figure 2.4e). The brick mould is dunked into a bucket of water before loading it.

2.9.3 Moulding

Moulding is the stage of brickmaking that comes after the preparatory stage. It changes the mixture of soil, coal ash and water into wet bricks of the desired shape and size (Amyikaiye et al., 2021). According to Amyikaiye et al. (2021), moulding is the shaping of raw clay mud into bricks using a hand-thrown method or a mechanical extruder. In support of this, Bossard (2022) claims that the mixture is spread on a brick mould manually, removing excess clay by hand. The local IKCs use the hand-thrown method of moulding with the aid of a wooden brick mould that looks like a ladder and carries six bricks. The IKCs in this study call a person responsible for brick moulding a 'brickmaker' ([2]*umfolomu*). The brick mould is filled and levelled to make sure that the bricks are the same size (Figure 2.4e). However, Bossard (2022) notes that the

[3] *Abafolomu* is the plural form of three umfolomu which are words used to refer to the brick makers by the IKCs.

brick sizes are not standardised because brickmakers use different brick mould sizes. After this, the bricks are emptied in a prepared levelled place to allow for the drying process to take place.

2.9.4 Drying

Drying is the stage of the brickmaking process that transforms raw wet bricks into dry raw bricks. The bricks are dried in the open air and sun for 2 to 3 days to enhance the evaporation of water from the wet bricks during which the position of the brick may be changed to ensure even drying (Figure 2.4f). This is influenced by weather conditions; drying is faster on dry on sunny days. Also, depending on soil properties, brickmakers sometimes cover them with straw to prevent cracks and to make them dry evenly (Bossard, 2022). The bricks are then packed and arranged (*ifasi*[4]) such that there are spaces in between them to allow for more drying and covered with a plastic sheet if it is raining (Figure 2.4g). When they are completely dried, they are laid on a prepared foundation in preparation for the firing process.

2.9.5 Firing

The process of firing involves burning raw dried bricks in a fire. The raw dried bricks are stacked in layers with some openings at the bottom for adding fuel. The firing process strengthens the bricks. To burn the bricks, the IKCs use firewood supplemented with coal. They crush and sieve coal. Firewood is collected from the nearby local forest while they buy coal from Ugie in the Eastern Cape. In preparation for the firing process, bricks are arranged in the form of a pyramid that is called a 'clamp kiln' and the IKCs refer to this as *iOnti*[5] (Figure 2.4h).

(a) (b) (c) (d)

Figure 2.4: Showing the first four stages in the process of traditional brick making: (a) excavation (b) heap of soil (c) sieving of soil (d) mixture (mud)

[4] *Ifasi* is the arrangement of raw bricks where they are packed with spaces in between them to allow for more drying process in the Sun.

[5] *Ionti* is an oven made of raw bricks in preparation for the firing process, called clamp kiln.

(e) (f) (g) (h)

Figure 2.5: Showing the last four stages in the process of traditional brick making: (e) using a brick mould (f) raw bricks arranged for drying (g)raw bricks (ifasi) covered with plastic (h) raw bricks arranged for the firing process

According to the IKCs, the firing process involves five stages as shown in Figure 2.5 below:

Figure 2.6: Showing stages in the firing process as hacking, insulation, firing, cooling and de-hacking

2.9.6 Hacking

This involves preparing and levelling the ground, laying the foundation and loading raw dried bricks into the clamp kiln. Bricks are layered standing on their narrow sides leaving spaces in between them (Bossard, 2022). As the bricks are piled up, small openings called fireboxes (Amyikaiye et al., 2021) are left to allow air to get inside the kiln to burn the fire. During the hacking process, spaces are left in between the rows of bricks and coal is poured into them. This is done to allow heat to be transferred to the whole clamp kiln. Fire boxes on the other hand serve as entrances for the firewood both large and light. Once the desired height of the clamp kiln is attained, it is covered with a protective layer of insulation made of clay mud which the IKCs call *idyasi*[6].

[6] *Idyasi* is an insulation cover made with clay to conserve heat energy during the firing process.

2.9.7 Insulation

Laying of the protective cover *(idyasi)* is done after the construction of *ionti* (oven). The whole clamp kiln (oven) is filled in with pieces of previously burnt bricks to conserve heat energy and is then covered with a layer of clay mud *(idyasi)* as a form of insulation to prevent heat loss during the firing process. IKCs use their bare hands to plaster the oven with clay mud. This process is done before the firing process commences. After the process has commenced and the fuel is burning, the fireboxes are also covered with clay mud leaving only small openings on the top of the oven to allow combustion to take place.

2.9.8 Firing

The process of firing the clamp kiln takes about seven days allowing the temperature to reach its peak. At this stage, a significant amount of heat and smoke is generated from the bottom to the top and the walls of the oven to make bricks hard. To start the fire, logs of firewood are placed through the fireboxes, then quick flammable materials such as light firewood, paper and grass are placed on top and in between the logs and coal is poured onto them. Ignition of these materials is initiated by lighting materials at the entrance of the firebox. Initiation of combustion begins at the bottom of the clamp kiln. As the fire burns inside the oven it is transferred and ignites the coal in the gaps in between the bricks enhanced by wind and then the whole clamp kiln burns. The clamp continues to burn for up to 7 days and the IKCs claim that, as heating temperature reaches its peak the oven is so hot that it cannot be touched by bare hands; here raw bricks are transformed into red bricks and blue bricks. Blue bricks are those which are at the centre of the oven and receive a lot of heat and become stronger than the red bricks.

2.9.10 Cooling

After 7 days the fireboxes are opened again after the firing process is completed. When all the wood and coal have burnt into ashes, the cooling process begins. Because of the lack of air and fuel supply, combustion stops and the fire dies leading to a drop in temperature. Cooling of bricks takes 2 to 3 days.

2.9.11 De-hacking

This involves the unloading of the fired bricks from the clamp kiln after they have cooled down. The process starts by uncovering the protective cover of insulation which is also hot and needs to cool down before removing it. After uncovering the clamp kiln, bricks are removed and packed ready to be counted. To check the quality of bricks, they have to be knocked against each other, a ringing sound indicates quality whereas a dull sound means the bricks are under fired.

2.10 Argumentation and Sense-making

Amsa et al. (2020) argue that argumentation enhances learners' critical thinking and understanding of science concepts as learners exchange ideas and elaborate on others' ideas in science lessons. This is in line with the context of this study: learners argued in groups during the group activity stage in trying to connect fire making and stories told when sitting around the fire at home with science concepts learnt in class. Anga'am (2021) postulates that argumentation improves learners 'understanding of science concepts and makes them aware of the need to integrate IK in science. This was borne out in this study where learners could link their IK with science concepts taught in class such as heat energy through arguing on the kind of science involved in fire making and stories.

Research has also revealed that a focus on learners 'sense-making has become popular in science education (Daae et al., 2022). Ha (2022) describes the fundamental goal of knowledge construction in science as sense-making and as such teaching strategies are needed to support learners make sense of conflicting situations. These scholars posit that the science curriculum and pedagogical strategies are designed to support learners to make sense of scientific concepts. Onwu and Mufundirwa (2020) argue that the use of pedagogical strategies that resonate with the way culture is transmitted supports learners 'sense-making of science concepts.

There are various definitions of sense-making and for this study, I adopted Odden and Russ's (2018) definition of sense-making as the process of building an explanation to resolve a perceived gap or conflict in knowledge. I adopted this definition because the study sought to explore how using the traditional brickmaking process can support learners to make sense of the conservation of heat energy and related concepts. This was so because learners seemed to experience a conflict between their IK and WS. This is based on the notion that sense-making promotes deep learning that allows learners to build connections between their existing knowledge and new knowledge (science) more easily and in this way to make sense of the world (Lowell et al., 2022; Zuckerman, 2019).

When learners make sense of a concept sense-making facilitates the process of transferring those ideas to new or different domains (Odden et al., 2018). For instance, during the demonstration of the traditional brickmaking process learners could see that when a fire was made to burn the bricks, heat moved from fire to bricks and when the bricks were covered with mud, heat loss was prevented. This afforded them an opportunity to make sense of the concepts involved in the conservation of heat energy such as heat transfer, insulation, heat gain and heat loss that seemed abstract to them (Taber, 2020).

Concurring, Daae et al. (2022) posit that sense-making occurs through active learning where learners construct knowledge. During this process, they create a shared understanding of concepts that are visible to everyone. For instance, in this study, learners were actively involved in the demonstration of the traditional brickmaking process as they interacted with each other, IKCs and the researcher in trying to understand the concepts related to the conservation of heat energy that were visible to everyone and constructed knowledge through argument. Their arguments were around connecting what was visible to them during the demonstration with the science concepts they learnt in class. In support of this, Turner et al. (2023) aver that sense-making is practised through communication, conversations, storytelling and narratives. So, if our goal as teachers is to help learners construct their own knowledge that makes sense to them so that they are able to explain a phenomenon, we need to consider conflicts that they encounter as a significant resource in sense-making (Ha, 2022).

2.11 Chapter Summary

In this chapter, I discussed literature relevant to the conservation of heat energy. I further discussed literature on the type of soil used to make traditional bricks, learners 'prior knowledge in science classrooms, IK, the benefits and challenges of integrating local IK in science, hands-on practical activity and visualisation, out-of-school context and the role of IKCs in science teaching and learning, Indigenous technology of brickmaking and argumentation and sense-making.

CHAPTER THREE: THEORETICAL FRAMEWORKS

3.1 Introduction

A theoretical framework provides a possible explanation for why things happen and is used as a way of broadly framing a study (Bertram & Christiansen, 2020; Creswell & Creswell, 2018). The central focus of this study was to explore how the traditional process of brick making can support Grade 7 Natural Sciences learners in a rural school to make sense of the topic of conservation of heat energy in particular. This is in line with the requirements of the South African curriculum that IK of learners be recognised in their learning of science. Accordingly, studies have revealed that if learning is related to learners' sociocultural background, it will be interesting and related to what they already know (Mavuru & Ramnarain, 2020).

It is against this backdrop that this study explored the relevance of Vygotsky's (1978) sociocultural theory in the integration of local knowledge in science. Hence, the theory was used as a theoretical framework and is discussed in this chapter. Also, to supplement Vygotsky's sociocultural theory, Ogunniyi's (2007a) CAT expanded by the DAIM was used as an analytical framework. This provided an analytical lens to examine how the construction of knowledge took place during the presentation by the IKCs. The reason for expanding CAT with DAIM involved among others the fact that CAT forms the basis of DAIM which is a pedagogical strategy (methodology) that creates discussion spaces within the classroom aligned to the learning objectives (Fakudze, 2021). Also, complementing Vygotsky's sociocultural theory was motivated in part by the belief that the theory does not emphasise the importance of arguments which help learners to make sense of the learning process. Lastly, in this chapter, I also discuss how the theories complement each other.

3.2 Theoretical Framework: Vygotsky's Sociocultural Theory

This study was informed and guided by Vygotsky's (1978) sociocultural theory because he recognises the need for cultural, cognitive and border crossing in learning (Aikenhead & Jegede, 1999). Also, Vygotsky believes that knowledge is constructed in dynamic interactions between people and their social environment. Essentially, he believes that learners' cognitive development occurs through social interactions. He further states that as learners engage in different activities and internalise the effects of working together, they acquire new ways of learning. In addition, Vygotsky (1978) avers that the development of higher mental functions of an individual cannot occur outside the sociocultural context within which it takes place. In support of this, Taber (2020) notes that learners come to school with some form of local knowledge from home, so when they learn science, they cross cultural borders. Shabani (2016) concurs that, based on the theory, the origin of knowledge should not be sought in the mind but is co-constructed through social interaction. Some of the important details of Vygotsky's seminal work include the importance of culture and social interaction as the basis of learning and development, mediation tools such as language and the concept of the ZPD.

Essentially, in Vygotsky's (1978) sociocultural theory, language plays a critical role in learning. In addition, he avers that learning needs to occur before development (Mayana, 2020; Scott, 2016). Within Vygotsky's sociocultural theory, I used the following tenets, namely mediation of learning, culture and language, social interactions, the ZPD and double stimulation.

3.2.1 Mediation of learning

Vygotsky (1978) posits that human activities take place in cultural contexts, mediated by language and other symbol systems to achieve the goal of learning. He believes that learning as a mediated process is social in origin and becomes individual because of linguistically mediated interaction between the child and more experienced members of society such as parents, teachers and peers (Stott, 2016). Concurring, Kakambi (2021) indicates that the process of mediating learning involves the interactions between the teacher, subject content and the learners for the construction of knowledge. In the context of this study, the Indigenous technology of brickmaking was used as a mediatory cultural tool to mediate learning of the concept of conservation of heat energy. To Vygotsky (1978), language and culture play a central part in learning because he believes that children develop independently in stages as a result of interactions.

3.2.2 Culture and language

Vygotsky (1978) gives great significance to culture and the stories that people tell and sees language as the supreme cultural and cognitive tool. In addition, he posits that language is the carrier of culture as it conveys all the information about culture, in both verbal and written forms. Moreover, Vygotsky (1978) underscores that meaningful learning is enhanced when learners learn through social interactions with materials from their culture. In support of Vygotsky's seminal work, Mukwambo et al. (2014) agree that the theory suggests recognising the cultural elements and practices of learners and leveraging these to facilitate an effective learning process. In concurrence, Mavuru and Ramnarain (2020) point out that different cultures hold different norms, values and expectations and this presents strong influential guidelines on educational practices. Against this backdrop, in the study, learners observed IKCs as they demonstrated the Indigenous technology of brick making using language to explain. During social interactions, the IKCs shared their wisdom and materials from their culture.

3.2.3 Social interaction

To Vygotsky (1978), social interaction is the basis of learning and development. He avers that knowledge is constructed in dynamic interactions between people and their social environment. Concurring, Shabani (2016) accentuates that based on the theory, the origin of knowledge should not be sought in the mind but should be constructed through social interactions. Considering the above argument, the study sought to explore how learners participated, interacted, argued and learnt during the practical demonstration of traditional brick making by the IKCs. The study was not only interested in what the more knowledgeable others (MKOs) brought to the interaction but also in what learners brought, and how the interactions shifted (or not) the learners' sense-making of the concept of conservation of heat energy. As noted above, learners also take the role of a MKO (Scott, 2016) as espoused by Vygotsky (1978). Essentially, social interactions play a role in the learner's ZPD.

3.2.4 Zone of proximal development

To Vygotsky (1978), the ZPD is the distance between the actual development level as determined through independent problem solving and the level of potential development as determined through problem solving under the guidance of a MKO as an adult or more capable learners. Considering this definition, this is the part of cognitive development where there is what the child can do on their own and what they can do with the help of an adult, peer, technology or the MKO until they reach the full potential of their ability. Scott (2016) concurs that the theory sees the ZPD as the area where the child needs more guidance that will allow them to construct higher mental functions. For example, in the context of this study, learners engaged in their ZPDs through participating in the presentation by the IKCs when demonstrating the Indigenous technology of brick making. The practical demonstrations were used to explore learners' independent problem-solving skills where they had to connect what they learnt in class with the practical demonstration and then make sense of the concepts involved in the topic. To understand how individuals make deliberate actions when faced with a conflicting situation, the principle of double stimulation was introduced.

3.2.5 Double stimulation

From a Vygotskian perspective, double stimulation is a method to study mental functions with the help of two types of stimuli (Sannino, 2015). To add, double stimulation is a mechanism to help human beings break away from a conflicting situation. Grant (2022) asserts that the first stimulus is usually a meaningless task, a problem situation or a contradiction which causes a paralysing conflict of motives. For instance, in the context of this study, learners were faced with a conflict of motives in the sense that they had to cross over from the IK worldview to the WS worldview but were not sure how to do this. They struggled to make sense of the topic of conservation of heat energy and related concepts presented in class, as they could not reason that the topic was thematic with their existing IK. To solve the problem, a second stimulus was introduced.

Sannino (2015) believes that with the help of the second stimulus, subjects or participants are likely to increase their control over the object to make sense of it and to ultimately change it to something more meaningful. In the study, a second stimulus in the form of the traditional brick making process was introduced and it served as a catalyst for sense-making of the topic; hence, learners were able to identify scientific concepts from the practical demonstration of brickmaking. To augment Vygotsky's (1978) sociocultural theory, Ogunniyi's (2007a) CAT was used as an analytical framework.

3.3 Analytical Framework: Ogunniyi's CAT

To Ogunniyi (2007a), the CAT takes into cognisance the fact that learners have different worldviews concerning science such as IK and WS (Langehoven et al., 2012). That is, Ogunniyi (2007a) claims that CAT happens when two different knowledge systems such as IK and WS co-exist and can only be possible through cognitive shifts to accommodate each other (Nuntsu, 2020). To add, Riffel (2020) accentuates that CAT occurs when different worldviews or perspectives are expressed on a topic or subject with the hope of resolving misunderstandings that arise; for example, when learners are involved in both science and IK.

Concurring, Onyambu (2017) maintains that the theory can be used when there is a lack of solution to the understanding of the phenomenon of border crossing between learners' IK and WS (Aikenhead & Jegede, 1999). Therefore, learners must be able to negotiate meanings across the two distinct systems of thought to integrate them (Ogunniyi & Hewson, 2008).

Ogunniyi (2007a) posits that as learners try to negotiate meanings across the two different systems of knowledge, that is, IK and WS, their minds keep shifting back and forth through five cognitive ideas such as the dominant idea – where an idea becomes dominant if it is most adaptable in a given context. Secondly, the suppressed idea – where an idea becomes suppressed in the face of more valid, predictive, empirically testable evidence. Thirdly, the assimilated idea – where a less powerful idea might be assimilated into a powerful one in terms of persuasiveness or adaptability of the dominant idea to a given context.

Also, the emergent idea – where there is no prior knowledge, a new one has to be developed. Lastly, equipollent ideas on the other hand occur when two competing ideas exert equal intellectual force on a learner. These can also describe movement of conceptions among learners involved in dialogue narrating the mobilisation of science or IK-based conceptions (Ogunniyi & Hewson, 2008). This is the reason why the theory was employed as an analytical framework for the study to understand the cognitive shifts that occurred in learners' minds as they interacted and argued with each other during the group discussions and with the IKCs and the researcher during the presentation of traditional brick making.

3.3.1 Dominant conceptions

A powerful idea explains and predicts facts and events. An idea is dominant if learners make a claim and back it up with observable empirical evidence or use convincing claims. For example, when learning about conserving heat energy in class, they understand that insulators are the best materials to conserve heat energy because they are poor conductors of heat. They carry out activities in class where they use different materials to back up this claim, but it becomes difficult for them to understand that clay bricks used to build huts at home also conserve heat energy and that there are other ways which can be used to conserve heat energy at home such as covering themselves with blankets which also serve as insulators.

3.3.2 Suppressed conceptions

A suppressed idea is found to be weaker than another idea in the same context. For example, smearing the house with cow dung keeps it cool in summer; this idea becomes suppressed if learners are taught that air conditioners keep houses cool in summer.

3.3.3 Assimilated conceptions

An idea becomes assimilated if it becomes part of another dominant idea. If learners understand that to keep food cool, they need to use a cooler box, it becomes difficult to make them understand that food can be placed inside a dug hole to keep it cool – this technique is particularly used by people in the fields when cultivating.

3.3.4 Emergent conceptions

An idea is said to be emergent if an individual has no previous knowledge of a given phenomenon. For example, learners are taught that one of the ways to conserve heat energy is by building eco houses. This is an idea that is new to them as they have no prior knowledge of such houses.

3.3.5 Equipollent conceptions

When two competing ideas or worldviews such as IK and WS have a comparably equal intellectual force on an individual, the ideas tend to co-exist without any conflict. For example, during the demonstration by IKCs, learners saw that the clamp kiln (brick oven) was covered with a layer of mud to prevent heat loss. So, they connected that information to the concept of insulation as its function is to prevent heat loss or gain. Then, they understood that insulators do not conduct heat energy, instead they conserve it. Concurring, Jegede's (1995) collateral learning theory states that learners construct scientific concepts side by side and with minimal interference and interaction with their Indigenous everyday concepts.

To add, Govender (2016) argues that argumentation is critical to producing, evaluating and therefore advancing knowledge. Therefore, it should be an essential element of science education and used to help learners engage with social construction of knowledge, both science and IK. In turn, this will help them learn both scientific and IK beliefs and it will become clearer when it is appropriate to apply one belief or the other. Therefore, CAT is contextually based and can be applied to two or more systems of thought (Govender, 2016). In support of this, Onyambu (2017) argues that cognitive ideas could shift back and forth in learners' minds from one cognitive idea to another and from one worldview to another as they try to understand a natural phenomenon such as how brick making conserves heat energy. Then the observed phenomenon can be interpreted in terms of IK from the cultural perspective of the learner or science learnt in school – depending on the context, they choose which worldview to base their argument on. Hence, in this study, they interpreted the observed phenomenon by connecting the two worldviews to make sense of the topic at hand. In the study, CAT was expanded by using DAIM.

Expanding on Ogunniyi's (2007a) CAT, Riffel (2020) accentuates that the DAIM is a teaching strategy that creates teaching and learning spaces for reasoning, dialogue, argumentation and communication. In support of this, Fakudze (2021) argues that DAIM provides a non-threatening learning environment that encourages learners to express their views freely with others, reflect what they have learnt and change their minds in the face of a stronger argument. This shared commitment is done towards respectful presentation of opinions. For example, in the context of this study, learners were involved in group discussions where they discussed their IK on fire making and the reasons for making it. They were free to share their ideas in a non-threatening environment respecting each other's opinions. Also, during the presentations by the IKCs, learners argued freely with each other and the IKCs.

Similarly, to CAT, DAIM takes the position that the two systems of knowledge, that is, IK and WS should complement each other instead of competing with one another (Ogunniyi, 2007a). Extending on Ogunniyi's (2007a) seminal work, Nuntsu (2020) explains that DAIM was proposed as a means for negotiating science and IK and it aims at reaching a consensus if possible. In this regard, Anga'ama (2021) points out that argumentation promotes learners' understanding of science concepts and makes them aware of the need to integrate IK into science and to understand that the two knowledge systems can complement each other in science classrooms.

In the study, during group discussions about making fire, learners were able to understand concepts related to conservation of heat energy such as heat transfer. Basically, in this study, DAIM was used as a methodological framework as discussed in the next chapter, to explore how its use could improve learners' ability to argue. However, I was aware of the limitation of using DAIM as a teaching and learning method that provides learners an opportunity to express their views freely, since learners in rural areas, in particular, still find it difficult to make arguments because they are not used to arguing. They have insufficient verbal ability in the language of teaching and learning and less courage to express their ideas (Amsa et al., 2020). This limitation in the study was addressed by code-switching between the learners' mother tongue (isiXhosa) and the medium of instruction (English); as a result, learners were free to express themselves using their mother tongue.

3.4 How the Two Theories Complement Each Other

In my view, the two theories complement each other. For example, Vygotsky's (1978) SCT emphasises the importance of culture and language during the mediation of learning so that learners can relate this to the topic being taught. Also, SCT explores learners' argumentations (CAT) as social interactions. This means when learners participate in classroom talk (Lemke, 2001), this is only possible through social interactions (SCT) involving the speaker and the recipient – this is argumentation (CAT). For argumentation to take place, learners use language as a cultural tool (SCT). In contrast, culture was suppressed (CAT) in our education system during the apartheid era and was dominated by WS. As a result, other ways of knowing were assimilated (CAT) into Western ways of knowing. In addition, categories in CAT were used to analyse ideas that emerged from learners during social interactions as suggested by Vygotsky (1978).

The goal of the study was to challenge the dominance of WS by suggesting that there are other ways of knowing such as IK. To address this, the study tapped into the cultural heritage of IKCs as espoused by Vygotsky, by asking them to present to the learners their Indigenous practice of traditional brickmaking. Vygotsky (1978) refers to IKCs as MKOs. As the IKCs presented in the learners' mother tongue, isiXhosa, which was suppressed, learners learnt something from the interactions between themselves and the teachers, themselves and the IKCs and among themselves. There was a shift in their ZPD (Vygotsky, 1978). However, during the lesson presentation in class, both languages, that is isiXhosa and English, were afforded an equal status through code-switching; this means we reached an equipollent cognitive state (CAT). Lastly, the study enhanced social interactions by tapping into the cultural heritage of IKCs.

3.5 Chapter Summary

In this chapter I discussed the theory that underpinned the study, Vygotsky's (1978) SCT and its tenets. I further discussed the analytical theory employed in the study, Ogunniyi's (2007a) CAT. Lastly, I discussed how the two theories complemented each other.

CHAPTER FOUR: RESEARCH METHODOLOGY

4.1 Introduction

Bertram and Christiansen (2020) and Nayak and Singh (2015) state that research methodology concerns how researchers go about finding knowledge about the world. This includes how they collect data depending on their views of what exists (ontology) and what can be known (epistemology) based on the principles, procedures and practices that govern research (axiology). Essentially, these scholars believe that research methodology is the strategy that translates ontological and epistemological principles into guidelines that show how research is to be conducted.

The main goal of this formative interventionist study was to explore how using the Indigenous technology of brickmaking can support a Grade 7 Natural Sciences class in a rural school making sense of the phenomenon of the conservation of heat energy. The study intended to make science accessible, clearer and more relevant to learners by integrating learners 'existing knowledge of science through using easily accessible cultural resources (Asheela et al., 2021; Shinana et al., 2021) such as traditional brickmaking in the context of my study. To achieve my goal, I chose a research methodology with an appropriate research paradigm and research design. The research methodology consists of two components, that is, the research paradigm and research design. In this chapter, I discuss the research paradigms underpinning the study followed by the research design employed.

4.2 Research Paradigm

A research paradigm is a conceptual lens through which a researcher examines the methodological aspects of their research project to determine the research methods that will be used and how the data will be analysed (Bagele & Chilisa, 2021; Bertram & Christiansen, 2020; Kivunja & Kuyini, 2017). These scholars further argue that a research paradigm tells us how meaning will be constructed from the data collected based on individual experiences. Against this background, the study was underpinned by an interpretivist paradigm (Cohen et al., 2018; Creswell & Creswell, 2018) complemented by an Indigenous research paradigm (Chilisa, 2012). This suggests that this study was guided by the assumptions, beliefs, norms and values of these chosen paradigms (Kivunja & Kuyini, 2017).

In the context of this study, the two research paradigms complemented each other in trying to support this investigation of how learners argue and make sense of the concept of conservation of heat energy during the presentation of traditional brickmaking by the four IKCs. Based on the Indigenous belief that knowledge is relational, both the learners and I had an opportunity to interact with the IKCs to understand and interpret the science concepts that emerged as they shared their wisdom on traditional brickmaking. I discuss these paradigms below.

4.2.1 Interpretivist paradigm

The study is located within the interpretive paradigm. This paradigm is significant in the study in that it supports the need to understand things in their real contexts. Cohen et al. (2018) assert that interpretive researchers see the world through the eyes of the participants rather than as outsiders. Concurring, Creswell and Creswell (2018) state that researchers immerse themselves in the context in trying to make sense of it from the participants 'point of view. The emphasis in the interpretive paradigm is on understanding the individuals and their interpretation of the world around them (Cohen et al., 2018; Kivunja & Kuyini, 2017). Similar views are shared by Bertram and Christiansen (2020) who argue that the purpose of the interpretive paradigm is to develop a greater understanding of how people make sense of the contexts in which they live and work. These scholars posit that data in the interpretive paradigm is generated in real situations that ultimately lead to descriptions of behaviours, perceptions and experiences. Tracy (2013) adds that another strength of the interpretive paradigm is that the researcher works with the participants as co-researchers rather than as subjects being researched.

Considering the above, in the context of my study, learners observed IKCs in their brickmaking site as they demonstrated the traditional method of brickmaking to demonstrate the conservation of heat energy and related concepts. In the process, the researcher, learners, IKCs and my critical friend were co-researchers because we all explored how mobilising the intervention strategy of traditional brickmaking could support the learners to make sense of the conservation of heat energy. This was a new knowledge construction strategy for all of us, aligning with Tracy's (2013) claim that this paradigm is a way of seeing both the reality and knowledge as constructed and reproduced through arguments, interactions, and practice.

However, one of the limitations of the interpretive paradigm is that it focuses on description at the expense of explanation (Nuntsu, 2020). It is also silent on relational dynamics between the researcher and the participants and it focuses on individuals. In trying to address this, the interpretive paradigm was complemented with the Indigenous research paradigm to enhance explanations. In the Indigenous research paradigm (Chilisa, 2012), knowledge is relational: it goes beyond individual knowledge and is shared among others. As a result, the researcher is answerable to all the participants.

4.2.2 Indigenous research paradigm

The Indigenous research paradigm entails including perspectives and methods that draw from IK, languages, metaphors, worldviews, experiences and philosophies of the former colonised, historically oppressed and marginalised social groups (Chilisa, 2012). Hart et al. (2010) argue that an Indigenous research paradigm is structured within an epistemology that includes a subjectivity-based process for knowledge development and a reliance on community elders and individuals as custodians of our culture.

Based on this perspective, the paradigm was deemed relevant in the context of the study in that IKCs shared their knowledge on the Indigenous technologies of brickmaking in trying to help learners make sense of the topic of conservation of heat energy. My interest in employing this paradigm as one of the paradigms underpinning my study was triggered by the fact that the Indigenous research paradigm allows researchers to be who they are while they are actively involved as participants and knowledge is relational and is shared with all (Hart et al., 2010). This does not only generate new knowledge but changes who researchers are and where they are located.

Moreover, Hart et al. (2010) assert that with this paradigm, there is a sense of commitment to the people that you work with as the researcher and there is an understanding of reciprocity and accountability to one another. In the study, I was answerable to all my participants, both the IKCs and learners. Also, we all benefited from the study in the sense that I managed to support learners to make sense of the topic by integrating the lesson with indigenous knowledge from the IKCs, while learners made sense of the topic from the demonstration. Moreover, IKCs became part of their children's education. This speaks to cultural revitalisation (Cocks et al., 2012; Smith, 1999).

The knowledge of traditional brickmaking that learners received from the IKCs which they received from their forefathers, will be passed on from generation to generation and the need to involve the IKCs in their children's learning will be recognised. Hence, Mertens (2016) states that with the Indigenous research paradigm, research is done by, with and for the Indigenous people and informs decolonisation. For instance, the demonstration was done by the IKCs interacting with the learners and the researcher and in turn the IKCs were involved in the education of their children and a new strategy of teaching and learning was developed. Similar views were shared by Triyanto et al. (2020) who argue that integrating IK in science is a way for the IKCs to gain a better space and access to school. Therefore, within the Indigenous research paradigm, the focus was on the Ubuntu perspective.

Scholars such as Mpu et al. (2020) and Seehawer (2023) describe the term Ubuntu as humanness that embraces the interconnectedness, not only of humans but of all creation, and emphasises communality. It is the quality of being human, involving caring, sharing, respect and compassion (Muwanga-Zake, 2010; Ogunniyi, 2018). To Seehawer (2018b, 2023), Ubuntu is understood as humble togetherness and humanness including the dimensions of being and becoming human. Therefore, the Ubuntu perspective goes beyond the idea of individual knowledge to the concept of relational, shared knowledge involving ethics of how to interact with others (Hart et al., 2010; Seehawer, 2018b). Consequently, with Ubuntu, relationality is what makes a person human as evidenced in the isiZulu saying that '*umuntu ngumuntu ngabantu*' which means whatever happens to the individual, happens to the whole group and *vice versa* (Seehawer, 2023).

Within the context of the current study, Ubuntu was enacted as learners interacted with each other, with me and with the IKCs as they were sharing their knowledge of traditional brickmaking. When we arrived at the brickmaking site, all four IKCs were so welcoming, hospitable and willing to share their wisdom, knowledge and skills of the Indigenous technology of brickmaking. During these social interactions as espoused by Vygotsky (1978), there was mutual respect between the researcher, the critical friend, the learners and the IKCs. Also, during these interactions, continued enactment of humanness through relating positively (Seehawer, 2023) with each other was evident. For instance, in our culture when we meet people, we greet them and introduce ourselves, sitting down not standing. This is done to show respect as well as to establish positive relations with them. So, when we arrived at the local brickmaking site, we did the same thing in trying to show respect to the elders and to establish positive relations. After the presentation, we sat down and shared stories about firemaking, how the bricks are used to build traditional houses in which these elders live and ate what we had brought.

Furthermore, the study used focus group interviews as one of data data-gathering tools. This is part of Ubuntu because using sharing circles (Afonso-Nhalevilo, 2013; Chilisa, 2012; Lavallee, 2009; Mucina, 2011) creates togetherness, unity and a non-threatening environment where different opinions are respected. Lastly, similarly to Mutanho's (2021) study, clan names were used during social interactions instead of pseudonyms to level power gradients as it is regarded as disrespectful in our culture to call elders by their names.

4.3 Research Design

A research design is a plan of how the researcher will systematically collect and analyse data that are needed to answer the research question(s) (Bertram & Christiansen, 2020; Cohen et al., 2018; Creswell & Creswell, 2018). Accordingly, a research design occupies a very critical point in a study since the success of the entire study depends on it (McChester et al., 2014). In addition, these scholars assert that a research design answers important questions such as how the data were collected and analysed and shows the reader how the results were obtained and why. In light of the above discussions, a qualitative case study research design was employed in the study.

4.3.1 Qualitative case study research design

A case study is a systematic and in-depth study of individuals or groups in their real-life settings for an extended period through the use of several collection methods (Bertram & Christiansen, 2020; McChester et al., 2014; Nayak & Singh, 2015). In a case study, the researcher aims to get a deeper understanding of the participants' points of view (Cohen et al., 2018; MacChester et al., 2014). However, one of the limitations of using a case study design is that results cannot be generalised. In this study, I employed a case study design in trying to get an in-depth understanding of how to integrate the information gained from traditional brickmaking by the IKCs to help learners make sense of the concept of the conservation of heat energy. Also, by employing a case study design, I was hoping that this might help me to better understand learners 'points of view as they were interacting with each other, the IKCs and the researcher during the presentation by the IKCs. At the same time, I hoped to get a better understanding of the IKCs 'experiences of traditional brickmaking in relation to conserving heat energy.

My case in this study was a Grade 7 Natural Sciences class from a rural school in the O.R. Tambo Coastal District of the Eastern Cape in South Africa. I used this class to get an in-depth understanding of how mobilising the process of traditional brickmaking can support learners to make sense of the topic of the conservation of heat energy as one of the challenging topics in the class. I employed a qualitative case study design in this study because it lends itself well to capturing information of an explanatory nature answering the 'what' and 'why' questions (Crowe et al., 2011) such as how the intervention being implemented can support learners to make sense of the aforementioned topic.

Moreover, the case study design offers additional insight into why the intervention strategy might be chosen over other strategies (Crowe et al., 2011). For example, in the context of my study, through studying the case in question, I can recommend without doubt that the intervention strategy of using the traditional brickmaking process can be employed in many science lessons such as physical properties of materials, emission of greenhouse gases, climate change and others and can be used across subjects such as in Mathematics. In the case of my study, the units of analysis were the learners 'argumentation during group discussion, their interaction with each other and the IKCs during the practical demonstration of traditional brickmaking and how they used the IK of brickmaking to make sense of the concept of conservation of heat energy.

Therefore, the case study sought to get a deeper understanding of how the Indigenous technology of brickmaking could support learners in a rural school to make sense of the concept of conservation of heat energy. This teaching strategy was adopted to make the topic relevant to learners by making them active participants in negotiating their learning (Mashoko, 2022). Hence, the study employed a participatory observation approach where all the participants participated fully including myself as a co-researcher

4.3.2 A participatory approach

Birhane et al. (2022) postulate that a participatory approach provides a distinct opportunity to learn from. This includes knowledge that is created by people who are directly affected by the existing or new project and it leads to individual and collective empowerment. Furthermore, Hall et al. (2021) argue that the participatory approach establishes trust and rapport between the researcher and the participants and it actively involves participants in the research issue. Henceforth, within the context of this study, I believe that a learner-centred, culturally relevant strategy and a participatory approach would help me achieve the goal of the study. This is in line with one of the principles that underpins the South African CAPS curriculum which suggests active learning as a way of moving away from rote and uncritical thinking to allow learners to work effectively as individuals and with others in a group (DBE, 2011, p. 5).

In support of this, scholars such as Hermanandez-de-Menendez et al. (2019) and Jesionkowsa et al. (2020) contend that active learning is a learner-centred approach which directly involves learners in the learning process. To these scholars, active learning allows learners to be active participants in the learning process and motivates them to take ownership of their learning by doing meaningful activities and critically thinking about what they are doing.

4.4 Research Goal and Research Questions

Research goals of the study include the motives, desires and purpose of doing the study or anything that the researchers want to accomplish, and each study has its own purpose (McChester, 2014). Therefore, the decision about what theory and knowledge are relevant for the study depends on the research goals and research questions. Hence, it is important for the research questions to have a clear relationship with the research goal. In line with the above discussion, the research goal and the research questions that inform this study are stated below:

4.4.1 Research goal

The main goal of this formative interventionist study was to mobilise the Indigenous technology of brickmaking to support a Grade 7 Natural Sciences class in a rural school to argue and make sense of the topic of conservation of heat energy. To achieve this, the following research questions were addressed.

4.4.2 Research questions

1. How do Grade 7 Natural Sciences learners experience learning the topic of conservation of heat energy?
2. How do Grade 7 Natural Sciences learners interact, argue and participate during a presentation by the indigenous knowledge custodians on the traditional way of brickmaking?
3. How do Grade 7 Natural Sciences learners' argument and sense-making shift (or not) as a result of the practical demonstration of the Indigenous technology of brickmaking by the indigenous knowledge custodians and by using exemplar lessons that integrate learners' local indigenous knowledge on this topic?

Thus, within the context of this study, the participatory observation approach which encourages openness and equity in knowledge sharing, experiences and ideas (Hall et al., 2021), was adopted using Ogunniyi's (2007a) DAIM as discussed below.

4.5 Methodological Frameworks

In the following section, I elaborate on two methodological frameworks that informed this study. The first one is the DAIM, followed by the Transformative Model of Education for Sustainable Development (TMESD).

4.5.1 Dialogical argumentative instructional model

Langehoven et al. (2018) argue that the DAIM is a teaching model that enables learners to talk about their opinions and express their understandings and beliefs to make sense of science concepts. George et al. (2020) further explain that DAIM is one way of creating teaching and learning spaces where learners 'views are appreciated giving them a chance to make meaning of science concepts. Through using DAIM as a teaching method, teachers provide learners with the skill of argumentation.

The DAIM views the two worldviews, that is IK and WS as complementing each other instead of competing and it aims to reach cognitive harmonisation around conflicting or controversial views (Langehoven & Stone, 2013). They argue that as learners try to negotiate IK and WS in their cognitive processes the two worldviews attempt to align themselves with each other by seeking regions in the thought systems, ideas or concepts that share common elements to accommodate, adapt and reconcile them to each other to make sense. In other words, these scholars believe that using DAIM as a teaching strategy for scientific argumentation as well as for integrating IK in science classrooms enhances teaching and learning of scientific concepts.

However, one of the limitations of using DAIM in the context of my study was that learners found it difficult to argue as they were not used to argumentation. More challenging to them was the use of language foreign to them like the language of instruction. They were unable to express their views in a logical manner, supported with evidence. To counteract this challenge, I encouraged them to code-switch between their mother tongue and the language of instruction during group discussions. This problem was more evident with boys than girls. DAIM created an environment conducive to learners' discussion among themselves, with the indigenous knowledge custodians, my critical friend and myself during the presentation by the IKCs using their mother tongue as they were trying to reconcile the two worldviews to make sense of the topic under consideration. This was translated into English by my critical friend.

Langehoven and Stone (2013) also believe that DAIM is a learner-centred approach that promotes discussions in science. So, these scholars aver that teachers should be able to design teaching strategies that create non-threatening environments for learners to be able to negotiate IK and WS so that they appreciate the relevance of science in real-life settings. To achieve the aim of navigating between IK and WS, these authors suggested a DAIM model that follows a series of stages as shown in Figure 4.1 below:

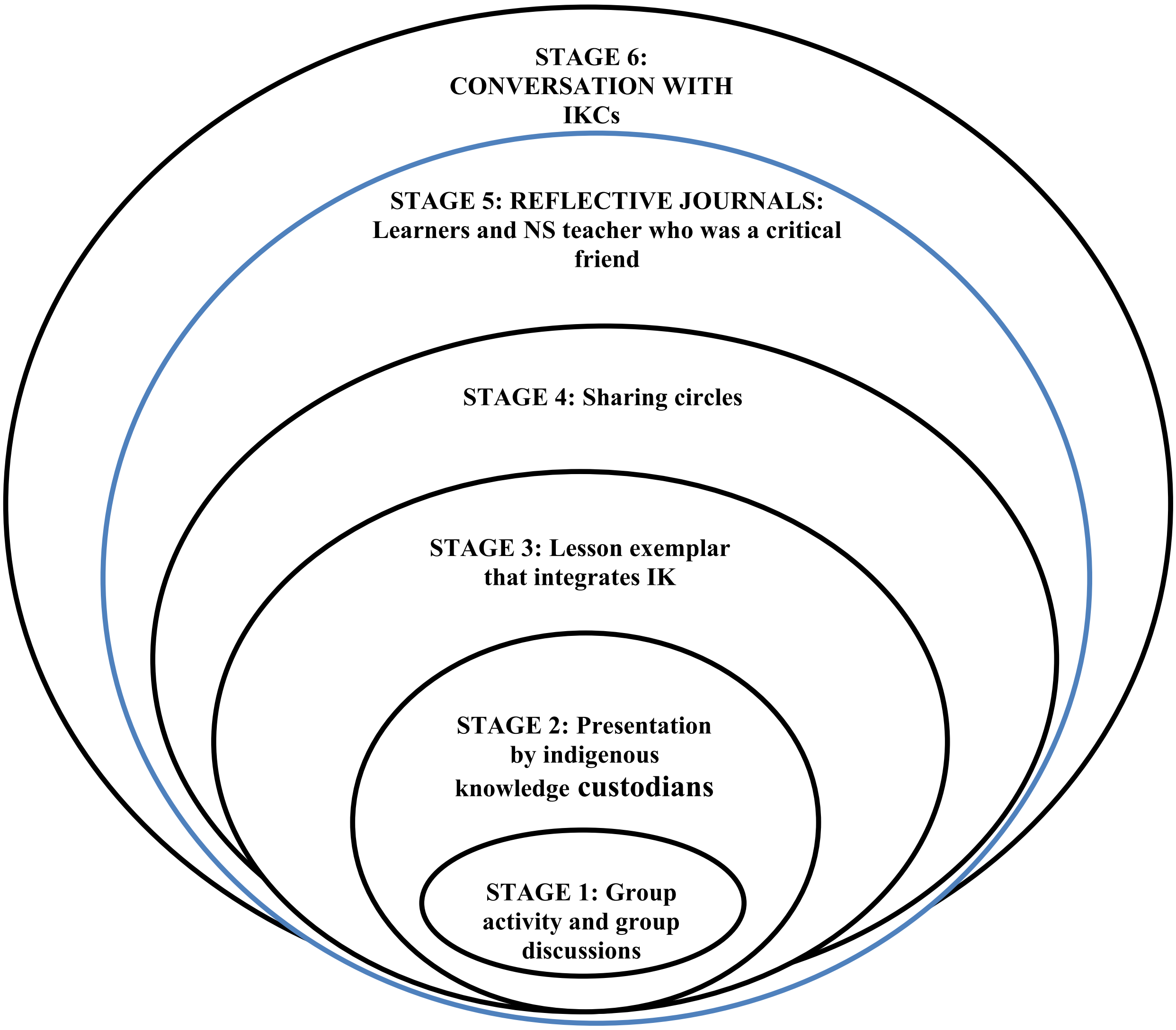

Figure 4.1: The DAIM for integrating IK in science (Adapted from Langehoven & Stone, 2013, p. 6 and Langehoven & Ogunniyi, 2018, p. 76)

In contrast to the Langehoven and Stone (2013) DAIM model in stage 1 (group activity and discussions) in this study, learners worked in groups and shared views on making fire and stories told when sitting around the fire, and then identified scientific principles related to these stories. For Stage 2 (presentation by IKCs and participatory observation), we visited a local brickmaking site with the learners and my critical friend to observe the practical demonstration of traditional brickmaking to find out if this could help learners make sense of the topic. In Stage 3 (lesson exemplar) I consolidated the lesson by presenting a lesson exemplar that integrated IK into the topic focusing on the concepts that emerged during the practical demonstration by the IKCs. Stage 4 (sharing circles interviews) took the form of focus group interviews (sharing circles) (Lavallee, 2009) where we sat in a circle with the learners (this a traditional way of sitting when sharing stories) in trying to create a non-threatening atmosphere where learners freely expressed their views, respecting opinions of others (Fakudze, 2021).

The aim of the focus group interviews (sharing circle) was to find out if learners ’sense-making of the topic shifted or not after the intervention. Stage 5 (reflective journals) took the form of reflective journals of learners and the science teacher who was my critical friend. These were also intended to find out if the learners ’sense-making shifted or not after the presentation and the use of the lesson exemplar. This was so because not all learners were part of the focus group interview. Also, I was mindful of the fact that some learners were shy to speak, so reflective journals afforded all learners an opportunity to reflect on what transpired during the practical demonstrations by the IKCs. They also helped me to see if there was a shift or not in their sense-making of the topic.

In Stage 6 (conversation with the IKCs), after the whole process, I went back to the local brickmaking site to those women who presented the traditional brickmaking process to find out how they felt about presenting to learners. They felt so privileged to be afforded an opportunity to showcase their knowledge and skills to learners. They were proud of the fact that their culture was being appreciated at school. One of them, the eldest in the group even commented that they were more knowledgeable than people who were educated when it came to cultural practices such as fire making and cooking with iron pots.

In this regard, Langehoven and Stone (2013) assert that DAIM is an effective strategy for teaching science by connecting it with IK. These scholars believe that argumentation clarifies the science in IK and the IK in science. Within the context of the study, this was evident as learners identified science concepts that emerged from the practical demonstration of traditional brickmaking. For example, when the IKCs covered the brick oven with a layer of mud to prevent heat transfer, learners linked that with insulation in science. In all, the use of DAIM in the study through social interactions (Vygotsky, 1978) among learners and the IKCs necessitated argumentation led them to reach a collaborative consensus, hence sense-making of the topic of conservation of heat energy. Concurring, Riffel (2020) states that DAIM occurs when two worldviews such as IK and WS are expressed with the hope of reaching a collaborative consensus in the end.

4.5.2 Transformative Model of Education for Sustainable Development

Within the context of this study, the research process was informed by the TMESD (Chikamori et al., 2019). The TMESD model socialises learners to be informed agents who can transform their society into a sustainable society through thinking about how the past has brought them the present actions and what action at the present can take them forward towards a sustainable future. This resonates with the goal of the study as the study sought to find out if integrating the Indigenous technology of brickmaking (learners 'past) can support learners in making sense of the conservation of heat energy (learners 'present). It was hoped that if the strategy worked, that would mean some form of curriculum transformation with new teaching strategies that integrate IK into future science lessons (sustainable future). In turn, this would benefit society as their children would learn the Indigenous technology of brickmaking and pass this knowledge on to the next generation, a process of cultural revitalisation.

Chikamori et al. (2019) accentuate that the TMESD model consists of three sub-processes, that is: '*knowing the present', 'past-present relationships' and the 'future-present'*. To these scholars, the "past-present relationships" are known as '*retroductive learning'* and the "future-present relationships" as '*retrodictive learning'* '(see Figure 4.2 below). They claim that the present depends on the past and it gives pre-conditions that enable or constrain the future in relation to 'knowing the present'.

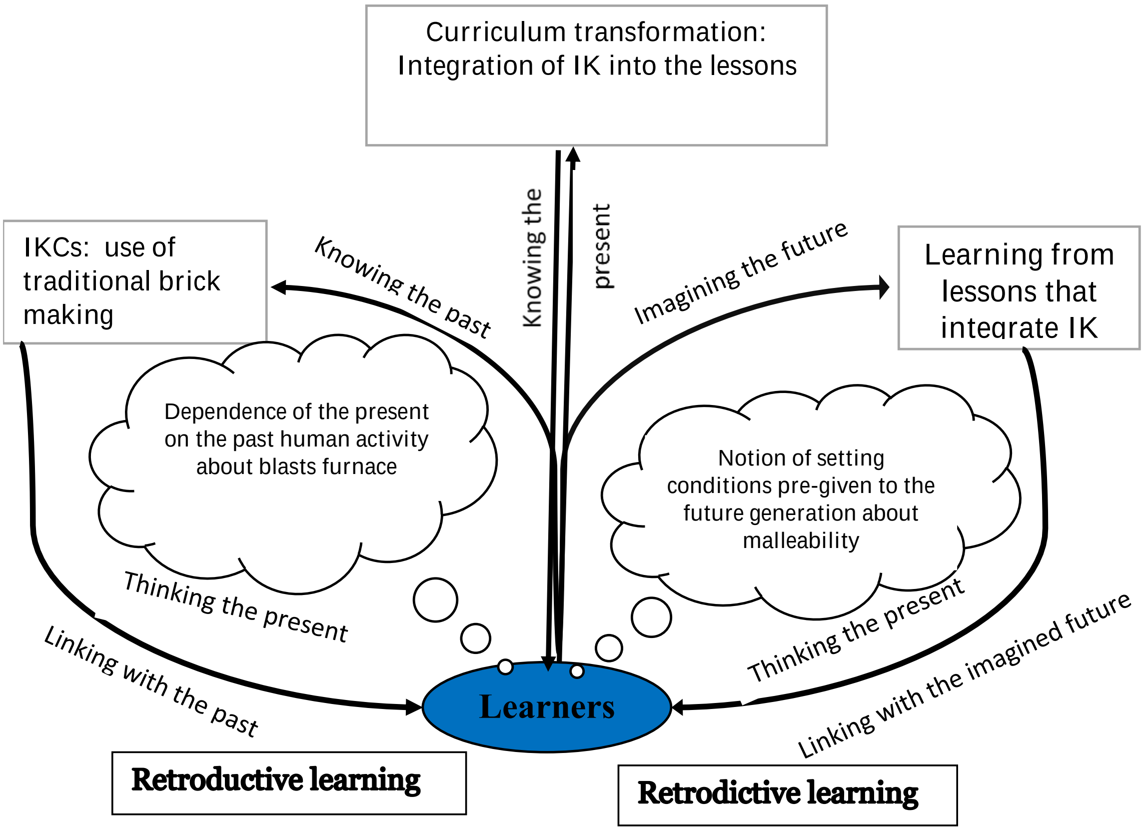

Figure 4.2: Shows the process of IK integration in science in this study (adapted from Chikamori et al., 2019, p. 9)

4.6 Research Site, Participants and Sampling

The study was conducted at [7]Ubuntu Primary School (pseudonym) in Nyandeni Local Municipality in the O.R. Tambo Coastal District in the Eastern Cape in South Africa (Figure 4.3). The O.R. Tambo Coastal District is one of the districts in the new Service Delivery Model. It combines several districts along the coast such as Libode, Ngqeleni, Port St Johns, Lusikisiki and parts of Flagstaff. The school has an enrolment of about 380 learners from Grades R to 7 and 12 teachers with a teacher-learner ratio of about 1:32. It has an old, dilapidated infrastructure with two prefabricated blocks of 10 classrooms and one block with three classrooms built with concrete bricks by the community. The school did not have a science laboratory to help learners conduct practical activities; this is one of the reasons that triggered me to conduct the study where I used the traditional brickmaking process as an easily accessible resource to mediating learning about the conservation of heat energy (Asheela et al., 2021). Budiastra et al. (2021) believe that the lack of resources or infrastructure to mediate the learning of science is obstacle to carrying out the learning process based on inquiry.

At this school, learners and teachers are all Black and isiXhosa speaking. The learners come from diverse sociocultural backgrounds (Mavuru & Ramnarain, 2020) and are from poverty-stricken families who depend on social grants and a few of them come from the middle-income group. Learners do not pay school fees as the school is classified as a [8]quintile 1 school. Public schools in South Africa are categorised into five groups called 'quintiles' according to income levels of the community around the school, unemployment rate and level of education of the community. This resulted in schools in quintiles 1, 2 and 3 being referred to as no-fee-paying schools and those in quintiles 4 and 5 as fee-paying schools because of the areas in which they are located and access to infrastructure (TIMSS, 2019).

The participants in the study were Grade 7 Natural Sciences learners from the school where I teach. I chose this grade because I was the learners' classroom teacher who also taught them Natural Sciences and the topic of the conversation of heat energy was part of the syllabus. This is the reason why convenience and purposive sampling were used in the study (Bertram & Christiansen, 2020; Cohen et al., 2018). Being a teacher at the school made interacting with my research participants easier as I knew them. Furthermore, learners were taken to a local brickmaking site. This was convenient because the practical demonstration of brickmaking could only be demonstrated on-site. Mavuru and Dudu (2021) believe that practical activities can be done anywhere be it in the classroom or an out-of-school context and engaging learners in practical activities improves their conceptual understanding. Learners voluntarily participated in the study. However, because they were minors, consent was sought from the parents or guardians.

In addition, four IKCs, all women who are more knowledgeable (Vygotsky, 1978) of the process of traditional brickmaking, were the participants in the study. Verbal and written consent was sought from the IKCs as the gatekeepers of the brickmaking site. Initially, I planned to work with two men and two women for gender balance, but when we arrived on the site on the day of the presentation, we found only women with one man who also left. In our culture, it is believed that one man cannot be among women as his manhood will be doubted. Traditional brickmaking is done by both men and women equally, hence those women continued with the practical demonstration even though there were no men. This means traditional brickmaking is cultural knowledge that is neutral in terms of gender. As happened in Mayana's (2020) study, the four IKCs co-presented and complemented each other very well in the study and to see them imparting that kind of knowledge and skill of traditional brickmaking to learners as women was quite fascinating. Also, one science teacher from school took part in the study as my critical friend. I invited him to observe and video-record, with their permission, the practical demonstration by the IKCs. At the beginning of the research process, I planned to work with another science teacher from a neighbouring school because I was the only science teacher at school then. Coincidentally, a new teacher arrived at school and was willing to take part in the study as he was also doing his mini-thesis at the Honours level in Mathematics. We co-planned a lesson module that integrated learners 'local knowledge on the topic of conservation of heat energy. We reflected together on what transpired during the practical demonstration by the IKCs.

So, in this study, my learners and I were co-researchers because we were all less knowledgeable about the process of traditional brickmaking. This means I conducted the research with the learners, not on them. In fact, learners were actively involved in knowledge co-construction. The study sought to understand how the use of the Indigenous technology of brickmaking could be used to support Grade 7 learners to make sense of the concept of the conservation of heat energy. In trying to bring back learners' voices into curriculum transformation, the study sought to find out how learners found learning the concept of the conservation of heat energy, followed by the intervention where IKCs presented their Indigenous technology of brickmaking combined with a lesson module which consolidated the whole process.

The sample size of this study was small because the aim was not to generate results for a larger population of Grade 7 Natural Sciences learners in the O.R. Tambo Coastal District. In this study, the focus was on a single phenomenon in its real-life setting (Crowe et al., 2011). Therefore, I used a Grade 7 Natural Sciences class in my school which consisted of 24 learners, 10 girls and 14 boys. Learners were taken to a brickmaking site to observe the four IKCs demonstrate the traditional method of brickmaking. It was hoped that by taking learners to an out-of-school context (Gurler, 2021), they were likely to initiate interactions, engage in shared thinking and raise questions during the practical demonstration.

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[7]The pseudonym 'Ubuntu 'given to the school is consistent with the Ubuntu perspective that underpinned the study to emphasise that knowledge in this study goes beyond individual knowledge to relational, shared knowledge including ethics of how to interact and respect each other.

[8]Quintile refers to categories of public schools in South Africa according to income levels of the community around the school with quintile 1 being the poorest while quintile 5 is the least poor (Nuntsu, 2020).

Figure 4.3: Shows the map of the Eastern Cape with O.R. Tambo Coastal District where the study occurred (Wikimedia.org/ Wikipedia)

Table 4.1: Profile of the IKCs

Clan names	**Age**	**Gender**	**Home language**	**Education**	**Place of birth**	**Occupation**
MaDlamini	85	Female	IsiXhosa	Standard 4	Tabankulu	Retired hospital general worker
MaKhiwa	41	Female	IsiXhosa	Grade 12	Ngqeleni	Brick maker
MamThembu	59	Female	IsiXhosa	Grade 9	Ngqeleni	Brick maker
MaSikhosana	52	Female	IsiXhosa	Grade 9	Idutywa	Brick maker

4.7 Data-Gathering Methods

The term 'data' refers to the evidence that researchers collect to find answers to the questions asked (Bertram & Christiansen, 2020). This study collected data using four data-gathering techniques to answer my research questions: group activities, observations (participatory and lesson observations), focus group interviews (sharing circles), and learners 'reflective journals.

Using a variety of data collection methods enables the researcher to gather enough data to be able to answer the research questions. Crowe et al. (2011) similarly argue that using triangulation has been seen as a way of increasing validity, which means the extent to which the research method is appropriate to answer the research question. All these interactions were video recorded with the permission of the participants. My critical friend helped with this. I now discuss each of these data-gathering methods.

4.7.1 Group activities

Williams (2011) says that the purpose of using group work is to get information and other resources in order to respond to a given task which may or may not be assessed. This resonates with the purpose of using group work in this study, which was to determine learners ’prior knowledge. This, in turn, helped to answer research question one. To facilitate active learner participation in the study (Sedlacek & Sedova, 2017; Vygotsky, 1978), learners were divided into four mixed groups of six (boys and girls) and asked to share stories about making a fire that are told in their homes and community when they are seated around the fire (Lavallee, 2009; Liveve, 2022). Each group was given 5 to 10 minutes to have a discussion and their responses were recorded on newsprint posters. They were given the following guiding questions for their discussion:

a) How do we make a fire at home and why do we make it?
b) What stories are told at home when you sit around the fire?
c) How do these stories relate to the science learnt at school?
d) Why are traditional huts made of clay bricks?
e) What relevance do you think this has in science, in particular in the topic of the conservation of heat energy?

As mentioned earlier, DAIM was used to scaffold group discussions. This model created a thinking space for learners as they were involved in dialogical argumentation on all three levels as espoused by Langehoven and Stone (2013): intra (individual), inter (group) and trans (whole class). At first, each learner was required to find information from home on making a fire and the reasons for making a fire; then they discussed that in groups. Later, groups presented their findings in class which were discussed by the whole class, at the same time as identifying science related to making a fire and reasons for making it. During the process of group discussion, the spirit of Ubuntu was developed as learners respected each other's ideas and were willing to share all the knowledge from home. Some learners struggled to argue as they were not previously used to this strategy and language was also a challenge, especially for some boys. Hence, I allowed them to trans-language which afforded an opportunity for all of them to take part in the discussions; even those learners regarded as weak were able to voice their views. This supports an understanding by Langehoven and Stone (2013), that a teacher as a facilitator consciously creates thinking spaces for learners. The group discussion took about 60 minutes. I now discuss participatory and lesson observations as the events that followed group discussion.

4.7.2 Participatory and lesson observations

Tracy (2013) states that participant observation is a method where the researcher generates understanding and knowledge by watching, interacting, asking questions, making audio or video recordings and reflecting after the intervention. This suggests that the researcher goes to the research site of the study and observes what is actually taking place there, engaging in the very activities set to be observed (Bertram & Christiansen, 2020; Cohen et al., 2018). This resonates with this study because as the IKCs were demonstrating the traditional method of brickmaking, I observed them, interacted with them and the learners by asking questions while my critical friend was video recording with the permission of the IKCs and learners. The researchers, as participant observers, reported on things they had witnessed and recorded as opposed to things told by other people (Tracy, 2013).

Within the context of this study, I observed science that emerged from the practical demonstration, not only concepts related to the conservation of heat energy but several concepts that emerged such as the emission of greenhouse gases that contribute towards climate change. This was evident as IKCs were firing raw bricks using coal as one of the fossil fuels that emit gases harmful to the environment. Amyikaiye et al. (2021) similarly warn that the traditional brickmaking process is associated with the release of harmful gases that pollute the atmosphere and have adverse effects on human health and the surrounding environment. This is due to the absence of mitigating measures when it comes to this informal traditional brickmaking industry. This is especially pertinent, as reiterated by Mzililkazi (2024), because the mitigation of greenhouse gases such as carbon dioxide is needed to avoid catastrophic climate change. However, the IKCs 'level of expertise and their willingness to share the traditional process of brickmaking was extraordinary, even though they were all women. This showcased the power of Indigenous African women in the bottom-up decolonisation of the curriculum.

Furthermore, the researcher as a participant observer reflected on her own biases and engaged all senses (Tracy, 2013). During the practical demonstration, my focus was on the science behind this Indigenous technology and yet other issues emerged though I did not pay much attention to them. For example, the IKCs explained that their motive for engaging in this small brickmaking industry was to make a living. They told us that this business helped them to put food on the table, send their children to school and build their homes. I was not much interested in this kind of information. However, I realised that I was being insensitive and disrespectful towards these elders who showcased the spirit of Ubuntu by agreeing to share their knowledge and wisdom with us. Hence, at a later stage, I decided to help them find potential buyers for their bricks to honour the notion of mutual benefit.

Tracy (2013) describes a participant observer as one who does not only study people but also learns from them. For instance, during the practical demonstration, I did not only study the science behind traditional brickmaking; I also learnt how these bricks were made which is the knowledge that will be passed on from generation to generation for cultural revitalisation. In addition, my critical friend who was also a Mathematics teacher discovered that several Mathematics concepts emerged from this practical demonstration such as *area, volume* and others used by the IKCs when counting the number of bricks produced. Interestingly, learners identified concepts from other subjects such as *income and expenditure* from Economics and Management Sciences. This points to the nature of IK being holistic rather than focusing on fragmented knowledge as the nature of science (Aikenhead & Jegede, 1999).

In this study, two types of participatory observations were done. During the demonstration at the brickmaking site by the IKCs, I was a participant observer, but I was also observing how learners interacted and argued with the IKCs as they presented. Values that arise from an Ubuntu perspective such as respect, kindness, consensus and mutual care were evident in these interactions. For instance, learners asked questions from the IKCs with respect because in our culture questioning of adults is not allowed. The IKCs appreciated being part of their children's education and, as a result, they were so kind towards the learners, and they ensured that learners understood the presentation clearly by asking them questions to capture their attention. However, they were not happy about their names being anonymised in the research study because they believed that they had contributed powerful knowledge to the study.

Secondly, when consolidating and mediating the learning of the concept of the conservation of heat energy after the practical demonstration, my critical friend observed the lesson presentation which we had co-planned. Mutual benefit was evident from the feedback that I got from my critical friend. As much as he criticised the lesson constructively, he also learnt a new teaching strategy of integrating IK into his science lessons. The lesson exemplar also benefited both the teacher and the learners equally. For example, learners commented that the more knowledgeable learners in different groups helped those who were left behind to understand the lesson. This eased the burden of the teacher to ensure that learners were on the same level of understanding.

Thereafter, learners were required to share how they had the practical demonstration by the IKCs and the teaching of the lesson that integrated IK in the conservation of heat energy. This was done through focus group interviews. I now discuss focus group interviews (sharing circles) below.

4.7.3 Focus group interviews (sharing circles)

McMillan and Schumacher (2010) posit that focus group interviews are small group interviews of selected individuals to assess a problem. In the context of this study, focus group interviews were used to complement learners 'journal reflections as some learners seemed to struggle to articulate themselves. Learners were given an opportunity to choose those who participated in the focus group interviews. Focus group interviews were aligned with the traditional Indigenous approach where learners sat in a circle during the interviews, known as 'sharing circles' (Afonso-Nhalevilo, 2013; Chilisa, 2012; Lavallee, 2009; Mucina, 2011). This created a non-threatening and relaxed environment for my learners. As a result, my learners expressed themselves freely especially since clan names were used during the interviews to level power gradients. As a result, they saw me as one of them instead of seeing their teacher. To date, my learners still see me as one of them, using my clan name, although they do so with respect. This enables them to argue and ask questions freely in class and they find it easy to confide in me with whatever problem they face. The sharing circles arrangement also affords everybody equal power to share their views. During the interviews, learners took turns sharing the information, giving each other an opportunity to share their knowledge.

However, I was mindful of the fact that some learners dominated the interviews denying others an opportunity to speak; I managed to address this issue. It was interesting to note that learners appreciated the strategy of integrating IK into science learning and teaching. They argued that some science concepts learnt at school relate to what they do at home. They commented that they would appreciate it if other subjects could adopt the same strategy. This challenges scholars such as Horsthemke and Schafer (2007) who claim that their findings revealed that learners found IK outdated.

The purpose of focus group interviews was to establish how learners found the experiences of having the IKCs presented to them and learning the concept of the conservation of energy using their local IK. The interviews were video recorded with the permission of the participants so that we could watch the videos with the learners and my critical friend. Thereafter, some follow-up questions were asked for validation purposes.

4.7.4 Learners' reflective journals

A learner's reflective journal is an effective tool that enables teachers to collect data about their teaching and aids learners in developing a good understanding of what is taught (Hojeij et al., 2021). As in Mayana's (2020) study, at the beginning of the year in 2023, I introduced my learners to how to write journal reflections and encouraged them to reflect after every lesson taught. At the beginning of the year, learners struggled to express themselves in English and some preferred to reflect in isiXhosa; but as time progressed, I encouraged them to reflect in English. Muwanga-Zake (2010) acknowledges that most people appreciate and communicate more effectively in their home language.

Initially, this technique was meant to prepare learners for the context of the study so that when the data collection process began, they would be used to doing this. However, I found this helpful as it gave me some insights into learners' understanding of the lessons taught and how to improve my teaching practice. This also improved learners' language proficiency. In the context of this study, learners were encouraged to reflect using the notebooks provided. They reflected on their observations, thoughts and actions during and after the research study. All learners answered guided questions provided for reflective journals. Those learners who were too shy to talk were able to reflect when given a chance to write. Henceforth, to avoid being biased when I analysed data from the learners' journal reflections, I requested them to anonymise their journals. This gave me an in-depth understanding of the learners 'shift in sense-making of the conservation of heat energy. I did this because I did not want to end up selecting only the journals of those learners whom I always regarded as the best in class. So, this gave me a genuine insight into the learners' shift in sense-making of the topic and afforded me an opportunity to treat them equally.

The purpose of using reflective journals was to establish from all the learners including those who were unable to express themselves during the focus group interviews, how they found the experiences of having IKCs presented to them and the lesson that integrated IK in the topic of the conservation of heat energy. The reflective space also helped me and my critical friend to reflect on what transpired during the practical demonstration by the IKCs and on how to integrate the information gained from the presentation into science learning, particularly the concept of the conservation of heat energy.

Table 4.2: Summary of data-gathering methods used in this study

Stage	**Method to be used to gather data**	**Purpose**	**Research question**
Stage 1	Group Activity	To determine learners' individual prior- knowledge, To find information from the community about making a fire.	1 & 3
Stage 2	Participatory observation and lesson consolidation	To find out the influence of integrating IK in teaching, Mediation of learning using traditional brickmaking to make sense of the topic of the conservation of heat energy and using a module that integrates IK in the topic of conservation of heat energy in class.	2
Stage 3	Focus group interview	To find out learners' experiences of learning the topic of the conservation of heat energy, Establish how learners found the experiences of having the indigenous knowledge custodians presenting to them.	1 & 3
Stage 4	Learners' journal reflections	To find out the influence of the practical demonstration by the indigenous knowledge custodians and the lesson exemplar that integrated IK in the teaching of science.	2 & 3

4.8 Data Analysis

Thematic analysis was used in the study. This is a method of identifying, analysing and reporting themes in data (Braun & Clarke, 2006). This method is suitable for analysing qualitative data. During the process of data analysis, I read through the data collected, developed categories, developed codes and created sub-themes. Common sub-themes were combined to form themes which were linked to relevant literature. Firstly, I analysed focus group interviews and commenced with the data analysis process by writing it as a narrative story (Nhase, 2019; Nuntsu, 2020). From those narratives, as in Nuntsu's (2020) study, I then identified some episodes and colour-coded them (see Appendix J). Within the narratives, I identified themes and categories. Concepts from Vygotsky's (1978) sociocultural theory, Ogunniyi's (2007a) CAT (see Section 3.2 and 3.3) and Langehoven and Stone's (2013) DAIM six stages were used as lenses to analyse emerging data from group discussions amongst learners, IKCs and me, focus group interviews and learners' reflective journals.

4.9 Validity and Trustworthiness

According to Cohen et al. (2018), validity is an important key to effective research. They argue that if a piece of research is invalid it is worthless. Bertram and Christiansen (2020) disagree with qualitative researchers who argue that the term 'validity' does not apply to interpretive research. They realise the need for a qualifying check on their work to know if the research is worthwhile. For this reason, they adopted different terms such as 'trustworthiness'. For interpretive research to be trustworthy, it must reflect the participants' reality.

Considering this, in this study, a variety of data-gathering techniques were employed for triangulation purposes. Furthermore, I watched videos from the focus group interviews together with the participants and my critical friend, and then follow-up questions were asked for validation purposes. Member checking was also done. In addition, the demonstration of the Indigenous technology of brickmaking by the IKCs landed itself as a validation process for the integration of IK in science. Moreover, I piloted my data-gathering tools, particularly focus group interviews, to ensure that questions asked were unambiguous at the Southern African Association for Research in Mathematics, Science and Technology Education Eastern Cape colloquiums, SAARMSTE 2023 conference, and the 2nd Pan African Science Education Research (PASER) postgraduate student conference 2023 where I presented my work to my Community of Practice as part of the validation process.

4.10 Ethical Considerations

This deals with the issue of ensuring that the interests of the participants of this study are recognised and protected as stipulated by the University's Research Ethics Committee. In this section, I discuss some aspects of ethical considerations.

4.10.1 Respect and dignity

The study employed the perspective of Ubuntu as a quality of being human involving sharing, caring, respect and compassion, ensuring a happy and qualitative human community life in the spirit of a family (Muwang-Zake, 2010). In light of the above, both the learners and the IKCs were respected by using clan names because in our culture it is disrespectful to call an elder by name. Therefore, using clan names levelled power relations by treating the participants as equals concerning their values, interests and needs. They were regarded as co-learners in the study. I also negotiated their willingness to volunteer in the study, using the Ubuntu perspective that knowledge was relational and shared with all.

I requested two male and two female IKCs to take part in the study to avoid raising power issues and to show respect for both genders. Since this was an interventionist study, the final decision regarding the issue of anonymity depended on the participants. In my culture, IKCs find pride in their work, and therefore they requested me to use their real clan names. As in Nuntsu's (2020) study, the practical demonstration of traditional brickmaking was done at a convenient time and venue which was the brickmaking site in the context of this study. Permission was also sought from the participants to video-record their presentation. Lastly, all participants were promised that the information gathered would not be shared with any third parties without their permission except my supervisor and that all signed consent and assent forms would be kept in a locked cabinet at school.

4.10.2 Transparency and honesty

The aim of the study, reasons for choosing the site and activities that took place during the study were explained to the participants earlier before they signed and agreed to participate in the study. Participants were assured that the study would not disrupt their daily activities as it took a few hours of their time, and the bricks made during the practical demonstration formed part of their daily activity. Consent and assent forms were written in both isiXhosa and English because some of them could not read and write hence I also sought verbal consent. However, asking the IKCs to sign consent forms was a challenge because in my culture that meant I did not trust their verbal consent. I explained and requested permission from the parents or guardians of learners as they were minors to take them to an out-of-school learning context, the brickmaking site.

Permission to conduct the study was sought from all the gatekeepers, namely the Eastern Cape Department of Education, the school principal of Ubuntu Primary School where the study was conducted, the science teacher who was my critical friend, the IKCs as the gatekeepers of the brickmaking site and the learners and their parents or guardians.

4.10.3 Accountability and responsibility

The study adhered to the principles and policy guidelines for educational research. My responsibility was to ensure that all data gathered in hard copy was stored safely in lockable cabinets while data gathered in soft copy, electronically, was secured with passwords. Also, consent was sought from the IKCs to use their real names as they wanted their identity revealed.

4.10.4 Integrity and academic professionalism

The data collected was given to the participants as part of member checking. I ensured that the study was my own original work and that I used my own ideas. When I used other people's ideas, I acknowledged them and correctly referenced them according to the referencing guidelines of Rhodes University.

4.11 Chapter Summary

In this chapter, I discussed the research methodology used in conducting this study. I also outlined the research goal and research questions of the study. The paradigms informing the study as well as the research design employed were also discussed. Two research paradigms complemented each other in the study, that is, the interpretive paradigm and the Indigenous research paradigm mainly focusing on an Ubuntu perspective. A qualitative case study research design was employed. Also, two methodological frameworks (DAIM) and TMESD, the research site, sampling and participants, data-gathering tools and research process were discussed. Lastly, data analysis, validation, trustworthiness and ethical considerations were discussed. In the next chapter, I present, analyse and discuss the data generated from the learners 'group activities and the presentations by the IKCs.

CHAPTER FIVE: GROUP ACTIVITY AND PRESENTATIONS BY INDIGENOUS KNOWLEDGE CUSTODIANS

5.1 Introduction

The main goal of this formative interventionist study was to explore how the use of traditional brickmaking can support Grade 7 Natural Sciences learners in a rural school to argue and make sense of the topic of conservation of heat energy. In the previous chapter, I presented the research methodology informing the study.

In this chapter, I thus present, analyse and discuss data generated from observations during the learners' group activity and the practical demonstrations done by the four IKCs. The data presented here is aimed at answering research questions one and two:

- How do Grade 7 Natural Sciences learners experience learning the topic of conservation of heat energy?
- How do Grade 7 Natural Sciences learners interact, argue and participate during the presentations by the indigenous knowledge custodians on the traditional method of brickmaking?

5.2 Summary of the Qualitative Data Generated During Group Activities

In the group activity, learners were divided into four mixed groups of six (boys and girls) to collect information from the community about making fire and stories told when sitting around the fire. Similar to Nuntsu's (2020) study conducted in South Africa, learners were given five guiding questions to focus on and to subsequently direct their discussions in their respective groups. This strategy was intended to ensure that the data generated from the group activity was relevant to the study. The five guiding questions were:

a) How do we make fire at home and why do we make it?
b) What stories are told at home when you sit around the fire?
c) How do these stories relate to the science learnt at school?
d) Why are traditional huts made of clay bricks?
e) What relevance do you think this has in science, in particular in the topic of conservation of heat energy?

Each group was given 10 minutes for discussions and the responses were recorded on newsprints. After the group discussions, which were in accordance with the guiding questions, each group presented their findings to the entire class as shown in Figures 5.1–5.5 below. Learners were also given codes such as L1F which means learner number one female, L3M which means learner number 3 male and so on. The groups decided to name their groups. All the groups were thus given codes, for example, G1TB for group one Trail Blazers, G2FS for group two Future Stars, G3SM for group three Social Makers and G4H for group four Hustlers.

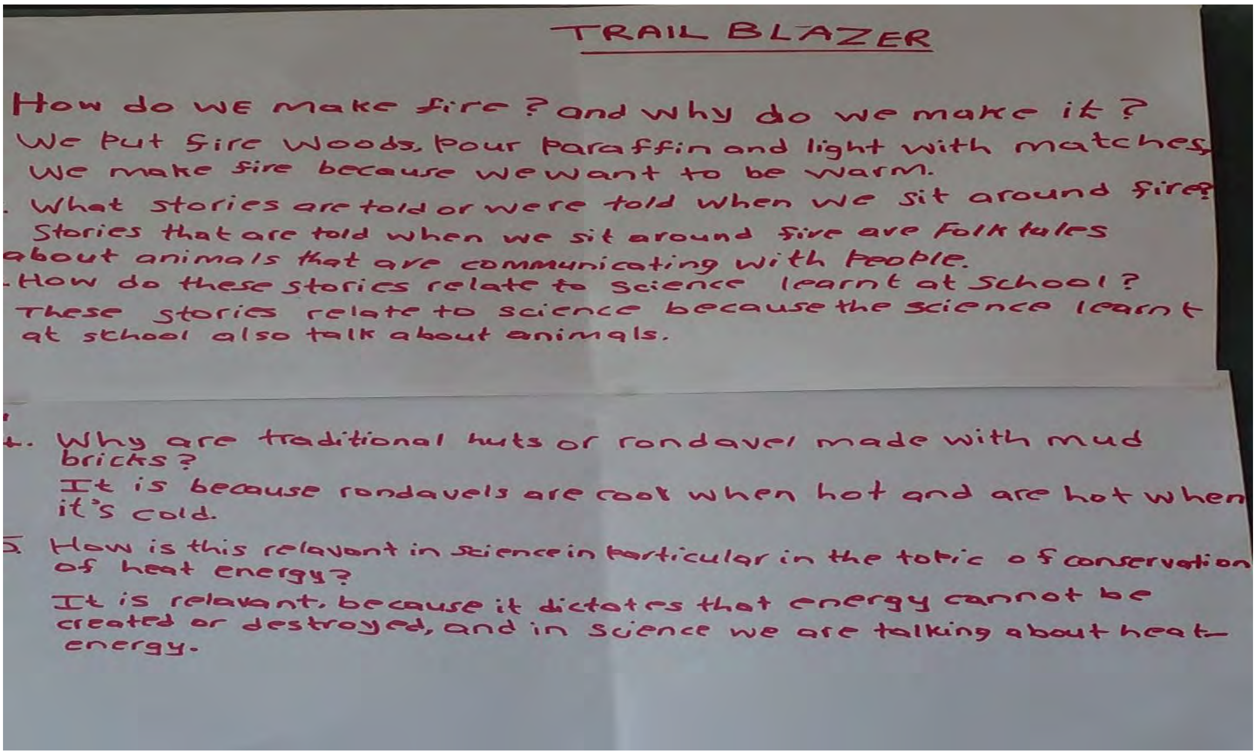
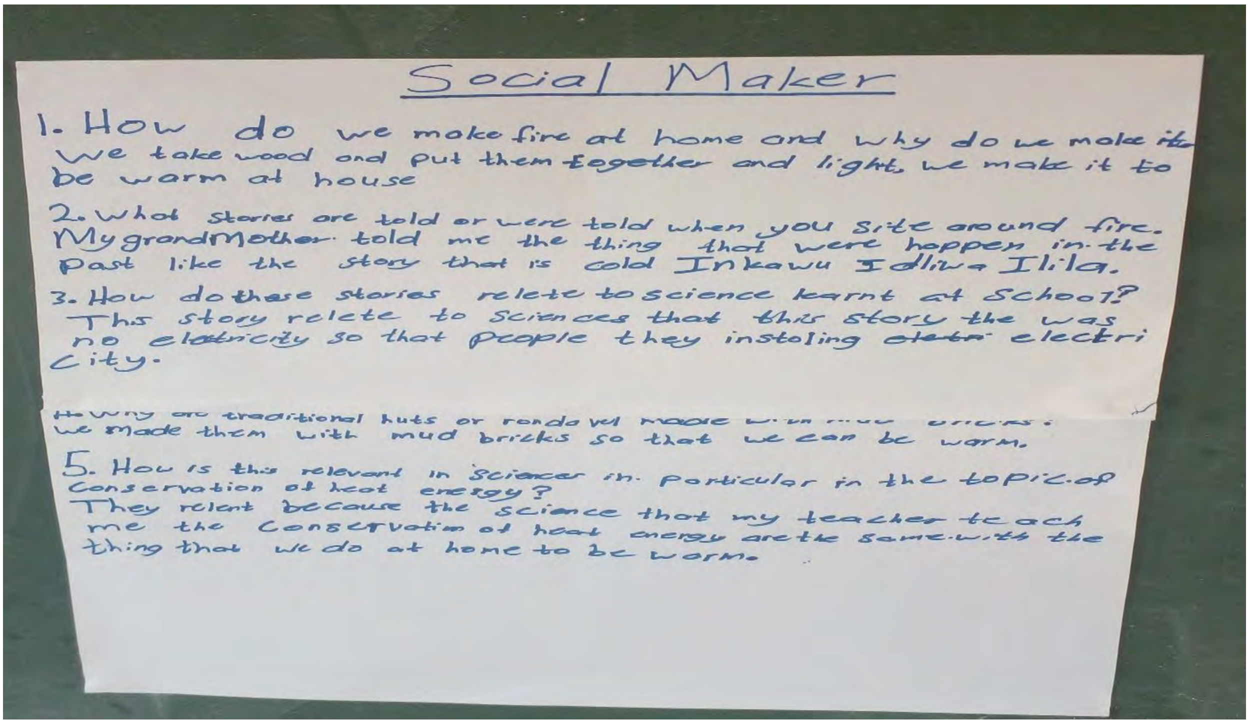


Figure 5.1: Newsprint presented by Trail Blazers



Social Maker

1. How do we make fire at home and why do we make it
We take wood and put them together and light, we make it to be warm at house

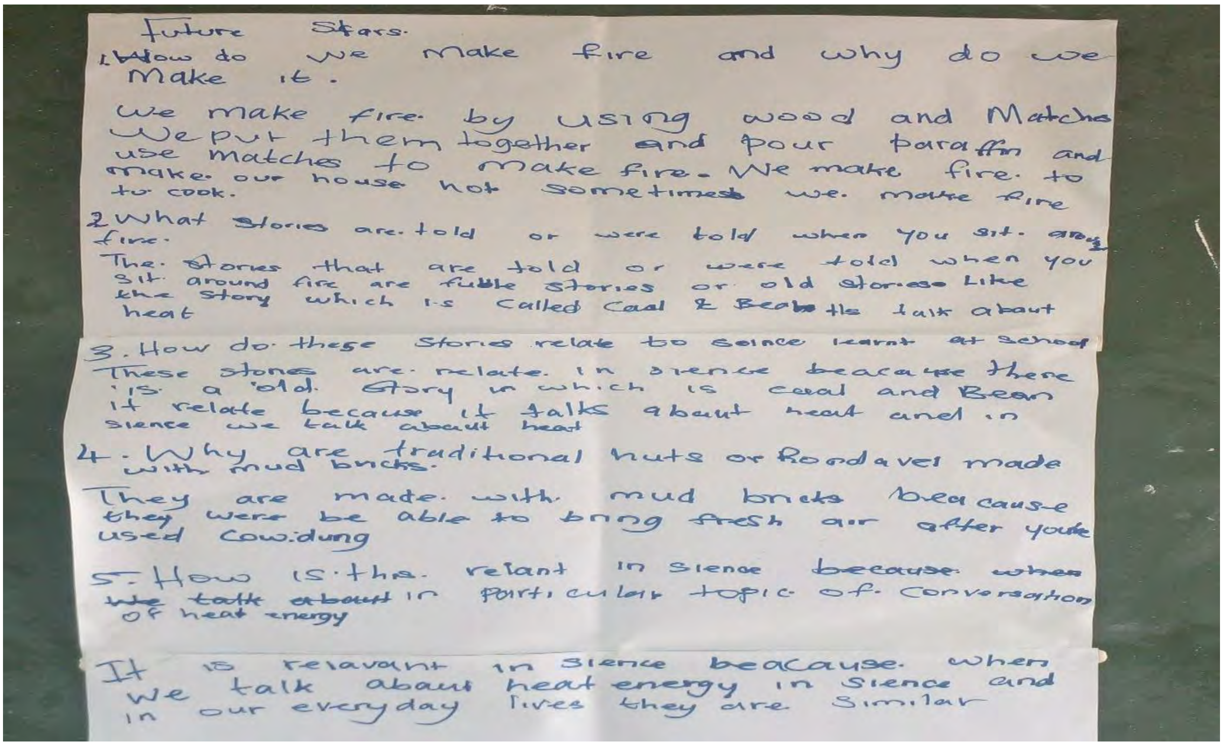
2. What stories are told or were told when you site around fire.
My grandMother told me the thing that were happen in the past like the story that is cold Inkawu Idliwa Ilila.

3. How do these stories relete to science learnt at School?
This story relete to Sciences that this story the was no electricity so that people they instoling electri city.

4. Why are traditional huts or rondavel made with mud bricks.
We made them with mud bricks so that we can be warm.

5. How is this relevant in Sciences in particular in the topic of Conservation of heat energy?
They relent because the science that my teacher teach me the conservation of heat energy are the same with the thing that we do at home to be warm.

Figure 5.2: Newsprint presented by Social Maker



Future Stars.

1. How do we make fire and why do we make it.
We make fire by using wood and Matches We put them together and pour paraffin and use matches to make fire. We make fire to make our house hot sometimes we make fire to cook.

2 What stories are told or were told when you sit arou fire.
The stories that are told or were told when you sit around fire are fable stories or old stories Like the story which is called Coal & Bean the talk about heat

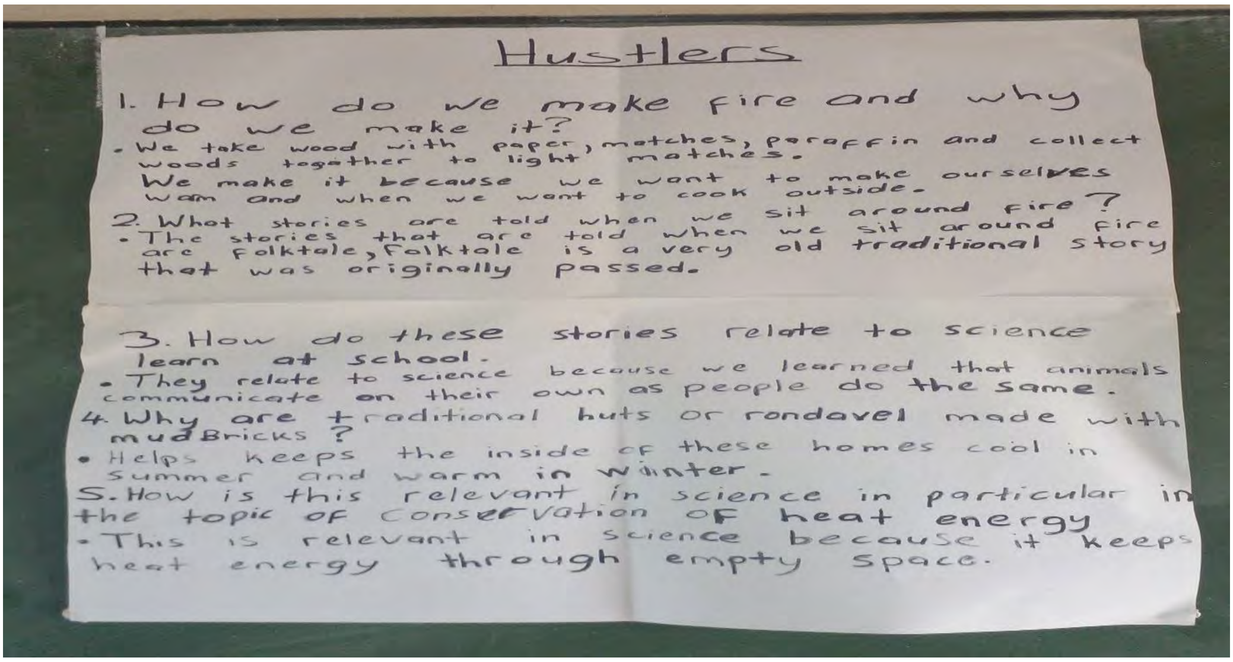
3. How do these stories relate to science learnt at school
These stones are relate in sience beacause there is a old story in which is coal and Bean it relate because it talks about heat and in sience we talk about heat

4. Why are traditional huts or Roondavel made with mud bricks.
They are made with mud bricks beacause they were be able to bring fresh air after youde used Cowdung

5. How is this relant in sience because when we talk about in particular topic of conversation of heat energy

It is relavant in sience beacause when we talk about heat energy in sience and in our everyday lives they are similar

Figure 5.3: Newsprint presented by Future Stars



Hustlers

1. How do we make fire and why do we make it?
• We take wood with paper, matches, paraffin and collect woods together to light matches.
We make it because we want to make ourselves wam and when we want to cook outside.
2. What stories are told when we sit around fire?
• The stories that are told when we sit around fire are Folktale, Folktale is a very old traditional story that was originally passed.
3. How do these stories relate to science learn at school.
• They relate to science because we learned that animals communicate on their own as people do the same.
4. Why are traditional huts or rondavel made with mudBricks?
• Helps keeps the inside of these homes cool in summer and warm in winter.
5. How is this relevant in science in particular in the topic of Conservation of heat energy
• This is relevant in science because it keeps heat energy through empty space.

Figure 5.4: Newsprint presented by Hustlers

Figure 5.5: Learners discussing in groups and then presenting in class

From the learners' group presentations, four themes emerged.

Fire making, cultural stories told around the fire, materials used to make traditional huts, and relevance to science. These themes are used to discuss the data to answer research question one of the study. I read all four learners' group presentations and then summarised them as shown in Table 5.1 below.

Table 5.1: Showing group responses from the group activity

From guiding questions	**Trail Blazers Code G1TB**	**Social Maker Code G2SM**	**Future Stars Code G3FS**	**Hustlers Code G4H**
Theme 1 Fire making	To make fire we use wood and matches.	We put together sticks and use matches to light up. We make fire because we want to warm ourselves.	We make fire by using wood and matches to make the house warm when it is cold.	We make fire to cook and to warm ourselves when it is cold.
Theme 2 Cultural stories told when sitting around the fire	Stories that are told when we sit around fire are folk tales which are old traditional stories that are passed on by mouth like the stories of animals talking to each other.	We are told stories about giants that ate people, but we have never seen them.	When we sit around the fire at home, we are told stories about how people used to make fire using stones and wood, and cook on it as there was no electricity.	Fables are told when we sit around the fire at home like the story of a burning coal and a bean seed.
Theme 3 Materials used to make traditional huts	Traditional huts are made with mud bricks covered with mud, grass and wood.	Rondavels are made with thatched grass, mud bricks and wood.	Traditional huts are made with mud bricks and have mud floors smeared with cow dung.	Traditional huts are made with wood, grass, mud bricks and have small windows.
Theme 4 Relevance to science	Stories relate to science in that we do learn about animals. Materials used to make traditional huts are relevant in science because they keep the huts warm in winter and cool in summer.	Making fire relates to science because it gives off heat energy. We see no relevance on stories told because we have never heard of giants in science. Traditional huts are made with materials that do not conduct heat.	There is relevance in science when we make fire and cook on it because heat is transferred from the fire to the pot. We see some relevance on the stories on how fire was made as there was heat transfer. The materials used to make traditional huts are insulators.	In making fire there is relevance in science because there is heat. In the fable of a burning coal there is some relevance in that it produces heat. With traditional huts having small windows means they prevent heat loss to keep the hut warm when it is cold.

To make more sense of the data during the discussion and analysis, I used the five cognitive states from Ogunniyi's (2007a) CAT. These are dominant, assimilated, suppressed, emergent and equipollent states (see Section 3.3). The results showed that all the groups seemed to know how fire is made and the reasons for doing it and that there are stories told when sitting around the fire at their homes. To Ogunniyi's (2007a) CAT, this means most learners appeared to hold a dominant IK worldview conception that suppressed the Western worldview. The Western worldview was suppressed in that when talking about heat transfer, none of the science textbooks we used to link this concept to stories told when sitting around the fire.

Regarding relevance to science, all the groups indicated that making fire relates to science as it gives off heat energy. For example, G1TB indicated that "*We make fire because we want to be warm*". Furthermore, pertaining to materials used to make traditional huts, all the groups could link them with science as they were able to identify some concepts related to the conservation of heat energy. For instance, G4H indicated that "*traditional huts are made with mud bricks because this helps to keep the inside of homes cool in summer and warm in winter*".

This means learners were able to negotiate meaning across the two distinct thought systems; that is, the WS and IK, and as such, they reached an equipollent cognitive state (Ogunniyi, 2007a). However, regarding stories told when sitting around the fire, most groups saw no relevance to science except G1TB who pointed out that *"folktales talk about animals and this relates to science because science learnt at school also talks about animals"* and G3FS who also indicated that *"this fable story is about coal and bean it relates to science because it talks about heat and in science we talk about heat"*.

On reflection, as I observed the group activity session, it was clear that learners found it difficult to make arguments because they were not used to arguing (Amsa et al., 2020). However, they were so interested in participating in the groups because being involved in argumentation helped them engage with their existing everyday knowledge (Govender, 2016; Gwekwerere, 2016). Also, participating in the group activity provided the learners with an opportunity to express their views freely in a non-threatening environment (Fakudze, 2021; Onwu and Mufundirwa, 2020) and they respected each other's opinions.

However, I observed that the boys seemed to be more comfortable presenting in isiXhosa, a language that has been suppressed in science, rather than the language of instruction. This talks to gender responsiveness in science classrooms as espoused by Abraha et al. (2023). To these authors, teachers need to be sensitised on gender and have gender-sensitive environments that enhance and facilitate equal participation of both boys and girls. Even those boys who are usually quiet in class and regarded as slow learners talked. In contrast, girls mostly presented in English and enjoyed being selected as group leaders. This means that when learners are given a chance to interact in a relaxed atmosphere and are allowed to use the language they are comfortable with to scaffold learning, they can co-construct knowledge better. This resonates with Vygotsky's (1978) sociocultural theory which emphasises the importance of culture and language during the mediation of learning to enable learners to relate what is taught in class with their existing knowledge. Moreover, this aligns with Ogunniyi's (2007a) equipollent cognitive state, in that both languages were afforded equal status during these group presentations.

When it came to making fire and stories told at home when sitting around the fire, learners knew how to make fire and the reasons for making it and could connect that knowledge with science; however, only a few could connect the stories told at home when sitting around the fire with science. This is in line with what Onwu and Mufundirwa (2020) claim, that not all IK can be used with science.

On the other hand, research has revealed that a storyteller does not give an analysis of the story but leaves this to each listener, who brings their experiences to the analysis of the story (Seehawer et al., 2022). Considering the above, I could conclude that the stories told by learners were related to science. For example, learners were able to relate stories about animals to science because in science they also learn about animals and their behaviours. Also, the story of a bean seed and coal was related to science, as a bean seed is a plant which they learn about in science and coal gives off heat energy which is related to heat transfer.

5.3 Presentation by IKCs

Table 4.1 shows the profile of the four community members who demonstrated the traditional brickmaking process to the Grade 7 Natural Sciences class of Ubuntu Primary School that visited them at their brickmaking site. The knowledge from the presentation by the IKCs was then used to co-develop a lesson exemplar that integrated learners' IK on the topic under consideration.

Figure 5.6: Showing the four IKCs (MaMthembu on the far left, next to her is MaDlamini, MaSikhosana on her right and MaKhiwa on the far right)

Figure 5.6 above shows the four IKCs who co-presented their skills, wisdom and knowledge of traditional brickmaking to the Grade 7 Natural Sciences learners. Clan names were used instead of giving them pseudonyms, for example, IKC one is MaDlamini, IKC two is MaKhiwa, IKC three is MaMthembu and IKC four is MaSikhosana. The clan names were used throughout the entire thesis to level power issues.

The background of the four community members shows that there were similarities and differences between them. All of them were female and isiXhosa home language speakers. Both MaMthembu and MaKhiwa were born in Ngqeleni and had been in the brickmaking industry for all their lives, including MaSikhosana. Their ages were different with MaDlamini being the oldest. She was a retired hospital cleaner from one of the nearby hospitals. She decided to join the brickmaking industry after she retired from the hospital.

She indicated that she received a warm welcome from other brick makers who were willing to share their knowledge of brick making that was passed on to them by their ancestors and lamented that *"Xa ufika uyafundiswa ngabanye abanolwazi kuba ngeke uzenze izitena ungakhange ufundiswe"* (You cannot make bricks without learning from the person who is more knowledgeable in the field). When asked why she is still in the industry at her age, she said "*kunzima ukushiya apha xa sele ungene ngenxa yemali esiyenzayo"* (It is not easy to leave the industry because of the kind of money we make for a living). Her highest standard is four whereas both MaMthembu's and MaSikhosana's highest standards is Grade 9. MaKhiwa is more educated than the rest of them with Grade 12 as the highest standard.

5.4 Summary of the Presentations by IKCs

The IKCs demonstrated and explained the process of traditional brickmaking. All of them were women and they presented in isiXhosa. Data generated from this formative intervention by the IKCs sought to address the following research question:

> *How do Grade 7 Natural Sciences learners interact, argue and participate during the practical demonstration of traditional brickmaking by the indigenous knowledge custodians?*

All 24 Grade 7 Natural Sciences learners, including those who participated in the focus group interview (sharing circles), participated in the presentation by the IKCs. Also, I invited a critical friend to participate and video-record the presentations with permission from the participants. The presentations afforded the IKCs an opportunity to showcase their skills, wisdom and knowledge of traditional brickmaking. From the IKCs' presentations, I developed some episodes, then combined sub-themes into themes in relation to the theory or literature. The themes and sub-themes are shown in Table 5.3 below.

Table 5.2: Shows the sub-themes and themes that emerged from data and supporting theory or relevant literature

Themes	**Sub-themes**	**Literature**	**Theory**
Theme 1: Nature of social interaction	Learner talk Asking questions Observing	Kim et al. (2018); Kim (2022)	Vygtsky (1978) SCT
Theme 2: Nature of participation	Explaining	Asheela et al. (2021); Bobek et al. (2016); Evagora et al. (2015)	Vygotsky (1978) SCT
	Promoted hands-on practical demonstration and visualisation	Mavuru & Ramarain (2020)	Vygotsky (1978) SCT; Engestrom (2014) CHAT
	Promoted double stimulation	Morselli & Sannino (2021)	

Theme 3: Nature of learning opportunities	Promoted border crossing and collateral learning Promoted arguments and dialogue Using language as a cultural resource Sense-making	Aikenhead & Jegede (1999) Fakudze (2021); Amsa et al. (2020); Kim et al (2018); Govender (2016) Hewson et al. (2009) Fitzgerald & Palincsar (2019); Sengul et al. (2020)	Ogunniyi (2007a) CAT Ogunniyi (2007a) CAT; Vygotsky (1978) SCT; Langehoven & Stone (2013) DAIM Vygotsky (1978) SCT Vygotsky (1978) SCT

In this section, I present and discuss the themes that emerged from the presentations by the IKCs concerning literature and theory. Vygotsky's (1978) sociocultural theory (SCT), Ogunniyi's (2007a) CAT as well as the theoretical constructs from DAIM were used during data interpretation and discussion. For instance, Vygotsky (1978) argues that learners' cognitive development occurs during social interactions. He further states that as learners participate in different activities and internalise the effects of working together, they acquire new strategies of learning.

On the other hand, extending on Ogunniyi's (2007a) CAT, Fakudze (2021) argues that DAIM provides learners with a learning environment which motivates them to express themselves freely, exchange views and reflect on what they have learnt and even change their minds once presented with a stronger argument. As learners argued, they used language which ultimately led to knowledge construction and sense-making of science concepts. This makes language a cultural resource that makes science relevant. Drawing from Ogunniyi's (2007a) CAT, Anga'ama (2021) concurs that argumentation enhances learners' understanding of science and alerts them to the need to integrate IK with science and makes them understand that the two worldviews can complement each other in science classrooms.

5.4.1 Nature of social interactions between IKCs and learners

When we arrived at the brickmaking site, the IKCs were so welcoming and generous, willing to share their wisdom, skills and knowledge of brickmaking with the learners. This is an aspect of Ubuntu and as such, through the interactions, relationships were established. To our surprise, we discovered that I was related to some of the IKCs and some shared the same hometown with my critical friend, Gingqi. Notably, the four IKCs decided to co-present the traditional method of brickmaking to my Grade 7 Natural Sciences class from Ubuntu Primary School.

I observed that learners were very excited and motivated to learn as the environment was non-threatening to them. They expressed themselves freely and asked questions of the community members when trying to understand their presentations. By asking questions from the elders, learners broke cultural barriers (Ivana, 2022) because, in the isiXhosa culture, we are not allowed to question the elders. This author believes that each culture has its own set of norms, such as those regarding behaviour and communication and there is a mutual understanding among members of the same culture. Therefore, within the context of this study, questioning elders in our culture is not allowed yet my learners broke this cultural barrier. For example, L3F asked MaMthembu who was demonstrating how the mould was made: *"Kutheni nidibanisa uthuthu lwamalahle kunye nomhlaba xa nisenza udaka lwezitena?"* (Why do you mix wood ash from coal with soil when you make the mould?). MaMthembu answered and said: *"Senzela ukuba izitena ziqine zingaqhekeki"* (We are doing it to make bricks strong and not crack).

The IKCs co-demonstrated the process of brickmaking. MaMthembu and MaSikhosana started by demonstrating how to make a mixture of mould by combining sand soil, clay soil and wood ashes from the coal they had used previously to burn the bricks and water. MaDlamini, the eldest in the group, explained why they mixed sand soil and clay soil: "*Xa sisebenzisa umhlaba oludongwe wodwa ziyaqhekeka izitena yilonto sidibanisa nomhlaba oludongwe"* (We mix sand soil and clay soil because if we use clay soil alone bricks crack). Learners observed and asked questions as the IKCs demonstrated the traditional method of brickmaking. For instance, L8M asked: *"Ke ngoku niwenza njani umlilo eontini, nisebenzisa ntoni ukubasa?"* (How do you make fire in the oven, what do you use to make fire?). MaKhiwa answered that *'sisebenzisa iinkuni namalahle, siqale sokhele ngeenkuni ezincinane, xa sele kuvutha sifake ezinkulu sibe sesigalela amalahle'* (We start fire by using light wood, then when it has started to burn, we add logs followed by coal).

Although the IKCs had not formal teaching experience, they encouraged learners to ask questions to ascertain if they clearly understood their presentations. For instance, MaMthembu noticed that the boys were not that active, and she asked L10M: *"Kanane besithe sizomisa kanjani izitena xasizikhupha kwifolomu, zithatha ixesha elingakanani ukoma?"* (How do we dry raw bricks from the brick mould and how long does it take them to dry?). L10M answered: "*Benithe nizibeka elangeni futhi kuxhomekeka kwimo yezulu ukuba zoma nini"* (You said you dry them in the sun, and it depends on how clear the weather is for them to dry).

My critical friend and I were co-learners in the study. So, we also interacted with the learners and the IKCs during the presentation by asking questions. For instance, my critical friend wanted to know from the IKCs how they make sure that the bricks were the same size and asked: *"Ndiqaphela ukuba izitena zenu ziyalingana zonke, nenza njani ukuqinisekisa lo nto?"* (I notice that all your bricks are the same size, how do you make sure that they are the same size?). Then MaSikhosana answered: "*Sisebenzisa umfolomu onendawo ezintandathu ezenziwe zabulingana"* (We use a brick mould that is divided into six parts which are almost the same size). L6F asked a follow-up question: *"Kutheni lento niyombathisa ngodaka ionti?"* (Why do you cover the oven with a layer of clay mud?). MaKhiwa answered: *"Senzela ukuba umoya ungangeni ukuze zitshe izitena kodwa siyasishiya isikroba sokungenisa umoya ozovuthisa umlilo*" (We want to prevent air from getting inside the oven to allow the firing process to take place, however, we do leave some openings to allow air to burn the fire). MaKhiwa also encouraged learners to take notes (as shown in Figure 5.7) as she was demonstrating to them how the coal changes after it has been burnt so that it is re-used in the mould mixture.

At this stage, I asked the IKCs to explain how the fire is transferred to the whole clamp kiln because they said, to make fire in the oven, they start from the bottom of the clamp kiln. MaDlamini explained that "*Xa sisenza ionti, izitena sizibeka sishiye izithuba ngaphakathi kwazo ukuze umlilo uthungelane kwionti yonke ukuqala ezantsi ukuya phezulu"* (As they build the oven, they arrange bricks such that there are spaces in between them to allow heat to be transferred to the whole oven starting from the bottom to the top of the oven). My critical friend (Gingqi) who is also a Mathematics teacher, after observing how the bricks were counted after they were removed from the oven, asked the learners "*Do you notice how the IKCs count the number of bricks they have made and what do we call that in Mathematics?"* L1F answered "*They do not count the bricks one by one; they use 'area' in Maths"*.

Figure 5.7: Learners taking notes as they observed the presentation by the IKCs

5.4.2 Nature of participation

In trying to make us understand clearly the method of traditional brickmaking, MaKhiwa and MaSikhosana took us through a step-by-step process of traditional brickmaking. As the IKCs demonstrated the process, both the learners and I took notes and asked questions from the IKCs to ensure that we followed the process correctly, while Gingqi (my critical friend) took photos and video recorded the process with the permission from all the participants. I thus discuss the step-by-step process of traditional brickmaking as explained by the IKCs below.

Process of traditional brick making

The IKCs explained that there are five major steps to brickmaking as shown in Figure 2.3 (see Section 2.10). I thus discuss these steps below.

- **Excavation**

This is the first step in the brickmaking process – it involves manual mining of the soil suitable for brickmaking. This involves removing the topsoil using tools like shovels, fork spades and wheelbarrows (see Figure 2.4a). According to the IKCs, this is normally done by men who were not there on the day of our visit but had already mined the soil the previous day in preparation for the process. They use any available soil within the area regardless of its quality as long as it is sand soil or clay soil. MaDlamini claimed that *"Udongwe lulungile ukwenza izitena kodwa silidibanisa neminye imihlaba kuba luyaqhekeka"* (Clay soil is good but it cracks once used alone). Topsoil is dug using spades, pick heads and fork spades and is gathered in a heap (see Figure 2.4b).

- **Preparation**

This comes after excavation – the soil that has been gathered in a heap is then sieved to remove larger particles from smaller particles. This is done using a sieve made of wire mesh (see Figure 2.4c). After being sieved, the soil is then mixed with the remains of the burnt coal that was used for firing the kiln and had been previously sieved. Water that is used in the mix is accessed manually from the nearby river using buckets. Water is then poured on the heap of the mixture of soil and ashes from the coal, which is used to strengthen the bricks, and stirred and shovelled continuously to allow the penetration of water into the mixture (see Figure 2.4d). MaDlamini explained: *"Udaka silwenza siluyeke lulale ukuze ludibane kakuhle*" (We mix all these materials and leave the mixture overnight so that they mix properly). Similar to Amyikaiye's et al (2021) study, the mixture is left overnight to enhance the softening of lumps and is covered with plastic to prevent evaporation from taking place. The brickmakers (*abafolumu*) then knead the prepared mud using their bare hands to break the lumps. They then use a spade to transfer the mixture to the wooden brick mould that has six compartments and is open at the top (see Figure 2.4e). The brick mould is made wet in a bucket of water before loading it with the prepared mud.

- **Moulding**

Moulding is the stage of brickmaking that comes after the preparatory stage. It changes the mixture of soil, wood ash, coal ash and water into wet bricks of the desired shape and size (Amyikaiye et al, 2021). According to this author, moulding is the shaping of the raw clay mud into bricks using a hand-thrown method or a mechanical extruder. For the local IKCs, the hand-thrown method of moulding involves the manual use of a wooden brick mould that looks like a ladder and carries six bricks. MaKhiwa explained: *"Sithi ngunomfolom umntu olapha efolomini"* (We call a person responsible for brick moulding, a brickmaker). The brick mould is filled and levelled to make sure that the bricks are the same size (see Figure 2.4e). After this, the bricks are emptied in a prepared levelled place to allow for the drying process to take place. MaMthembu said: *"Xa unomfolomu eyokhupha izitena kufuneka abaleke ukuze zingamoshakali"* (The brick maker has to run when emptying the bricks from the brick mould to avoid damaging the bricks).

- **Drying**

Drying is the stage of the brickmaking process that transforms the raw wet bricks into dry raw bricks. The bricks are dried in the open air and sun for about two to three days to enhance the evaporation of water from the wet bricks (see Figure 2.4f). This is influenced by weather conditions. For instance, it takes a few days for bricks to dry on sunny days and windy days but more on cloud days. After three to five days of drying, the bricks are packed and arranged (*ifasi)* so that there are spaces in between them to allow for more drying – they are covered with plastic if it rains (see Figure 2.4g). When they are completely dry, they are laid on a prepared foundation in preparation for the firing process.

- **Firing**

The process of firing involves burning raw dried bricks in fire. This is done to strengthen the bricks. To burn the bricks, the IKCs use firewood supplemented with coal (see Figure 5.8c). They crush and sieve the coal. Firewood is collected from the nearby local forest whil they buy the coal from Ugie in the Eastern Cape. In preparation for the firing process, bricks are arranged in the form of a pyramid that is called a clamp kiln and the IKCs refer to this as *'Onti'*.

(a) (b) (c)

Figure 5.8: Showing types of fuel used for firing*: (a) coal (b) light firewood to start fire* (c) firewood logs to strengthen the fire

The IKCs also presented the five stages of the firing process as shown in Figure 2.5 (see Section 2.10). The firing process includes hacking, a protective layer of insulation, firing, cooling and de-hacking. I thus discuss these stages.

Hacking: This involves preparing and levelling the ground, laying the foundation and loading raw dried bricks into the clamp kiln (see Figure 5.9a) which the IKCs call *iOnti* (oven). As the bricks are piled up, small openings called fireboxes (Amyikaiye, 2021) are left to allow air to get inside the kiln to burn the fire. During the hacking process, spaces are left in between the rows of bricks and coal is poured into them (see Figure 5.9a). This is done to allow heat to be transferred to the whole clamp kiln. Fire boxes on the other hand serve as entrances for the firewood, both large and light. Once the desired height of the clamp kiln is attained, it is covered with a protective layer of insulation made of clay mud which the IKCs call *idyasi* (jacket).

Insulation: Laying of the protective cover *(idyasi)* is done after the construction of *ionti* (oven). I then asked the IKCs: *"Kwenzeka ntoni ngaphakathi eontini, nenza njani ukuqinisekisa ukuba izitena ziyabugcina ubushushu?*" (What happens inside the oven and how do bricks conserve heat energy?). Madlamini responded that "*Ionti xa siyenza sifaka amaqhekeza ezitena ezishiyekileyo xa bekutshiswa ukwenzela ukugcina ubushushu bungaphumi emva koko sityabeke ngodaka ukwenza idyasi"* (The whole clamp kiln (oven) is filled in with pieces of previously burnt bricks to conserve heat energy and then is covered with the layer of clay mud *(idyasi*) as a form of insulation to prevent heat loss during the firing process) (see Figure 5.9c). The IKCs used their bare hands to plaster the oven with clay mud (see Figure 5.9c). This process is done before the firing process commences. After the process has commenced and the fuel is burning, the fireboxes are also covered with clay mud leaving only small openings on the top of the oven to allow combustion to take place.

Firing: According to the IKCs, the process of firing the clamp kiln takes about seven days allowing the temperature to reach its peak. They know that the temperature has reached its peak when they can no longer touch the oven with their bare hands. At this stage, a significant amount of heat and smoke is generated from the bottom to the top and the walls of the oven to make the bricks hard. When making the fire, logs of firewood are placed through the fireboxes, then quick flammable materials such as light firewood, papers and grass are placed on top and in between the logs and crushed coal is poured on them. Ignition of these materials is initiated by striking a matchstick on them at the entrance of the firebox (see Figure 5.9d). Initiation of combustion begins at the bottom of the clamp kiln. As the fire burns inside the oven, it is transferred and ignites the coal in the gaps (see Figure 5.9a) in between the bricks, enhanced by the wind, and then the whole clamp kiln burns. MaKhiwa elaborated that "*Xa ubushushu sele buphezulu izitena ziyatsha, ezi zisondeleyo emlilweni ziyaqina kakhulu, sithi xa sizibiza zi"* 'blue bricks'. *Ezi zingasondelanga kakhulu emlilweni sizibiza ngokuba zi* 'red bricks' (As the heated temperature reaches its peak, raw bricks are transformed into red bricks and blue bricks. Blue bricks are those which are at the centre of the oven and receive a lot of heat and become stronger than the red bricks).

Cooling: After the firing process is completed, that is when all the wood and coal have burnt into ashes, the cooling process begins. Due to lack of air and fuel supply, combustion stops, and the fire extinguishes leading to the drop in temperature. Cooling of bricks takes place over two to three days. For instance, MaDlamini warned us: *"Ungazibambi ngezandla izitena nasemva kwezintsuku zintathu kuba ezinye zisatshisa ziyabugcina ubushushu kakhulu"* (Be careful not to touch the bricks with your bare hands even after these three days as they are still hot because they conserve heat energy a lot).

De-hacking: This involves the unloading of the fired bricks from the clamp kiln after they have cooled down. The process starts by uncovering the protective cover of insulation which is also hot and needs to cool down before it is removed. After uncovering the clamp kiln, bricks are removed and packed ready to be counted (see Figure 5.9e). MaMthembu cautioned that *"Xa uzisusa izitena kwi onti, susa sibe sinye ngexesha kuba azikapholi kakuhle"* (When removing the bricks from the oven, remove them one by one as they have not completely cooled down). To check the quality of bricks, the IKCs said bricks have to be knocked against each other, a ringing sound indicates quality whereas a dull sound means the bricks are under fired.

(a) (b) (c)

Figure 5.9: Showing the first three practical stages of the traditional brick-firing process: (a) coal in gaps between the bricks (b) hacking (c) clamp kiln insulated with mud

(d) (e) (f)

Figure 5.10: Showing the last three practical stages of the traditional brick-firing process: (d) firebox at the bottom of the clamp kiln (e) fire burning on the firebox (f) de-hacked bricks arranged

5.4.3 Nature of learning opportunities

The practical demonstration of traditional brickmaking by the IKCs revealed that they are more knowledgeable (Vygotsky, 1978) when it comes to Indigenous technologies which are also scientific. For example, the IKCs sieved the mixture of soil to separate larger particles from smaller particles. Sieving is one of the methods of separating substances physically in science. This was also evident as learners were able to identify scientific concepts that emerged from the practical demonstration, such as mixture, strength as one of the physical properties of materials, heat transfer, insulation and so on. This is shown in the mind maps and concept maps developed by learners in Figures 6.7 and 6.8 below (see Section 6.2).

Surprisingly, learners did not only identify science concepts but also integrated across other subjects such as Mathematics and Economics and Management Sciences. The practical demonstration allowed learners to visualise science and promoted border crossing as espoused by Aikenhead and Jegede (1999) from the community to school. In the context of this study, the practical demonstrations allowed the learners to swim against the stream of the huge river that stood between home culture and school culture. Moreover, during the presentation, language was used as a tool that enabled learners to make sense of the concepts involved in science, particularly the topic of the conservation of heat energy. Like Simasiku's (2022) study conducted in Namibia, the method of traditional brickmaking in this study can be used to teach the following topics as shown in Table 5.3 below.

Table 5.3: Showing science behind the IK of brickmaking

WESTERNISED SCIENCE	INDIGENOUS KNOWLEDGE EXAMPLES
Practical activities	*Ukuhluzwa komhlaba namalahle kusetyenziswa isefu yocingo* (Sieving soil and coal using a wire mesh sieve) is an Indigenous method of separating mixtures.
Mixtures	Combining wood ashes from coal and soil.
Methods of physical separation (sieving)	Using a traditional sieve to separate the mixture of soil and coal to remove larger particles from the smaller particles.
Properties of materials (strength)	Burning the bricks to make them strong.
Methods of heat transfer (conduction, radiation, convection)	Firing of the oven (*onti*) where the fire begins from the bottom, then heat and smoke moves up the whole oven in the process heating the bricks. Also, drying raw bricks in the open sun.
Insulation	*Ukumbathiswa kweonti ngedyasi* (covering the oven with a protective layer of clay mud). Clay mud is used because it is does not conduct heat.
Conservation of heat energy	Filling in the gaps with broken pieces of damaged fired bricks and covering the oven with a layer of clay mud (*idyasi*) to prevent heat loss. Cooling the oven after three days to reduce heat gain.
Combustion	Leaving openings after covering the oven to allow air to burn the fire in the oven.

It was evident that there are relations and dialogue (Seehawer & Breidlid, 2021) between WS and IK when teaching the topic of conservation of heat energy using the practical demonstration of traditional brickmaking. For instance, the table above shows that from the practical demonstration, more science topics can be taught other than conservation of heat energy and related concepts. Furthermore, mobilising the formative intervention of traditional brickmaking revealed that the two knowledge systems, that is, WS and IK can work together in a complementary manner as espoused by Ogunniyi's (2007a) CAT. For example, learners reached the equipollent cognitive state as they understood that the processes involved in traditional brickmaking are scientific and this helped them to make sense of the topic of conservation of heat energy.

5.5 Chapter Summary

In this chapter, I presented, analysed and discussed data from learners' group activities and the four IKCs' presentations. The main aim of the chapter was to answer my first and second research question of this study. I also used my observations during the participatory observation to check whether learners' sense-making of the topic of conservation of heat energy shifted or not as they interacted with the IKCs. It became evident that IK could be used to teach scientific concepts that seem abstract to learners as the learners were arguing with each other on the kind of science concepts that emerged from the practical demonstrations.

Moreover, the interactions between the IKCs and the learners were made possible using the learners' local language, isiXhosa, as this allowed them to engage freely in a non-threatening environment. The IKCs engaged learners actively and as a result, they were free to ask questions, breaking the cultural barrier (Ivana, 2022) of not questioning elders. The use of easily available resources (Asheela et al., 2021; Shinana et al., 2021) from the community such as brickmaking, enabled learners to identify science concepts that emerged from their presentations. Lastly, the findings from the learners' group activities on *stories* told when sitting around the fire revealed that they deemed that some stories were not relevant to science. Arguably, this depends on the listener's analysis of the story as espoused by Seehawer et al. (2022). In the next chapter, I present, analyse and discuss data generated from focus group interviews (sharing circles), lesson observations and learners' reflective journals.

CHAPTER SIX: LESSON OBSERVATION, FOCUS GROUP AND LEARNERS' JOURNAL REFLECTIONS

6.1 Introduction

In the previous chapter, I presented, analysed and discussed qualitative data from learners' group discussions and the participatory observation during the practical demonstrations by the four IKCs. In this chapter, I thus present, analyse and discuss qualitative data from lesson observations in which I used a lesson exemplar that integrated IK into the topic of conservation of heat energy, focus group interviews (sharing circles) and learners' journal reflections. The data sought to answer my research question three:

> *How do Grade 7 Natural Sciences learners' sense-making shift (or not) as a result of the practical demonstration of the Indigenous technology of brick making by the indigenous knowledge custodians and by using exemplar lessons that integrate indigenous knowledge in this topic?*

6.2 Data Generated from Lesson Observation

Kraus (2023) defines observing as watching and mentally grasping an ongoing process. This resonates with the process of lesson observation in this study. Gingqi, who was my critical friend, observed the lesson module that I presented in class to learn from and reflect on it.

Thus, in this section, I discuss data generated from three lesson activities that I presented on heat energy transfer and conservation of heat energy and the intervention lesson that integrated IK into the above-mentioned topic. All the lessons were video recorded with the permission of the participants.

Table 6.1: Shows data-gathering tools and codes discussed in this section

Data-gathering tools	Codes used
Lesson on practical activity before intervention	**LPABI**
Lesson module that integrated indigenous knowledge	**LMIK**
Sharing circles interview Learner-codes in sharing circles interview	**SCI** **L1MB, L2DU, L3MX, L4MZ, L5T, L6DL**
Learner journal reflections	**L1JR-L8JR**

Adapted from Nuntsu (2020, page 73)

A lesson that introduced learners to forms of heat transfer and conservation of heat energy was taught in class before the intervention, hence, the study employed a Vygotskian perspective of double stimulation (Sannino, 2015). Learners were given a practical activity and investigation to perform. This was coded as LPABI (lesson on practical activity before intervention). After the lesson presentation in class, learners were taken to a local brickmaking site where traditional brickmaking was presented with the hope of identifying science concepts related to the conservation of heat energy from this demonstration. After the presentation by the IKCs, my critical friend and I co-planned an exemplar lesson that integrated IK into the topic of the conservation of heat energy. This was coded as LMIK in the study. The lesson module was taught in class while my critical friend observed.

Then, I used a sharing circle interview coded as SCI in the study, to ascertain how learners found the presentation by the IKCs and the exemplar lessons that integrated IK into the conservation of heat energy. The aim was to see whether there was a shift or not in learners' sense-making of the aforementioned topic. During the SCI, learners' clan names were used to level power gradients (Mutanho, 2021) and to create a non-threatening environment so that they could argue freely. They were coded, for example, L1MB (for learner one whose clan name was Mambhele). The SCI was complemented by using learners' journal reflections since not all learners took part in the SCI. However, only eight learners managed to submit their journal reflections. The journal reflections were coded as L1JR to L8JR (learner 1 journal reflections to learner 8 journal reflections).

6.2.1 Data generated from lessons on heat transfer and conservation of heat energy

As mentioned earlier, I presented two lessons on the forms of heat transfer and conservation of heat energy prior to the intervention exemplar lessons that integrated IK into science. In the first lesson, learners investigated different methods or forms of heat transfer (see Figure 6.1 below). In the second lesson, they performed a practical activity on insulation and energy saving where they used different materials to find out the best insulator of heat (see Figure 6.2 below). Thereafter, they were asked to draw a line graph of the collected materials (see Figure 6.3 below). These activities were done in four groups of six and this helped them to collaborate, assisting learners who struggled to identify materials that were best at conserving heat energy for a longer time.

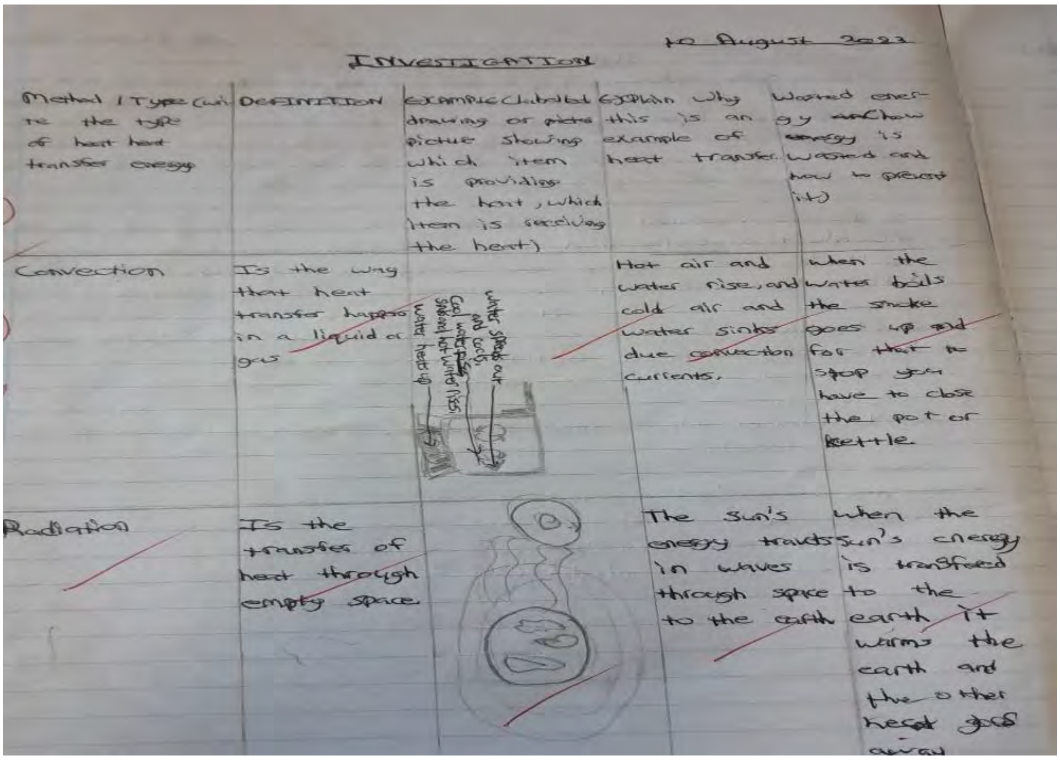
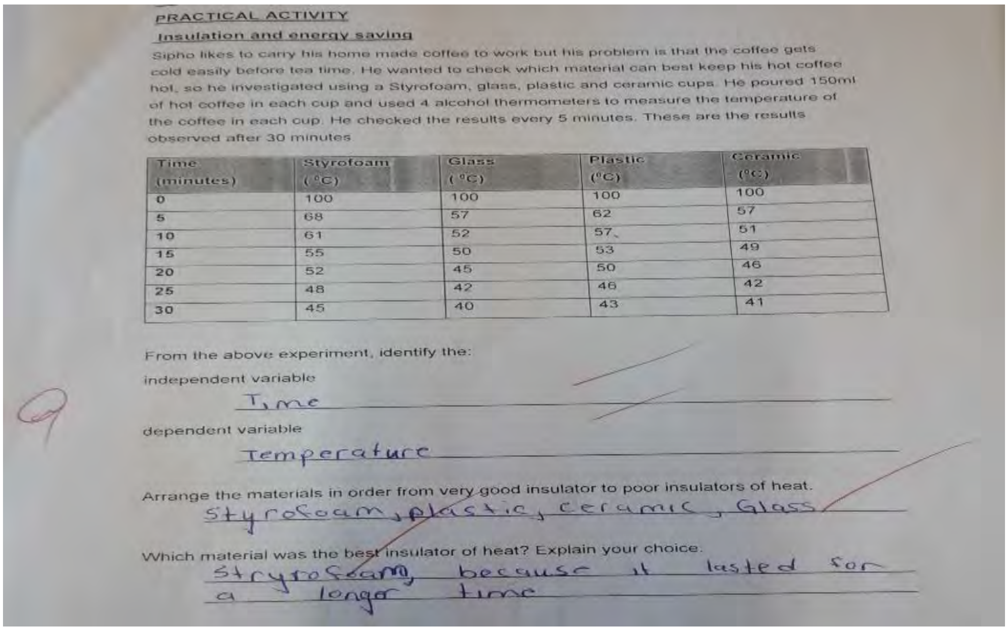


Figure 6.1: Learners' investigation on forms of heat transfer



PRACTICAL ACTIVITY

Insulation and energy saving

Sipho likes to carry his home made coffee to work but his problem is that the coffee gets cold easily before tea time. He wanted to check which material can best keep his hot coffee hot, so he investigated using a Styrofoam, glass, plastic and ceramic cups. He poured 150ml of hot coffee in each cup and used 4 alcohol thermometers to measure the temperature of the coffee in each cup. He checked the results every 5 minutes. These are the results observed after 30 minutes

Time (minutes)	Styrofoam (°C)	Glass (°C)	Plastic (°C)	Ceramic (°C)
0	100	100	100	100
5	68	57	62	57
10	61	52	57	51
15	55	50	53	49
20	52	45	50	46
25	48	42	46	42
30	45	40	43	41

From the above experiment, identify the:

independent variable

Time

dependent variable

Temperature

Arrange the materials in order from very good insulator to poor insulators of heat.

Styrofoam, plastic, ceramic, Glass

Which material was the best insulator of heat? Explain your choice.

Styrofoam, because it lasted for a longer time

Figure 6.2: Learners' practical activity on insulation and heat energy saving

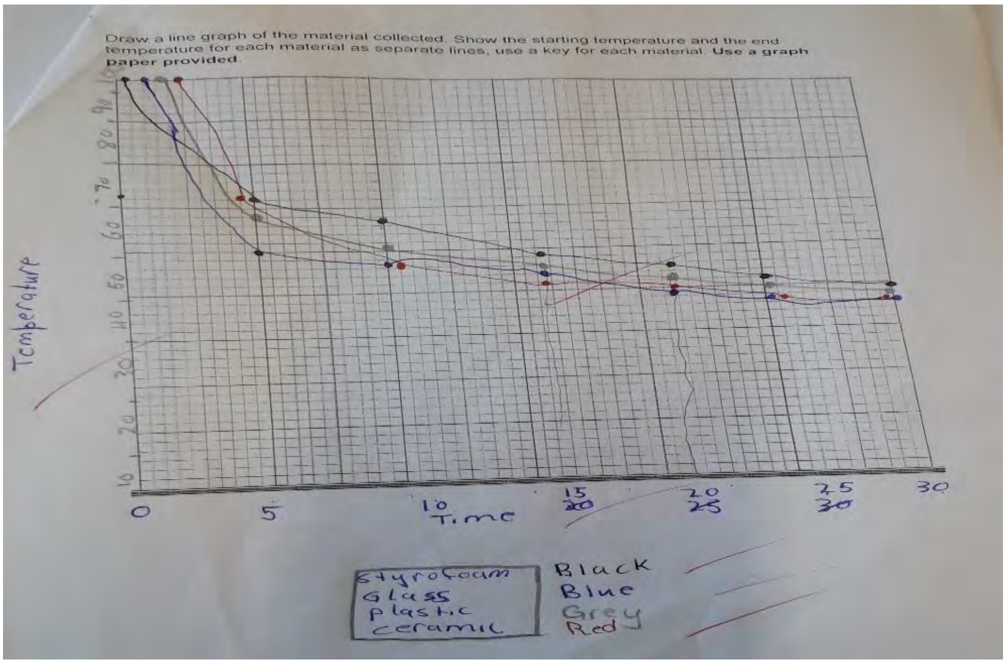


Figure 6.3: Learners' line graph on energy-saving materials

Although learners seemed to understand these concepts as they were introduced to them, they could not connect them with their local knowledge from home. For example, they could not connect conduction with cooking on fire using an iron pot at home, insulation with covering themselves with blankets to keep them warm when it is cold and radiation with being warmed by the fire when sitting around it. During the SCI, they commented that they were not aware that what they learnt in class was what they do at home every day. For example, one of the learners, L2DU said: *"I did not know that making fire at home was related to science"*. So, integrating IK into the topic of conservation of heat energy and related concepts provided learners with an opportunity to make sense of the concepts that seemed abstract to them (Handayani et al., 2018) in the first two lessons above.

6.2.2 Data generated from the exemplar lessons that integrated IK into conservation of heat energy

Onwu and Mufundirwa (2020) in their 'two-eyed seeing' approach underscore that learners should be engaged in lesson activities that introduce them to familiar real contexts that are likely to stimulate their interest and curiosity to learn new concepts. In line with this viewpoint, I taught the exemplar lesson that integrated learners' local knowledge of firemaking which I had co-planned with my critical friend. He subsequently observed me in class as I was presenting the lesson. The lesson took about two hours and learners were actively involved in the lesson doing the activities in four groups of six as espoused by the South African curriculum document, CAPS (DBE, 2011) which emphasises the importance of an active and critical learning approach as opposed to rote and uncritical learning. As mentioned earlier, the exemplar lesson integrated IK into the conservation of heat energy and consisted of five activities. In the first activity (see Figure 6.4 below), learners were required to relate to their knowledge of fire making from home in answering the questions provided about fire making. They were able to connect the concept of heat transfer to fire making from home.

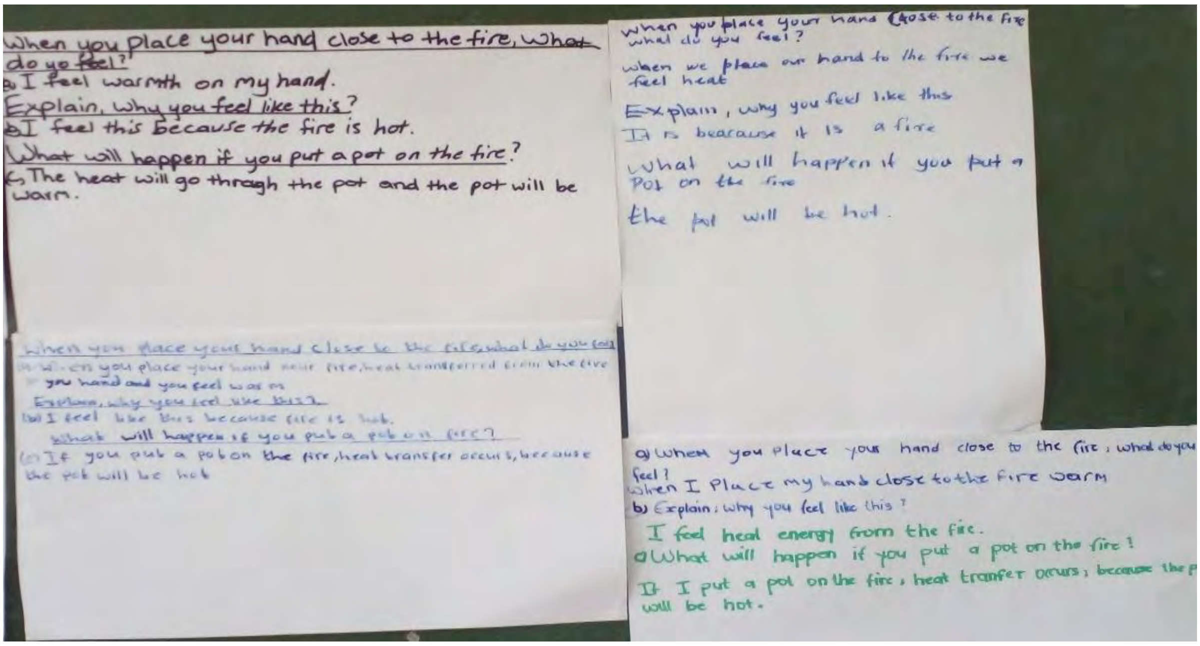


Figure 6.4: Shows learners' responses on questions asked in activity 1 of the lesson exemplar

In the second activity (see Figure 6.5 below), they used an illustration of people sitting around a fire and their knowledge from home related to the illustration where they could identify forms of heat transfer. They also shared *stories* told at home when sitting around the fire, and thereafter, one learner from each group shared one of these *stories* while others identified science embedded in those *stories*. Through using this illustration and their knowledge from home, learners were able to identify and define each form of heat transfer.

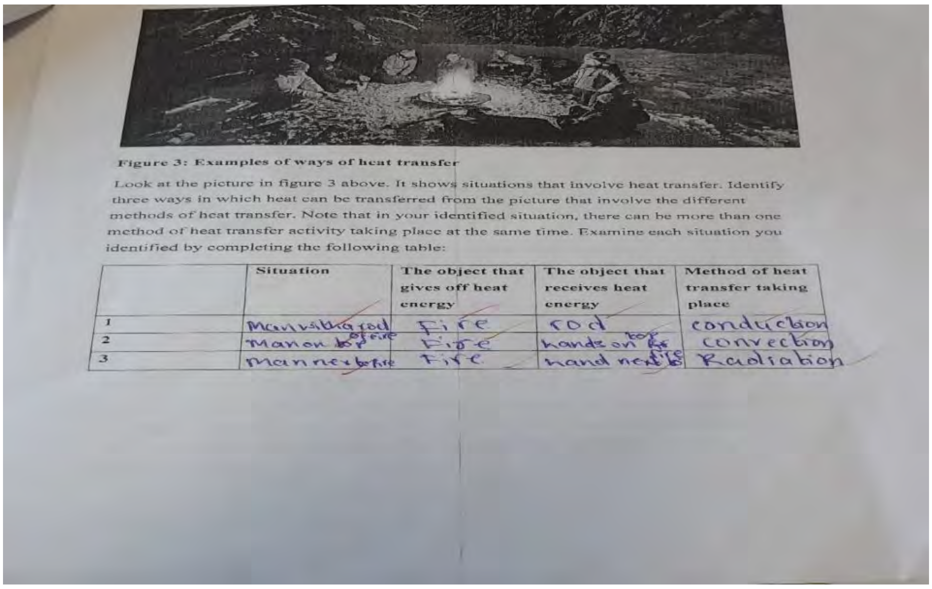


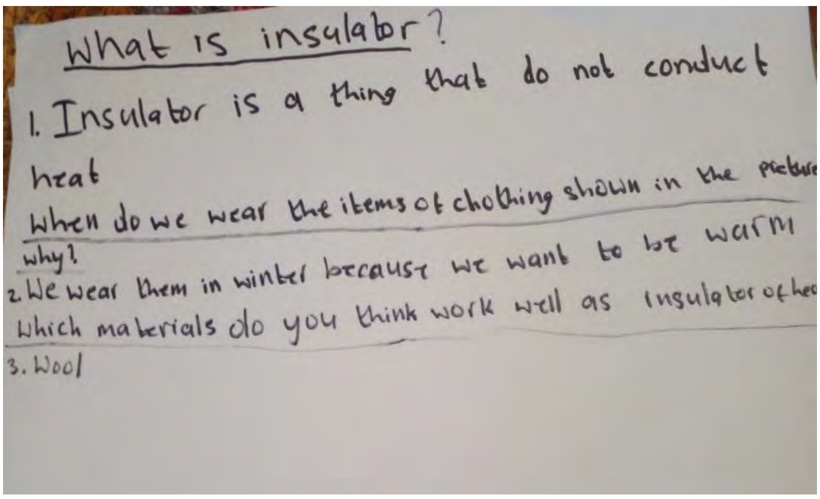
Figure 3: Examples of ways of heat transfer

Look at the picture in figure 3 above. It shows situations that involve heat transfer. Identify three ways in which heat can be transferred from the picture that involve the different methods of heat transfer. Note that in your identified situation, there can be more than one method of heat transfer activity taking place at the same time. Examine each situation you identified by completing the following table:

	Situation	The object that gives off heat energy	The object that receives heat energy	Method of heat transfer taking place
1	Man with a rod	Fire	rod	conduction
2	Man on top of fire	Fire	hands on top	convection
3	Man next to fire	Fire	hand next to fire	Radiation

Figure 6.5: Shows an activity where learners identified forms of heat transfer from an illustration

In the third activity (see Figure 6.6 below), learners identified insulating materials that conserved heat energy from the illustration provided, defined an insulator, and were able to recognise the best insulator that conserved heat energy the most from those provided.



What is insulator?
1. Insulator is a thing that do not conduct heat
When do we wear the items of clothing shown in the picture why?
2. We wear them in winter because we want to be warm
Which materials do you think work well as insulator of heat
3. Wool

Figure 6.6: Shows learners' responses in activity 3

After doing the third activity, learners were asked to draw a mind map (see Figure 6.7 below) from the traditional brickmaking process demonstrated to them by the IKCs. In this mind map, learners wrote all the science concepts that emerged during the practical demonstration.

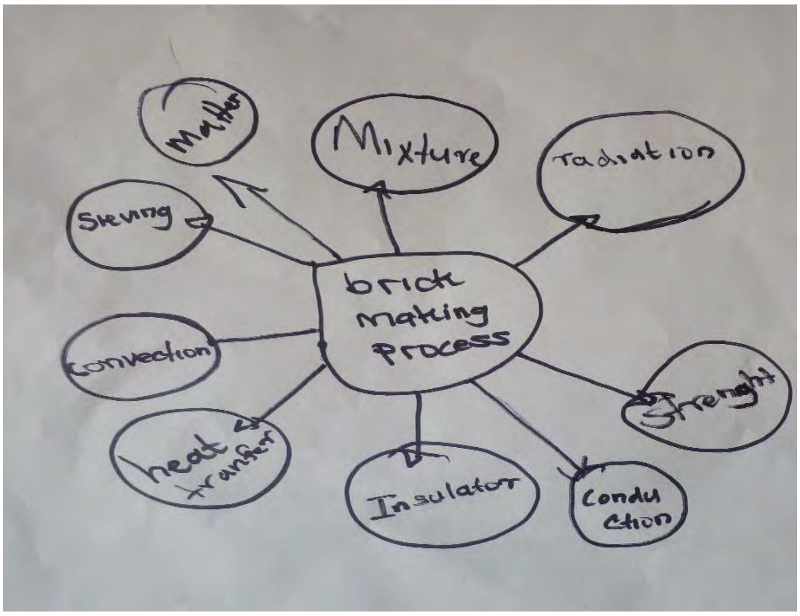


Figure 6.7: Mind map of concepts that emerged from traditional brick making process

Thereafter, they were asked to use the mind map to identify science concepts related to the conservation of heat energy and draw a concept map (see Figure 6.8 below). Using easily accessible cultural tools (Asheela et al., 2021) such as the traditional brickmaking process enabled learners to connect their IK to science learnt in class; hence, they were able to identify science concepts that emerged from this process such as heat transfer, insulation, radiation, heat loss, heat gain and others.

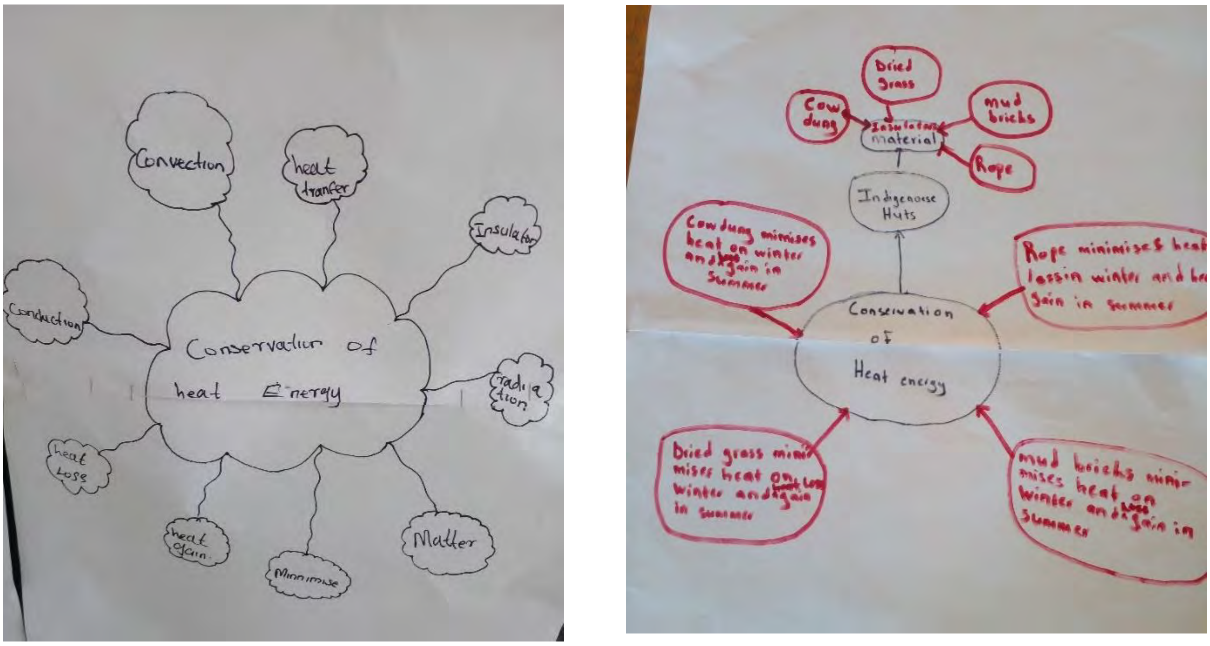


Figure 6.8: Concept map of conservation of heat energy

In the last activity, learners were asked to design a hot box that prevented heat loss using insulating materials from home such as old blankets and cardboard boxes. Learners were able to design a working hot box that conserved heat energy using their knowledge from the exemplar lesson taught. They tested it by cooking samp using an iron pot and it was well cooked.

In light of the above discussion, it appeared that integrating learners' IK of traditional brick making into the topic of conservation of heat energy enhanced their understanding of the topic of conservation of heat energy (Mavuru & Dudu, 2021). Also noteworthy was that learners were motivated to easily learn as they were able to connect new concepts to their previous knowledge (Ahied et al., 2020). Similar views were echoed by Onwu and Mufundirwa (2020) who accentuate that when learners are actively engaged in matching relevant pieces of knowledge from both science and IK, they are motivated to try and reach an understanding of science concepts. This resonates with the objective of using the exemplar lesson that integrated IK into the conservation of heat energy, which was intended to actively engage learners in learning the topic through teaching concepts related to the topic, alongside their identified Indigenous practice of making fire.

The intention was to explore how effectively learners could navigate the river that seemed to stand in their way of crossing over from home culture to school culture and vice versa without abandoning their ways of knowing to science knowledge. Essentially, the lesson intended to find a common ground on which the two knowledge systems could meet to equip learners with knowledge and skills that would enable them to apply such acquisition in real-life situations (Mavuru & Ramnarain, 2020). The CAPS document supports this idea as it states clearly in its specific aim 3 that learners should understand that science can be relevant in everyday life (DBE, 2011). This was achieved as learners were able to connect their IK of making fire to science concepts related to the conservation of heat energy. For example, in one of the activities they were able to state that when they put their hands close to the fire, they will be warm because heat will be transferred from the fire to their hands. It could be surmised that they seemed to clearly understand the concept of heat transfer. To find out more about learners' experiences of using the exemplar lesson that integrated IK into conservation of heat energy, a sharing circle interview was used.

6.3 Data Generated from the Sharing Circle

Sharing circles are like focus groups and they are concerned with gaining knowledge through discussions (Chilisa, 2012; Lavallee, 2009). The purpose of using a sharing circle interview in this study was to establish how learners found the experience of having the IKCs present to them and learning the concept of conservation of heat energy using their local knowledge. Not all learners participated in the SCI and only six learners were selected by others to participate.

One of the learners, L5T, when asked the reasons for being selected to represent others in the SCI, commented that *"they selected me because they know I can speak without being ashamed of others".* Using SCI resonates well with the way cultural knowledge is shared at home through storytelling when sitting around the fire. This is a traditional way of sitting in a circle and it levels power relations. It also provides all participants with an opportunity to express their views in a non-threatening environment where everyone gets an equal opportunity to share knowledge and is free to argue. Notably, this approach resonates with the Ubuntu perspective where people relate to one another as equals and with respect for their values, needs and opinions (Ogunniyi, 2018; Seehawer, 2023).

Within the context of this study, to ameliorate power dynamics, my clan name and those of the learners were used during the SCI. This created a friendly atmosphere where learners freely shared their knowledge and thoughts and respected each other's views. However, there were those learners who tried to dominate the interview, but I managed to control the situation by explaining to them that it was important that everyone should get an equal chance to share their opinions. Mostly, girls were more vocal as they could proficiently express themselves in English. This was evident as L4MZ said: "I *was chosen to be part of the interview because they know that I can speak English clearly and with confidence*". To mitigate the situation, I allowed the boys, who struggled to express themselves in English, to use isiXhosa, their mother tongue language. As a result, even those who were shy about expressing their views were able to speak. This showcased the spirit of Ubuntu, being there for each other and respecting and valuing each other and revealed that learners who were regarded as weak in class could argue when provided with an opportunity to do so.

To add, using clan names helped in building relationships between the learners and me as they viewed me as the co-constructor of knowledge rather than their science teacher. Even after the data-gathering process, learners still used my clan name in class while respecting me as their teacher. Another important aspect that emerged from these relations was that similar to Seehawer et al.'s (2022) study, a community was developed. It appeared that through the use of clan names, some of the learners shared the same clan name as me. This reduced tensions and improved power relations, and as a result, learners freely asked questions in class and actively participated in my lesson.

During the SCI, learners indicated that they enjoyed observing the IKCs' practical demonstration of traditional brickmaking. What was outstanding to them was the science that emerged from this demonstration. They mentioned the fact that they were not aware that traditional brickmaking has science embedded in it. For example, L6DL commented: *"I was not aware that mud is an insulator, if it used to cover ionti* (oven) *it conserves heat energy"*. Also, they acknowledged the fact that what they do at home relates to science taught at school; the only difference was that at school there were terms used. For instance, L5T, stated that "*to keep water warm until the next day at home, we warm it in the pot, pour it in a bucket then cover the bucket with a blankets, but I was not aware that we are preventing heat loss"*. L4MZ, commented that during the practical demonstration, *"I learnt that if ionti* (oven) *is not covered with mud clay, heat will be lost and bricks cannot burn properly but if it is covered with mud clay to prevent air from getting inside, it becomes hot as it gains more heat"*.

Regarding the lesson consolidation using the exemplar lesson that integrated IK into science, learners found this experience very interesting. For instance, L5T commented that *"I could understand the lesson easily; I could understand terms like radiation which emerged from fire* *making which we do at home. This is the knowledge that I was not aware that it is related to science at school".*

From the above excerpts, it was evident that learners easily understood science concepts when their IK is integrated. This is consistent with the views of Seehawer (2021), who argues that integrating learners' IK into science familiarises them with science concepts by connecting them to their daily life activities. More so, learners revealed that they had prior knowledge of making fire from home and this helped them to understand the lesson clearly and easily. This was evident as L6DL stated: "*I enjoyed the lesson, it helped me to understand science more".* For example, *"I already know that at home we make fire to keep the house warm and heat spreads to the whole house and that when cooking, heat moves from the fire to the pot".*

In line with these learners' points of view, it was evident that learners come to school with their local knowledge but due to cognitive dissonance (Le Grange, 2007), they are unable to connect this knowledge with science and in the process make sense of the science concepts. This made me realise that I had been depriving my learners of an opportunity to see science as fun and interesting by using methods of teaching and learning that decontextualised science from learners' sociocultural backgrounds (Mavuru & Ramnarain, 2020). Hence, learners considered it an abstract and boring subject. However, the intervention strategy used helped them cross the river that was situated between their home and school. After the intervention, science was clearer, accessible and relevant to them through the use of contexts familiar to them. Consequently, their sense-making of the topic and related concepts shifted.

6.4 Data Generated from Learners' Journal Reflections

The purpose of using journal reflections from learners was the same as that of the SCI as explained earlier – to find out how learners found the experiences of observing the IKCs' presentations and the exemplar lesson that integrated IK into the topic of the conservation of heat energy. However, the focus was on those learners who did not participate in the SCI; some because they were too shy to speak but able to write. Only eight learners managed to submit their journals, mostly girls. These girls claimed that they enjoyed the strategy of reflecting after every lesson taught. As a result, they even suggested that they would appreciate it if other teachers could adopt this strategy as it helped improve their language proficiency and would help their teacher identify areas where they lacked understanding of the lesson. This was evident as L3MX commented that *"to me, if we can do reflections after each and every lesson* *taught so that the teacher can know if we understood the lesson or not. I feel like other teachers can use the same method"*. L1MB also commented that *"I like doing reflections after the lesson because this improved my English writing and speaking"*.

It was evident from the data presented by the SCI and LJR that IK from the practical demonstration of traditional brick making by the IKCs and the consolidation lesson that integrated IK into the conservation of heat energy was related to science learning in class. This made science relevant, and the learners found it clearer and easier to understand (Mavuru & Ramnarain, 2020). The local materials such as mud bricks and fire making as presented by local people served as a resource that was used to learn science at school (Aikenhead & Jegede, 1999).

Table 6.2: Shows relevance between WS science and IK

Western Science	**Indigenous Knowledge from the indigenous knowledge custodians**
Mixtures	IKCs combined soil, coal ashes and water to make a mould for the bricks
Methods of physical separation	Sand soil, clay soil and coal ashes separated to remove larger particles from smaller particles using a sieve made of wire mesh
Physical properties of materials	Raw bricks burnt in oven to strengthen them
Heat transfer	When making fire to burn raw bricks, IKCs arranged the bricks so that spaces are left in between the bricks to allow heat to be transferred evenly in the whole oven
Radiation	Raw bricks left in the sun to dry
Insulation	IKCs covered the oven with a layer of clay mud because it is a good insulator
Conservation of heat energy	Covering the oven with a layer of mud aided heat gain and prevented heat loss. Also, after seven days the outer covering of mud was removed to allow the oven to lose heat

Source: Adapted from Simasiku (2022, p. 233)

Table 6.3: Shows integration of IK in the conservation of heat energy concepts from the topic

IK	WS
Firemaking in the oven to burn the bricks	Heat energy and heat transfer
Covering the oven with clay mud to keep the oven hot	Insulation, conservation of heat energy, heat gain, heat loss
Drying of raw bricks in the sun	Radiation
Starting the fire at the bottom of the oven to allow heat to be transferred to the whole oven including those bricks at the top	Convection
Leaving open spaces on the outside of the oven so that air burns the oven for seven days	Oxygen supports combustion

The data from the lesson observation, SCI and LJR from learners were colour-coded to identify themes (see Appendices I & J). After identifying the similarities, themes were constructed and presented in Table 6.4 with relevant theory and literature.

Table 6.4: Shows themes that emerged with relevant theory and literature

Themes	Literature	Theoretical Framework
Learners' attitudes towards learning science improved	Agunbiade et al. (2017); Handayani et al. (2018); Sewry et al. (2023)	SCT
Observing natural environments enhanced learners' understanding of the link between IK and science	Aikenhead and Jegede (1999); Ogunniyi (2007a); Sannino (2015); Mavuru and Ramnarain (2020); Grant (2022)	SCT, CAT
Social interactions afforded learners an opportunity for argumentation	Vygotsky (1978); Ogunniyi (2007a); Langehoven and Stone (2013); Anga'ama (2021); Okoroh (2021)	SCT, CAT
Learners' sense-making of conservation of heat energy enhanced	Aikenhead and Jegede (1999); Mukwambo et al. (2014); Agunbiade et al. (2017); Mavuru and Ramnarain (2020); Seehawer (2021)	SCT, CAT

Table 6.5: Shows themes, sub-themes and categories grounded in data from SCI and LJR

Theme 1: Learners' attitude towards learning science improved
Sub-theme 1: **Enjoyment** **Interest** **Motivation**
Theme 2: Observing natural environments enhanced learners' understanding of the link between IK and science
Sub-theme 1: **Double stimulation and out-of-school learning** **Sub-theme 2**: **Contextualising science** **Sub-theme** 3: **Hands-on practical activities and visualisation influenced learning**
Theme 3: Social interactions afforded learners an opportunity for argumentation
Sub-theme 1: **Active participation and participatory approach** **Sub-theme 2**: **Use of language as a cultural tool** **Sub-theme 3**: **Observed shifts in leaners ZPD**
Theme 4: Learners' sense-making of conservation of heat energy and related concepts enhanced
Sub-theme 1: **Cultural river crossing (home to school and then back again)** **Sub-theme 2**: **Use of easily accessible cultural tools** **Sub-theme 3**: **Application of science in real-life situations (from school to home)**

I now discuss each of these themes in detail below.

6.4.1 Learners' attitudes towards learning science improved

It appeared that mediating the learning of conservation of heat energy using the Indigenous technology of brick making and consolidation using the exemplar lesson that integrated IK into the topic, aroused the learners' interest in learning science. This was evident in learners' responses when I asked them how the presentations, both from the IKCs and the lesson consolidation, changed or did not change their views about learning science. For instance, L6DL mentioned that *"I liked the lesson that integrated IK in science where fire making which we make at home was used to teach the concepts"*.

Also, in the LJR, L3JR commented that *"I found out that science was fun and easy to understand'* While L4JR said: *'It made me more curious to learn science"*. In this respect, it was clear that learners were enthusiastic about learning science when they could relate the activities, both in class and out-of-school learning, to their everyday life experiences as reiterated by Gwekwerere (2016). They explained that their interest in learning the topic was aroused by the fact that they could see the connection between the science concepts learnt in class and their local knowledge. One learner, L1MB put it this way: "*I enjoyed learning science when our knowledge from home was involved"*. This resonates with Agunbiade et al. (2017) who accentuate that when learners find science content relevant to their local knowledge and their immediate environment, their interest is likely to increase towards the subject. Concurring, Onwu and Mufundirwa (2020) underscore that contexts that are familiar and accessible to learners are likely to stimulate interest and curiosity in learning the science concepts.

6.4.2 Observing natural environments enhanced learners' understanding of the link between IK and science

The study involved a sequence of learning activities for learners to engage in. In the first lesson, learners were introduced to the concepts related to the topic of conservation of heat energy. They participated in practical activities that were carried out in class. However, to the learners, concepts such as conduction, insulation and others were abstract as they could not connect them to their prior knowledge. As a result, these concepts did not make sense to these learners; therefore, doing the practical activity in the lesson was a meaningless task to them (Grant, 2022). They experienced a conflict of motives (Sannino, 2015), trying to crossover from their home knowledge to science knowledge. The following statements illustrate these sentiments. For example, L2DU said: "*At home we live in huts made of mud bricks and we know that when it is hot, they are cool and when it is cold they are warm but I was not aware that it is because they are made of insulators"* and L4MZ commented that *"I did not know that when sitting at home around fire, heat is transferred to you through radiation and when cooking with the pot fire is conducted from the fire to the pot"*.

According to the perspective of double stimulus, the first activity done in class was the first stimulus and it necessitated the introduction of the second stimulus (Sannino, 2015). To help learners break away from the conflicting situation, I introduced them to the second stimulus in the form of traditional brickmaking and a consolidation lesson that integrated their local knowledge. These served as a catalyst for the sense-making of the concepts. Learners changed these activities to something meaningful and were able to make sense of the concept of conservation of heat energy and related terms. This resonates with Mavuru and Ramnarain's (2020) study which underscores that learners feel comfortable when using materials from their surroundings in learning science as it becomes less abstract. For example, when asked about their experiences of learning conservation of heat energy from the practical demonstration by the IKCs and using the exemplar lesson that integrated their local knowledge into the topic, learners said the following:

> *To me understanding the topic of conservation of heat energy was made easier, I did not know that making fire that we do at home was related to science* (L1MB).
>
> *Learning that covering mud bricks with a layer of mud (dyasi) keeps heat energy helped me to understand insulators* (L7JR).
>
> *I understand the topic better now because at home we make fire to warm ourselves and now in science we learn that fire transfers heat that makes us warm* (L1JR).
>
> *I enjoyed visiting the IKCs to see how bricks are made and how they conserve heat energy* (L2JR).
>
> *I liked the lesson module that integrated IK in science, through this method I was able to link concepts that emerged from fire making with science and made sense of them* (L6DL).

The excerpts above revealed that learners easily learn when they can make connections between their prior knowledge and new concepts (Ahied et al., 2020). Moreover, integrating IK into science familiarised learners with the topic by connecting it to their own daily life activities (Seehawer, 2021). Furthermore, engaging learners in hands-on practical activities and visualisation which involves learners observing real-life objects (Asheela et al., 2021) such as traditional brickmaking and firemaking, enhanced their understanding of the topic and related terms. Learners could see how heat transfer occurred as fire was made to burn the bricks with spaces left in between the bricks to allow the fire and heat to be transferred to the whole oven. One learner put this like this:

> *One of the mothers explained and demonstrated to us how fire is made in the oven in preparation to burn the bricks. She showed us that they first use small pieces of wood to kindle the fire, once its burning, they add logs and coal. Before making fire, bricks are arranged such that there are spaces in between them to allow heat to be transferred to the whole oven* (L4MZ).

The above excerpt shows how indigenous knowledge is passed on from generation to generation because the knowledge of firemaking that the IKCs demonstrated to the learners was passed on to them from their ancestors. The same view is shared by Kibirige and Van Rooyen (2006) who describe IK as a legacy of knowledge and skills unique to a particular Indigenous culture which encompasses wisdom that has been developed and passed on through generations.

6.4.3 Social interactions afforded learners an opportunity for argumentation

Where easily accessible cultural tools (Asheela et al., 2021) are used to mediate learning, the potential for social harmony is higher than where unfamiliar learning tools are employed (Mutekwe, 2018). This viewpoint is in line with the activities that took place in the context of this study. During the practical demonstration by the IKCs, learners interacted with each other and the IKCs. Also, during the lesson presentation they interacted with each other as they were working in groups. Research has revealed that where there are social interactions (Vygotsky,1978), there are discussions and arguments (Ogunniyi, 2007a). L1JR commented that *"arguing, asking questions and working in groups helped me to understand some of the concepts such as insulation".* As learners discussed and argued during both the participatory observation and lesson presentation, they used their Indigenous language, isiXhosa. In support of this, Vygotsky (1978) argues that meaningful learning is enhanced when learners learn through social interactions using language as a cultural tool. Using their mother tongue during these social interactions enabled an explicit understanding of the concepts that emerged.

In class, learners worked in four groups of six. This gave them an opportunity to be actively involved in the knowledge construction as they were able to come up with some mind maps on the concepts that emerged during the practical demonstration and participatory observation. When prompted about how they found the experiences of the participatory observation and lesson presentation, learners commented that "*I enjoyed the lesson module, we were actively involved in the lesson, co-operated with each other, those who understood the lesson helped to* *make others understand as well"* (L6DL). L2JR also noted: *"We were actively involved in the lesson doing presentations"*.

Working in groups also afforded them an opportunity to ask questions and help each other in understanding the lesson better. Those learners who understood the lesson shared the information with others in the group to help them understand – this means they were more knowledgeable than others (Vygotsky, 1978). This was evident as L5DU said: *"Another thing that I liked was that asking questions was easy, in a non-threatening environment, working as a group, helping each other. All questions were easy to answer"*.

Therefore, it was evident that both the practical demonstration by the IKCs and the lesson exemplar that integrated learners' local knowledge explored learners' independent problem-solving skills as learners were able to connect IK with science concepts learnt in class. Taking them to the brickmaking site (out-of-school learning), offered them an environment for active learning and interacting with others and the IKCs freed them from the formal science classroom constraints that inhibited enjoyment of science learning (Agunbiade et al., 2017). On the other hand, the lesson observation was a guide for me as a teacher to reflect on my own teaching practice.

6.4.4 Learners' sense-making of the concept of conservation of heat energy was enhanced

The study revealed that as learners argued and interacted with each other and the IKCs using their mother tongue language ultimately led to knowledge construction and sense-making of the science concepts involved in the conservation of heat energy and related concepts. At the beginning of the lesson, learners seemed to struggle to make sense of the concepts involved in the topic because they could not relate them to their IK. However, the intervention strategy of traditional brickmaking enabled learners to navigate the huge river that seemed to stand in their way of crossing over from home to school and from school to home. The following comments illustrate these sentiments:

> *I enjoyed the demonstrations by the indigenous knowledge custodians who are more knowledgeable in our culture, it has made my understanding of science better and easier. I would appreciate it if more of these demonstrations can be organised so that we integrate this knowledge in science* (L4MZ).

Through this method I was able to link these concepts with fire making and made sense of them, such as heat transfer, radiation and conduction (L6DL).

I have learnt that when making bricks, there is science involved because concepts such as heat transfer emerged (L1JR).

I learnt a lot about heat transfer, I now know that when I put my hands closer to the fire heat will be radiated to my hands (L3JR).

The excerpts above indicated that mediating learning of conservation of heat energy using the interventionist strategy of traditional brickmaking enabled learners to make sense of the topic by negotiating meaning across the two knowledge systems (Ogunniyi, 2007a; Seehawer & Breidlid, 2021), that is IK and WS. To them, the two knowledge systems complemented each other instead of competing (Mukwambo et al., 2014) as they were able to identify science concepts learnt in class from the practical demonstration. When asked if they had any suggestions about how to improve science learning, L2DU commented: "*I think if we can be given an opportunity to explore for ourselves by doing practical activities and find more knowledge from home, then combine this knowledge with science to see if this works well for us".* This suggests that learners were able to make sense of the knowledge systems according to what fit best in the given context, rather than drawing on WS only (Seehawer, 2021).

In all, integrating learners' local knowledge in science has the potential to make science relevant and accessible to learners (Mavuru & Ramnarain, 2020). The strategy afforded learners with an opportunity to cross the cultural borders as espoused by Aikenhead and Jegede (1999). However, in the context of this study, I prefer to use the metaphor of cultural river crossing because our learners cross rivers instead of borders. They struggle to cross these rivers and this is what they do every day when coming to school – in the same way, they struggle to link their local knowledge to scientific concepts which is an experience they encounter every day in science classrooms. Therefore, through integrating the IK of brick making in the topic, learners navigated this river and made sense of the topic. They even commented that their understanding of the concepts would enable them to use the concepts in their real-life situations. For example, L5T suggested: *"If we can integrate our prior knowledge in science, that can give us a better understanding of the science concepts learnt at school and can help us apply them in our real-life situations".*

On reflection, I noticed that integrating IK into science motivated all learners to take part in the lesson – even those who were regarded as slow learners participated. I was impressed to see one of those learners involved in meaningful argumentation in his group. As a result, the group chose him to be part of the sharing circle interview and he contributed a lot of knowledge in the interview.

6.5 Chapter Summary

In this chapter, I analysed, presented and discussed the data generated from the lesson observation, SCI and LJR. These data generation methods were used to answer my research question three. In the next chapter, I present the summary of findings, recommendations and conclusion.

CHAPTER SEVEN: SUMMARY OF FINDINGS, RECOMMENDATIONS AND CONCLUSION

7.1 Introduction

In the previous chapter, I presented, analysed and discussed the data generated from the lesson observation, SCI and LJR. The three data generation methods were used for triangulation purposes. In this chapter, I thus present a summary of my findings and provide some recommendations thereof. I also suggest areas of future research, limitations of my study and personal reflections. The chapter is wrapped up with the overall conclusion of the study.

7.2 Overview of the Study

Essentially, this research study was conducted in response to a call for the decolonisation of the science curriculum through integrating learners' sociocultural backgrounds. Therefore, there was a need to explore and develop a culturally aligned (Mashoko, 2022) teaching and learning strategy such as using the method of traditional brick making to mediate learning.

It is against this backdrop that the main goal of the study was to mobilise the Indigenous technology of brick making to support Grade 7 Natural Sciences learners to argue and make sense of the topic of conservation of heat energy in a rural school.

To achieve this goal, the following research questions were addressed:

1. How do Grade 7 Natural Sciences learners experience learning the topic of conservation of heat energy before the intervention?
2. How do Grade 7 Natural Sciences learners interact, argue and participate during the presentation by the indigenous knowledge custodians on the traditional way of brick making?
3. How do Grade 7 Natural Sciences learners' sense-making shift (or not) as a result of the practical demonstration of the Indigenous technology of traditional brickmaking by the indigenous knowledge custodians and by using a lesson exemplar that integrated learners' local indigenous knowledge in this topic?

This research study consisted of three stages of data analysis. The first stage explored learners' experiences in learning the topic of conservation of heat energy before the intervention. The underlying assumption of this stage was to determine learners' prior knowledge. The identified learners' experiences were taken as learners' learning needs that informed the next stage. The first stage sought to answer research question one of this study.

The second stage focused on two observations, that is, participatory observation where the IKCs presented the practical demonstration of traditional brick making and the lesson observation where an exemplar lesson that integrated learners' IK in science was presented. The aim of this stage was to explore how integrating learners' IK in science teaching and learning helped learners to make sense of the topic of conservation of heat energy. The second stage sought to answer research question two of this study.

The third stage set to find out if there was a shift or not in learners' sense-making of conservation of heat energy because of the intervention strategies used. This stage sought to answer research question three. Data sets that emerged from the above-mentioned stages were analysed using concepts from SCT and CAT. The data generated from research question one and two were presented, analysed and discussed in Chapter Five of this study. In addition, data generated from the lesson observation, SCI and LRJ were presented in Chapter Six. I now discuss the summary of findings below by addressing the research questions sequentially.

7.3 Summary of Findings

I present the key findings that emerged from different stages of this study according to each research question.

7.3.1 Stage 1: Determining learners' prior knowledge

The main aim of stage one of the study was to determine learners' prior knowledge and to see if learners could link it with the concepts learnt in the topic of conservation of heat energy and related concepts. This information was evident in learners' responses to the group activity guided the questions provided. As noted earlier, data gathered in stage one sought to answer research question one:

> *How do Grade 7 Natural Sciences learners experience learning the topic of conservation of heat energy before the intervention?*

As detailed in Chapter Five above, the findings from the group discussion about making fire and *stories* told when sitting around the fire revealed that all four groups seemed to know how fire is made and the reasons for making it. Also, it was evident that learners seemed to know about *stories* told when sitting around the fire at home. For instance, G4H reflected that "*we make fire to warm ourselves when it is cold and to cook"*, while GITB commented that *"stories that are told when we sit around fire are folk tales which are old traditional stories that are passed on by mouth like animals talking to each other"*.

Regarding relevance to science, all the groups could relate fire making to science as it gives off heat energy. In addition, pertaining to materials used to make traditional huts, all learners linked these materials to science as they were able to identify concepts related to conservation of heat energy, such as insulators. For instance, G2SM indicated that *"traditional huts are made with materials that do not conduct heat".* On the other hand, learners could relate some *stories* told to science when sitting around the fire. G4H put it this way: "*A fable story about a burning coal and a bean is related to science because the coal is hot and in science we talk about heat"*.

These views showed the potential of integrating learners' prior everyday knowledge into science lessons (Kuhlane, 2011) so that they can negotiate meaning across the two distinct worldviews, IK and WS. It can be surmised, therefore, that learners could reach an equipollent cognitive state as espoused by Ogunniyi's (2007a) CAT because they could see that the two knowledge systems could work side by side instead of one dominating the other.

Furthermore, as I observed the group discussion session, it was clear that learners found it difficult to make arguments as they were not used to argumentation. However, they enjoyed participating in groups as this afforded them an opportunity for social interactions (Vygotsky, 1978) which facilitated argumentation (Ogunniyi, 2007a) that helped them engage with their IK which supported meaningful learning (Handayani, et al.,2018). Also noteworthy was that using their mother tongue language during group discussions provided learners with an opportunity to freely express their views in a non-threatening environment (Fakudze, 2021) with the more knowledgeable peers (Vygotsky,1978), which helped others to see the science embedded in these discussions. Interesting to note was that this helped even those learners who were always quiet in class and who were regarded as slow learners as they could contribute in their groups. This point of view supports Vygotsky's (1978) SCT which emphasises the importance of culture and language; when learners interact in a relaxed atmosphere using the language they are comfortable with it scaffolds learning (Bruner 2021). Resultantly, co-construction of knowledge becomes easier. So, both languages (that is isiXhosa and English) were afforded an equal status during these group discussions thereby enabling the reaching of an equipollent cognitive state (Ogunniyi, 2007a).

Essentially, the rationale of research question one in this study was to connect learners' prior everyday knowledge to the new concepts related to the topic of conservation of heat energy learnt in class for meaningful learning to take place. The findings revealed that stimulating learners' prior everyday knowledge in the lesson helped them comprehend new concepts during the learning activities (Ahied et al., 2020). Concurring, Taber (2020) echoes that learners come to school with some local knowledge from home, and when integrated into science learning, effective and meaningful learning occurs.

Henceforth, in the lesson Vygotskian scaffolding (Morselli & Sannino, 2021) was applied by using a variety of activities, such as getting information from home about fire making and discussing the information and related *stories* to help learners make connections between the new science concepts learnt in class and what they already knew. This encouraged learners to take responsibility for their own learning as they expanded their knowledge together in group discussions. In line with this point of view, Mavuru and Ramnarain (2020) postulate that one of the benefits of social interactions is shared construction of knowledge.

7.3.2 Stage 2: Observations

The rationale for the observation stage was to explore if learning opportunities were created or not for the Grade 7 Natural Sciences learners during the practical demonstration of traditional brick making by the IKCs and the presentation of the exemplar lesson that integrated learners' IK into the topic under consideration. Data generated from stage two sought to answer research questions two and three:

> *2.How do Grade 7 Natural Sciences learners interact, argue and participate during the presentation by the indigenous knowledge custodians on the traditional way of brick making?*
>
> *3. How do Grade 7 Natural Sciences learners' sense-making shift (or not) as a result of the practical demonstration of the Indigenous technology of traditional brick making*

by the indigenous knowledge custodians and by using a lesson exemplar that integrated learners' local indigenous knowledge in this topic?

7.3.2.1 Participatory observation

From literature, there is evidence to suggest that teachers seem to struggle to explain science concepts exclusively in English and they are not aware of the teaching strategies that can help them integrate learners' IK into science lessons (Glasson et al., 2010). Considering the above statement, I selected a formative intervention as an approach in this study because I imagined that it might address the problem of IK integration into science that we as teachers face.

Accordingly, to answer research question two, we visited the local brick making site to observe the traditional brick making process. The rationale for visiting the IKCs at their brick making site was to tap into their cultural heritage as custodians of this cultural practice and to explore if there was science embedded behind this process; in particular, those related to the topic of conservation of heat energy. This resonates with Kozaner's (2021) belief that changes in teaching strategies also affect areas where learning activities take place, which are not limited to classroom settings.

Based on the data analysis, it appeared that the IKCs were more knowledgeable in the traditional brick making process which appeared also to be scientific. This was evident as learners identified science concepts that emerged from the practical demonstration such as mixtures, strength as one of the physical properties of materials, heat transfer, heat gain, heat loss and others. This finding is consistent with Handayani et al. (2018), who asserts that authentic environments provide learners with an opportunity to construct their own learning. It appeared that the practical demonstration could be used to teach science concepts that seemed abstract to learners as they were involved in participatory learning (Ma, 2023) which exposed them to see things in reality in an out-of-school learning context as opposed to being confined to class. The same view is shared by Onwu and Mufundirwa (2020) who argue that learners effectively learn when learning is mediated by using contexts familiar to them. Essentially, the practical demonstration afforded learners with an opportunity to visualise science and engage in hands-on practical activities (Asheela et al., 2021).

Furthermore, as purported by Vygotsky (1978), the social interactions that occurred between the IKCs, learners, my critical friend and me were amazing. It was interesting to observe how learners interacted, participated and argued with the IKCs and among themselves, sharing knowledge and asking questions from the IKCs about how traditional brick making conserves heat energy. This was evident as L6F asked: *"Kutheni lento niyombathisa ngodaka ionti?"* (Why do you cover the oven with a layer of clay mud?). MaKhiwa answered that *"senzela ukuba zitshe izitena kungangeni moya kodwa siyazishiya izikroba ezincinci zokungenisa umoya wokuvuthisa umlilo eontini"* (We want to prevent air from getting inside the oven to allow the firing process to take place, however, we do leave some openings to allow air to burn the fire inside the oven). By asking questions from the IKCs, learners broke the cultural barriers (Ivana, 2022) of not questioning adults, but they did so with respect. Gurler (2021) reiterates that learners are likely to initiate interactions and engage in shared thinking and questioning during out-of-school learning activities.

In my view, the social interactions during the participatory observation were made possible using isiXhosa, our mother tongue, as a cultural tool. This created a non-threatening environment; hence, learners freely asked questions which enabled them to make sense of the concepts involved in the topic of conservation of heat energy. Engaging learners in discussions about the kind of science embedded in the IK of brickmaking using isiXhosa enabled all learners to actively participate. Even those learners who were usually marginalised in class because they were too shy to talk and some who are regarded as slow learners were actively involved. They freely expressed their views, and I was amazed at the kind of potential they possessed. As a consequence, one of them was selected to represent the class in the sharing circle and I could see that he had the potential to argue. So, using isiXhosa as a cultural tool helped me to see that learners' ability to argue improved as a result of creating a conducive space for them.

On the other hand, although the IKCs had no formal teaching experience, they were able to actively engage learners in the presentation by asking questions to ascertain if they understood the presentation. For instance, MaMthembu asked: *"Kanene besithe sizomisa kanjani izitena xa sizikhupha kwifolomu?"* (Could you remember how do we dry raw bricks from the brick mould and how long does it take them to dry?) L10M answered: "*Benithe nizibeka elangeni futhi kuxhomekeka kwimo yezulu ukuba zoma nini"* (You said you dry them in the sun and it depends on how clear the weather is for them to dry). Consequently, the findings showed that the study lent itself to the possibility of fostering the development of the Ubuntu spirit in learners, something which they were not aware of. They saw how the IKCs interacted with them during the presentation, their kindness and willingness to share their knowledge with them, and how they showed them respect although they were learners.

Also noteworthy was that the findings of this study revealed that from the practical demonstration of traditional brick making by the IKCs, more science concepts can be taught other than conservation of heat energy as illustrated in Table 5.4. Interesting to note was that learners did not only identify science concepts embedded in traditional brickmaking but there was also integration across other subjects such as Mathematics and Economics and Management Sciences. Learners identified concepts such as area and volume in Mathematics as the IKCs were counting the number of bricks made. They also identified concepts such as income and expenditure from Economic and Management Sciences as these elders were explaining that they also make a living from the selling of the bricks.

Therefore, it appeared that the practical demonstration enhanced and motivated learners to engage and learn science when their IK was integrated. Hence, they were able to connect and fill in the gaps between their local knowledge and conservation of heat energy and related concepts. Thus, mobilising the Indigenous technology of brick making helped learners to navigate the river situated between their home and school and enhanced their sense-making of the topic (see Section 1.2.1). To them, it became clear that IK and WS can work together in a complementary manner instead of competing (Ogunniyi, 2007a).

7.3.2.2 Lesson observation

The exemplar lesson that integrated learners' indigenous knowledge of firemaking was presented to consolidate the lesson after the presentation by the IKCs. The aim of the consolidation lesson was to find the influence of integrating IK into the topic of the conservation of heat energy.

The findings revealed that presenting the lesson exemplar that integrated IK into the topic of conservation of heat energy improved learners' attitudes towards learning science. When learners were prompted about their views of learning science using the strategy, L3JR reflected that *"I found out that science was fun and easy to understand"*. L6DL stated:

> *I enjoyed the lesson, it helped me to understand science more. For example, I already know that at home we make fire to keep the house warm and heat spreads to the whole house and that when cooking, heat moves from the fire to the pot.*

It was clear that learners were enthusiastic about learning science when they could relate the exemplar lesson to their everyday life activities (Gwekwerere, 2016). Furthermore, the findings of the study revealed that social interactions afforded learners an opportunity for argumentation. The exemplar lessons created a conducive learning environment that enabled discussions and active participation of learners. Through these interactions, learners took responsibility for their learning (Grant, 2022; Msomi & Akhurst, 2023) as they argued with each other in trying to identify science concepts that were embedded in the practical demonstration. This means learners actively contributed to their own learning and that of their peers. Concurring, Grant (2022) asserts that the SCT (Vygotsky, 1978) promotes discussions and argumentations between learners to expand their knowledge together and build problem-solving skills. Research has revealed that where there are social interactions (Vygotsky, 1978) there are discussions and arguments (Ogunniyi, 2007a). Consequently, the use of their mother tongue language (isiXhosa) when reflecting on their thinking during the lesson presentation led the learners to draw mind maps (see Figure 6.7) of the science concepts that emerged during the practical demonstration. From these mind maps, they identified concepts related to the conservation of heat energy and drew concept maps (see Figure 6.8). As reiterated by Vygotsky (1978), meaningful learning is enhanced through social interactions and the use of language as a cultural tool.

7.3.3 Stage 3: Reflective spaces

The main aim of Stage 3 was to find out if there was a shift or not in learners' sense-making of the topic of conservation of heat energy because of the presentation by the IKCs and the exemplar lesson that integrated IK into the topic of conservation of heat energy. This was manifested in learners' responses during the sharing circles interviews (SCI) and the learners' journal reflections (LJR). Stage three sought to answer research question three:

> *How do Grade 7 Natural Sciences learners' sense-making shift (or not) as a result of the practical demonstration of the Indigenous technology of traditional brick making by the indigenous knowledge custodians and by using a lesson exemplar that integrated learners' local indigenous knowledge in this topic?*

It was essential to examine the change that occurred while also investigating the effectiveness of the formative intervention using the Indigenous technology of brickmaking. In addition, the findings of the study revealed that observing natural environments enhanced learners' understanding of the link between IK and science. It became evident that engaging learners in hands-on practical activities and visualisation which involved them in observing real-life objects (Asheela et al., 2021; Mavuru & Dudu, 2021) enhanced their understanding of the topic. This was evident as L7JR reflected that *"learning that covering mud bricks with a layer of mud (dyasi) keeps heat energy helped me to understand insulators"*. Moreover, integrating learners' IK into science familiarised them with the topic by connecting it to their daily life activities and aroused their interest in learning science. In support of this point of view, Seehawer (2021) reiterates that contexts that are familiar and accessible to learners are likely to stimulate curiosity.

On the other hand, the research study showed that learners' sense-making of the concept of conservation of heat energy was enhanced. Mediating learning of this topic using the formative intervention strategy of traditional brick making enabled learners to make sense of the topic and related terms. This occurred as learners negotiated meaning across these two knowledge systems, that is, WS and IK. It became evident that learners understood that these two knowledge systems worked together in a complementary manner instead of competing (Ogunniyi, 2007a; Mukwambo et al., 2014; Seehawer & Breidlid, 2021) as they identified science concepts that emerged from the presentation. For instance, L1JR commented that *"I have learnt that when making bricks, there is science involved because concepts such as heat transfer emerged as bricks were fired"*. Also, L1MB reflected that *"to me understanding the topic of conservation of heat energy was made easier, I did not know that making fire that we do at home was related to science"*. So, as learners negotiated meaning across the two distinct thought systems (Ogunniyi, 2007a) they were able to integrate them and make sense of the topic and the related terms.

It also emerged that integrating learners' IK of brick making in the lesson enhanced their argumentation and sense-making of the topic and made them aware of the need to integrate IK into science and to understand that the two knowledge systems complement each other in science learning. When prompted on suggestions that might improve science learning, L2DU responded that *"Ndicinga ukuba singanikezwa ithuba lokuzikhangelela ngokwethu ulwazi ngokuthi senze practical activities futhi sifune ulwazi emakhaya sigqibe siludibanise nescience sibone ukuba ingaba ingasinceda na lonto"* (I think if we can be given an opportunity to explore for ourselves by doing practical activities and find more knowledge from home, then combine this knowledge with science to see if this works well for us).

On the other end of the spectrum, the focus of the LJR was on those learners who were not part of the SCI, to establish whether their sense-making of the topic shifted or not as a result of the lesson exemplar and the presentation by the IKCs. Findings from learners' reflective journals revealed that both the IKCs presentation and the lesson presentation enhanced their understanding of the topic. Also, learners made it clear that the presentations gave them the courage to argue and the ability to reflect. Like Simasiku's (2022) study, findings from the LRJ strengthened my research data-gathering tools. For instance, learners commented on how they enjoyed the strategy of reflecting after every lesson presented and on how this improved their English language proficiency and writing skills. As evidenced in what L3MX said "*Mna ndicinga ukuba singenza ireflections emva kwe lesson nganye efundisiweyo ukuze utitshala wethu aqonde ukuba sive ndawoni saphosakala phi. Ndinqwenela ukuba bonke ootitshala bethu basebenzise olu hlobo lokwenza nakwezabo izifundo"* (To me, if we can reflect after each lesson taught so that the teacher can know what we have understood or not in the lesson. I wish other teachers can use this strategy too in their lessons). One of the important aspects that the learners mentioned was that they wished that other teachers could also create reflective spaces for them in their subjects so that they (teachers) could be informed about their teaching practices.

7.4 New Knowledge in the Study

Previously, some studies have used the formative intervention strategies of IK integration into science. However, none of them has used the formative intervention strategy of traditional brickmaking to mediate learning on the topic of the conservation of heat energy. Therefore, using this strategy is new knowledge in this study. More so, mobilising the intervention strategy of traditional brickmaking revealed that other than mediating the conservation of heat energy, other science concepts can be taught using this Indigenous practice. It also became evident that integration across other subjects can be done using the traditional brickmaking process.

Another important aspect of the study that became new knowledge was using the mother tongue language of the learners (isiXhosa) which gave them the courage to argue; in particular, those learners who were regarded as too shy to speak and as slow learners. Using their mother tongue language allowed them to actively contribute to their learning and that of others to the extent that one of them was selected to participate in the SCI. This made their understanding of the topic easier, changing the narrative that they are shy to speak, and that some are slow to learn.

Also, similar to Mayana (2020), significant to this study was noting that learners appreciated the strategy of reflecting after the lesson to such a point that they felt that other teachers should employ the same strategy to inform their teaching practice, and in the process, improve learners' isiXhosa and English proficiency and writing skills.

Lastly, although the IKCs had no formal teaching, they could actively engage learners in their presentation by asking them questions to ascertain if they understood the lesson, which is a strategy that is mostly used by teachers.

7.5 Recommendations

Based on the findings above, I recommend that teachers as cultural knowledge brokers (Simasiku, 2022; Wyatt et al., 2017) should tap into the cultural heritage and wisdom of Indigenous elders – as they are the custodians of our culture and more knowledgeable on our cultural practices and beliefs – to enhance teaching and make science relevant. Teachers should invite IKCs into their science classrooms to participate in the education of their children. This in turn, can motivate learners to learn science and to appreciate and value their culture.

In addition, research question three of this study sought to find out if the presentation by the IKCs shifted (or did not shift) learners' sense-making of the topic of conservation of heat energy. The findings revealed that because of this presentation, learners' sense-making of the topic shifted. Supporting this viewpoint, Handayani et al. (2018) state that integrating IK into science supports meaningful learning. I therefore recommend that the DBE should capacitate teachers on how to teach contextualised and culturally responsive (Haimene, 2023) science lessons that are relevant to learners' everyday life experiences as espoused by Seehawer (2021). We as teachers need to navigate how to help learners cross the river that is situated between their home knowledge and school science as it is not going away.

Moreover, I recommend that as we change teaching strategies, we must also change areas where lessons take place such as out-of-school learning contexts. Taking counsel from this, Kozaner (2021) accentuates that change in teaching strategies also affects the places where learning activities take place, which are no longer limited to the classroom environment. To add, the findings of this study revealed that learners were actively involved in their learning, in shared thinking and in questioning during the out-of-school learning activity that took place at the local brickmaking site. In fact, Kozaner (2021) states that out-of-school learning integrates real objects, links the lessons to real events and encourages learners to participate as they are fun and engaging.

In this regard, as teachers, we work intensively with the curriculum, but the problem is the curriculum formulation and implementation (DBE, 2011). Considering this, the findings of the study revealed that learners were able to pull the threads together by identifying emerging concepts from the practical demonstration by the IKCs and were able to draw mind maps and concept maps. Hence, it could be argued that this study ignited a spark that it is time to document IK in science curriculum and textbooks. This might assist teachers in integrating IK into their science lessons and thus contextualise science content. Therefore, science teachers, textbooks and question papers need to address what the CAPS document advocates for and start integrating IK into science by drawing from learners' everyday life experiences.

Finally, I recommend that teachers should form professional learning communities (PLCs) in their schools, clusters and districts where they come together to learn with and from each other how IK can be integrated into science. This is a bottom-up strategy (Seehawer, 2018a) where teachers can do lesson studies by co-planning lessons that integrate IK into science and presenting them while others are observing with the aim of improving the quality of their teaching. These PLCs can even invite IKCs who are the custodians of our culture to do the presentations. Then, the improved lessons can be taught by teachers in their respective science classrooms.

7.6 Areas of Further Research

Further research in the field of Natural Sciences can be done on how to improve learners' argumentation because our learners are not used to argumentation. Henceforth, the use of DAIM can be considered as it creates a non-threatening atmosphere for learners to argue (Okoroh, 2021).

Furthermore, mobilising this formative intervention strategy of traditional brick making to mediate learning of the topic of conservation of heat energy can be conducted with teachers on how to co-develop exemplar lessons that integrate *stories* on fire making told at home when sitting around the fire. This could be done by teachers in their respective PLCs where lesson studies can be conducted.

7.7 Limitations of the Study

This study only involved a Grade 7 Natural Sciences class from Ubuntu Primary School (pseudonym) consisting of only 24 learners in the O.R. Tambo Coastal District. For this reason, the sample was too small, and the results cannot be generalised as representing all learners in the whole district or Eastern Cape province at large. However, the power of the Indigenous African women in the bottom-up decolonisation of the science curriculum in this study cannot be ignored as this improved the quality of the teaching and learning of science.

On the other hand, the SCI was conducted after school hours because I did not want to disrupt the normal school teaching time. This meant that learners might have come to the interviews tired and hungry from the normal school learning activities, and rush home because the school nutrition programme ends at 12 noon. This might have affected their participation in the interview.

Noteworthy also, was that although the use of the mother tongue, isiXhosa, played a significant role in this study as it created a non-threatening environment as reiterated by Fakudze (2021), I am aware that in the process of translation from isiXhosa to English some of the information might have been lost or distorted. Nonetheless, Gingqi, who was my critical friend was responsible for this by ensuring that the quality was maintained in transcribing the IKCs' presentation and the SCI.

Another significant aspect was that the study was conducted in an out-of-school learning context, and it cannot be ignored that learners tend to be more excited when the learning activity takes place outside the classroom. Therefore, it might happen that some of the learners did not pay much attention to the presentation, and instead were excited to get relief from the classroom confinement. Nevertheless, Gingqi and I tried to take care of this, including the IKCs who noticed that some learners were not paying attention to the presentation and drew them back to the presentation by asking questions.

7.8 My Personal Reflections

I joined Rhodes University in 2017, when I was selected by the then Libode Mega District, now O.R. Tambo Coastal District to do a BEd in Science Education. At the end of 2017, most of our colleagues were excluded from the course but I was fortunate to be one of the few that were left. At the beginning of 2018, when we were very demoralised by the exclusion of our colleagues, we met Professor Ngcoza who had just come back from sabbatical leave. He and Doctor Mutanho encouraged us not to lose hope and focus. They introduced us, for the first time in my years of teaching, to the concept of IK. Although, I used to come across this concept in the curriculum documents, I used to overlook it, because to me, it had no meaning.

Becoming one of the participants in Dr Mutanho's PhD study and witnessing an Indigenous Knowledge Custodian, MaMngwevu (clan name) presenting to us the process of making *umqombothi*[7], inspired me to pursue my studies by enrolling in the Honours degree. Her level of expertise was outstanding, and I was so fascinated to see that there was science embedded in this Indigenous practice of making *umqombothi.* This is where my passion for IK integration into science started. Hence, in my mini-research at the Honours level, the focus was on learners' perspectives on the integration of IK into science lessons. The findings of my mini-research study revealed that learners were very interested in seeing their IK being integrated into science lessons. It appeared that I had been depriving them of the opportunity to make meaning of science learnt in class by contextualising it.

In 2022, inspired by Professor Ngcoza and Dr Mutanho, who would cite Dr Chikunda who used to say, "*A university student who has not attained the PhD level is regarded as a university drop out"*, I decided to register for my master's degree. Notably, my passion for contextualising science in my classroom also triggered my interest to pursue my studies. I felt that our learners experience an everyday struggle, trying to cross the river situated between their home knowledge and science knowledge – what Aikenhead and Jegede (1999) refer to as 'border crossing'. Then I decided to explore some strategies that might help them cross over. MaMngwevu's presentation was the experience that aroused my interest to visit the IKCs in my study to observe them demonstrating to us the traditional process of brickmaking. This was the vehicle that I used to help my learners cross the river that was situated between their IK and learning the topic of conservation of heat energy in school.

Notwithstanding, in my quest to try and help learners navigate this river, there were many challenges that I came across. I had to go through several processes including getting permission from the IKCs who were the gate keepers of the brick making site. It was not easy

[7] *Umqombothi* is an alcoholic traditional beverage that is commonly made among the Xhosa and the Zulu cultures of South Africa (Mutanho, 2021).

to convince them to sign the consent forms. To them, verbal consent was enough – something which contradicted the university ethics requirements (Keane, 2021; Mutanho, 2021). To them, it felt like I did not trust their verbal consent. However, in the end, it was worth working with them. Taking learners outside the classroom was not easy to manage, as some regarded this as just an outing instead of a learning activity. However, with the help of two school governing body members who accompanied us to the site and the help of the IKCs who were presenting, we managed to maintain discipline.

The journey was challenging and rewarding at the same time because it has contributed to my professional development in many ways. I have developed a passion and knowledge on how to integrate IK into my science lessons. The study also introduced me to working in a Community of Practice (Lave & Wenger, 1991; Wenger, 1998) with my colleagues and my supervisors where the aspect of Ubuntu was showcased. I learnt a lot of values from my Community of Practice as they were caring, loving, respectful and kind to each other. I learnt that when we work together as a family, no one is left out. We used to sing the song "*ndibambe ngesandla ndingawi emlilweni"* (hold my hand so that I do not burn in fire). The song gave me the strength to keep going even though it was tough.

My own personal problems made me lose momentum during my 2023 academic year. Although I was emotionally drained, my supervisor reached out by involving other members in our CoP who encouraged me not to give up. Cherishing a story of a corn farmer and an African proverb that says *"If you want to walk fast, walk alone, if you want to walk far, walk together"* as shared by Professoror Ngcoza, gave me strength to continue. This used to remind me of a Xhosa saying: "*Ukhuni olunye kulula ukulophula kodwa xa zidibene zenza inyanda, kunzima ukuzophula"* (It easy to break one stick, but if they are combined to make a bundle, it is difficult to break them). In all, being there for one another (Ubuntu) in our CoP is what helped me complete my study. I thank God for bringing them into my life, I cannot forget their kindness and love towards me.

This study has taught me to value and respect other people's ideas, including those of my learners. Moreover, the study afforded me an opportunity to work with my learners as my co-researchers. The use of clan names during social interactions between the IKCs, my learners and me, helped to level power gradients (Mutanho, 2021). Moreover, the use of isiXhosa was also significant in the study. This created a non-threatening environment for everyone to participate. The Ubuntu and willingness shown by the IKCs to share their wisdom, knowledge and skills of traditional brick making was so heartwarming. They also felt very appreciated and that their culture was valued and had a place in science classrooms.

7.9 Conclusion

The main goal of this study was to mobilise the traditional brick making process to support Grade 7 Natural Sciences learners in a rural school to make sense of the topic of conservation of heat energy. To achieve this goal, the following data-gathering tools were used: group activity, participatory and lesson observation, a focus group interview (sharing circle) and LJR. The findings from this study confirmed that the processes involved in the traditional brickmaking process were scientific and this helped learners to make sense of the topic of conservation of heat energy and enhanced their argumentation. Also noteworthy was that employing DAIM enabled learners to actively participate, interact, argue and freely ask questions during the group activity and during the presentation by the IKCs.

Moreover, the study aimed to establish how the practical demonstration by the IKCs and the lesson exemplar that integrated indigenous knowledge in science shifted (or did not shift) the learners' sense-making of the topic of conservation of heat energy. The findings revealed that learners understood that their everyday lived experiences relate to science (Gwekwerere, 2016) but they could not connect this to science because of the science concepts used at school. Hence, integrating learners' IK of traditional brick making into the topic of conservation of heat energy positively shifted their sense-making of the topic.

Notably, the presentation of traditional brick making was done by women only and their level of expertise and enthusiasm was outstanding. This revealed the significance of the power of African women in the bottom-up decolonisation of the science curriculum. These women, uneducated as they were, carried powerful knowledge that enhanced learners' understanding of the topic. One of them, the eldest, MaMthembu commented that *"Singafundanga nje kodwa thina siyanogqitha nina bantu bafundileyo nabantwana banamhlanje ngokubasa umlilo. Soze silale singatyanga ikhona imbiza nomlilo kulento yokuhamba kombane"* (Uneducated as we are but we are more knowledgeable than you educated people and the youth of today when it comes to fire making. We know how to cook with fire and an iron pot when there is no electricity). The IKCs appreciated the fact that their cultural knowledge was acknowledged in science classrooms. This resonates with Triyanto and Handayani (2020) who postulate that integrating IK into science classrooms is a way for the local communities to gain a better space and access to school science and a way for learners to appreciate their culture and values.

Furthermore, it became evident in the study that social interactions afforded learners an opportunity to argue during group activities and during the lesson presentation and the presentation by IKCs which led to the co-construction of knowledge. This coheres with Mavuru and Ramnarain's (2020) study that accentuates that one of the benefits of social interaction is shared construction of knowledge. So, through argumentation, learners' understanding of concepts involved in the topic of conservation of heat energy and related terms was enhanced and they became aware of the need to integrate IK into science as reiterated by Ogunniyi (2007a) and Okoroh (2021) – this helps learners understand that the two knowledges can complement each other.

In addition, the findings of the study revealed that learners' language proficiency improved through using LJR and that both the learners and me learnt the skill of traditional brick making that was passed on to us by the IKCs who also learnt it from their forefathers, meaning there was mutual benefit in the study.

On the other end of the continuum, it appeared that there was a clash between Eurocentric perspectives of research ethics and IK. For instance, in this study, anonymity was a problem because the Indigenous women wanted their names to appear in the research as they had contributed powerful knowledge, uneducated as they were, which contradicts Eurocentric research ethics. Also, asking them to participate voluntarily and that they could withdraw at any time without any prejudice was regarded as disrespectful and insulting by these women. This means, although we take this as a polite gesture in a Eurocentric perspective, it takes another perspective in our culture. Therefore, this calls for reviewing the understanding of research ethics instead of assuming that they are universal. This resonates with the work of Keane (2021) who postulates that ethical research standards are not always universally moral, applicable and relevant. In summary, the findings from this study revealed that learner argumentation and hence sense-making of the topic of conservation of heat energy and other related concepts improved because of the IKCs' presentation and the lesson exemplar that integrated learners' IK into the topic under consideration.

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Appendices

Appendix A: Ethical Clearance

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/

27 April 2023

Prof Kenneth Ngcoza

Education Department

K.Ngcoza@ru.ac.za

Dear Prof Kenneth Ngcoza and Ms Lindiwe Godlo

Re: Making sense of the topic of conservation of heat energy: Using traditional brick making in a Grade 7 Natural Sciences class

APPLICATION NUMBER: 2023-7183-7528

This letter confirms that your research ethics application has been reviewed and **APPROVED** by the Education Faculty Research Ethics Committee (EF-REC). Your permission letter(s) where applicable have been received and you are free to proceed with your study.

Approval is granted for 1 year. An annual progress report is required in order to renew approval for an additional period. You will receive an email notifying you when the progress report is due.

Should any substantive change(s) be made during the research process, that may have ethical implications, you should notify the Education Faculty REC Chair via email. This includes changes in investigators. The REC Chair will advise as to whether a new application is necessary.

Do keep this clearance letter secure and accessible throughout your study and after its completion. It will be needed when a thesis is examined and when publications are submitted to journals.

Please also submit a brief report to the REC Chair on the completion of the research. This can be done via email. The purpose of this report is to indicate whether the research was conducted successfully and whether any ethics-related matters arose that the committee should be aware of, in order to guide future studies. Sincerely,

Prof Eureta Rosenberg

Chair: Education Faculty Research Ethics Committee

Appendix B1: Letter to the District Director Department of Education

The District Director
Eastern Cape Department of Education
O.R. Tambo Coastal District
P.O. Box 218
Libode
5160

District Director

Subject: Request for permission to conduct educational research with Grade 7 learners at Mconco Senior Primary School in the O.R. Tambo Coastal District.

I am Lindiwe Priscilla Godlo (Student number:17G6603), a part- time student doing Masters in Science Education with Rhodes University, South Africa and a teacher at Mconco Senior Primary School. I am a Natural Sciences and Mathematics teacher at Mconco S.P.S. I hereby humbly request your permission to conduct a research study with learners at Mconco Senior Primary which is in your District starting in June 2023. The purpose of the study is to make science relevant and accessible through using traditional brick making to support Grade 7 Natural Sciences learners from a rural school to make sense of the topic conservation of heat energy. The study will require the Grade 7 Natural Sciences learners to be co-researchers with me. Learners will be taken to a local brick making site where they will be required to observe and interact with the four community members who will be presenting about Indigenous technology of traditional brick making. Also, I will be presenting a lesson to them that will a use a module which integrates learners' local indigenous knowledge where one of the science teachers (my critical friend) will observe me. This will be done during working hours and the out-of-school learning to the brick making site will also take place during school hours. It is believed that changes in teaching strategies also affect areas where learning activities take place, which are no longer limited to classroom environment (Kozaner, 2021). Therefore, in light of the above, out-of-school learning is part of day-to-day learning activities at school hence I will negotiate with teachers who will be affected by this arrangement.

Written consents will be sought from all the participants (community members, from the parents or guardians of the learners and the learner themselves). I will also work with a Grade 5 Natural Sciences teacher who will be my critical friend in this study. He will observe the lesson presentation done by me and how the community members share their wisdom and skills on traditional brick making and how the learners interact with them.
I would like to assure your office that, should I be granted permission, the research ethics will apply throughout the process of the study. Identity of the participants and their views will be treated with high degree of confidentiality and anonymity.

Your consideration in this regard will be highly appreciated.

Yours Faithfully

Lindiwe Priscilla Godlo (School teacher, Mconco Senior Primary School and Rhodes University student)

Email address: godlolp@gmail.com

Cell number: 0782481037

Rhodes University, Research Office, Ethics
Ethics Coordinator:ethics-commitee@ru.ac.za
Telephone: +27 (0) 46 603 7727 f: +27 (0) 86 616 7707Room 220, Main Admin Building, Drostdy Road, Grahamstown, 6139

Appendix B2: Letter to the Principal of Mconco Senior Primary School

The Principal
Mconco Senior Primary School
Ngqeleni CMC
O.R. Tambo Coastal District
Ngqeleni
5140

Dear Sir

Subject: Request for permission to conduct educational research with Grade 7 learners at Mconco Senior Primary School in the O.R. Tambo Coastal District.
I am Lindiwe Priscilla Godlo (Student number:17G6603), a part- time student doing Masters in Science Education with Rhodes University, South Africa and a teacher at your school. As a Natural Sciences and Mathematics teacher at Mconco Senior Primary School, I hereby humbly request your permission to conduct a research study with my Grade 7 learners starting in June 2023. The purpose of the study is to make science relevant and accessible through the integration of learners' local indigenous knowledge in science. The study will use traditional brick making to support Grade 7 learners to make sense of the topic conservation of heat energy. The study will require the Grade 7 Natural Sciences learners and a Grade 5 Natural Sciences teacher (my critical friend) to be co-researchers with me. They will be required to:

1. Observe and interact with the four community members who will be presenting about the Indigenous technology of traditional brick making.
2. Present in class what they have observed and learnt while my critical friend will observe a lesson that I will teach.

Written consents will be sought from the parents or guardians of the learners and the learner themselves. I will also work with a Grade 5 Natural Sciences and Technology teacher who will be my critical friend in this study. He will observe me present a lesson that uses a module which integrates indigenous knowledge in science.

I would like to assure your office that, should I be granted permission, the reseach ethics will apply throughout the process of the study. Identity of the participants and their views will be treated with high degree of confidentiality and anonymity.

Your consideration in this regard will be highly appreciated.

Yours Faithfully

Lindiwe Godlo (teacher at Mconco Senior Primary School and Rhodes University Student)

Rhodes University, Research Office, Ethics
Ethics Coordinator: ethics-commitee@ru.ac.za
Telephone: +27 (0) 46 603 7727 f: +27 (0) 86 616 7707Room 220, Main Admin Building, Drostdy Road, Grahamstown, 6139

Appendix B3(A): Letter to the Natural Sciences Teacher (Critical Friend)

Enquiries: Ms. Godlo L.P.

Cell number: 0782481037

Dear ……………………………………….(Teacher Name)

Re: **Participation in research on the integration of local or indigenous knowledge when teaching the topic conservation of heat energy in the Grade 7 Natural Sciences class**

I am Lindiwe Priscilla Godlo (Student number: 17G6603), a part-time student doing Masters in Science Education at Rhodes University, South Africa. I am Natural Sciences and Mathematics teacher at Mconco Senior Primary School in the O.R. Tambo Coastal District. I hereby humbly request your permission to conduct a research study with you and learners at Mconco Senior Primary School. The study will explore mobilising traditional brick making with a view to contextualise and enhance learning of the topic of conservation of heat energy and the Grade 7 Natural Sciences learners will be co-researchers in this study. They will be required to (a) collect data from community members, (b) present in class, (c) interact with four community members who will be presenting about the traditional brick making and these activities will be observed and videotaped. Your role will be to assist videotape the lessons, assist in co-planning of lessons that include indigenous knowledge and assist observe my lessons since I cannot observe my own lessons. I will videotape and interview the learners and the community members. A written consent will be sought from the parents or guardians of the learners' and the learners themselves. In addition, you will be required to check and verify the findings of the study, this will help in validating the findings. I plan to conduct the study in June 2023.

The focus of the study is to explore how the use of the Indigenous technology of traditional brick making can support Grade 7 Natural Sciences learners to make sense of the topic conservation of heat energy. Kindly be informed that participation in this study is voluntary. It is therefore your right to decide whether you wish to participate or not. Also, participants are free to withdraw at any time as they wish to do so. The identity and views of the participants will not be revealed, and I will maintain anonymity, and data that will be collected will not be used for other purposes apart from this study. Should you agree to participate in the study, you are reminded that all information and data collected during the study must be kept confidential. The research ethics will apply throughout the process of the study. The data collected (hard and soft copies) will be kept in the school safe for at least a period of five years. The data collected will be used for reporting in my thesis and publications.

I can be reached at 0782481037 or email (godlolp@gmail.com).

Note: My supervisors Prof. Kenneth M. Ngcoza at Rhodes University, email address (k.ngcoza@ru.ac.za) and my co-supervisor Dr Chrispen Mutanho, email address (chrispenmutanho@gmail.com)
Your consideration will be highly appreciated in this regard.
Yours Sincerely
Lindiwe Priscilla Godlo
Rhodes University, Research Office, Ethics
Ethics Coordinator: ethics-commitee@ru.ac.za
Telephone: +27 (0) 46 603 7727 f: +27 (0) 86 616 7707 Room 220, Main Admin Building, Drostdy Road, Grahamstown, 6139

Appendix B3(B): Informed Consent for Critical Friend (Participant)

Project title: Making sense of the topic conservation of heat energy: Using traditional method of brick making in a Grade 7 Natural Sciences class.

Lindiwe Priscilla Godlo (17G6603), currently a masters' 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 study is to investigate how the use of traditional brick making can support a Grade 7 Natural Sciences class to make sense of the topic conservation of heat energy.

2. I will observe together with the researcher, learners when they participate, interact and argue during the demonstration of traditional brick making by the community members. The presentation will take place in an out-of-school context, a local brick making site and videotape the presentation with permission from participants. This will take place during school hours as it is part of learning, so I will arrange with other teachers affected.

3. That I will be observing the researcher when presenting a lesson in a Grade 7 Natural Sciences class. This will take place during school hours when I have off-periods. The lesson will take two hours.

4. By participating in this research project, I will contribute to knowledge and understanding how the presentations have facilitated my knowledge which I will use to develop lessons that contain IK.

5. My participation is entirely voluntary and should I at any stage wish to withdraw from further participation, I may do so without any prejudice.

6. I understand that participating in this study is voluntary and that I will not be compensated for participating.

7. The names of participants will be blocked in the thesis itself, unless if they express in writing their willingness to have their names included in the study.

8. There may be risks associated with my participation in the project. I am therefore aware 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 and hard drive only accessible through a secure password kept by me; and
   c) The researcher intends to publish the research findings in the form of a thesis towards a masters' degree in Science Education, and later present it in conferences or journal articles. However, confidentiality will be maintained.

9. Any further questions that I might have concerning the research or my participation will be answered by the Rhodes masters' student (godlolp@gmail.com) or the supervisor Professor Kenneth Mlungisi Ngcoza (k.ngcoza@ru.ac.za) and co-supervisor Dr Chrispen Mutanho (chrispenmutanho@gmail.com)

10. By signing this informed consent declaration, there are no legal implications.

11. 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, and I understand that anonymity might not be possible because we will be co-creating knowledge in this study. I therefore voluntarily agree to participate in the above-mentioned research project.

…………………………………..   ………………………….
Participant's signature Witness

Date …………………..   Date …………………..

Appendix B4(A): Letter to the Community Members

Enquiries: Ms Godlo L.P.
Cell number: 0782481037

Dear Sir/Madam

Re: Permission letter: Presentation to learners.

I am Lindiwe Priscilla Godlo (student number: 17G6603), a part- time student doing master's in science education with Rhodes University, South Africa and a teacher at Mconco Senior Secondary School. I am a Natural Sciences and Mathematics teacher at Mconco S.P.S. I hereby humbly request your permission to be a research participant in my research project that I will be conducting with my Grade 7 Natural Sciences learners at Mconco S.P.S. The focus of the study will be using traditional brick making to support Grade 7 Natural Sciences learners from a rural school to make sense of the topic conservation of heat energy. I plan to conduct the study in June 2023.

Since the focus of the study will be on the use of the Indigenous technology of traditional brick making to support Grade 7 Natural Sciences learners to make sense on the topic conservation of heat energy, your main role will be to present to the Grade 7 Natural Sciences learners how the traditional bricks are made and how heat energy is conserved in the process.

Your participation in this study is completely voluntary and you can withdraw at any stage you wish. I will ensure that your identity is treated with high degree of confidentiality and anonymity.

I henceforth request you to indicate your choice by making an (X) in an appropriate box below.

Agree…………….. ☐

Not agree………….. ☐

Signature:..

Your cooperation will be highly appreciated.

I can be reached at 0782481037 or email (godlolp@gmail.com) Note: My supervisor is Prof. Kenneth M. Ngcoza at Rhodes University, email address (k.ngcoza@ru.ac.za)

My co-supervisor is Dr Chrispen Mutanho, email address(chrispenmotahno@gmail.com)

Yours Faithfully

Lindiwe Priscilla Godlo

Rhodes University, Research Office, Ethics
Ethics Coordinator: ethics-commitee@ru.ac.za
Telephone: +27 (0) 46 603 7727 f: +27 (0) 86 616 7707Room 220, Main Admin Building, Drostdy Road, Grahamstown, 6139

Appendix B4(B): Xhosa Translation

Imibuzo: Ms Godlo L.P.

Umnxeba: O782481037

Mnumzana obekekileyo,

Igama lam ngu Lindiwe Priscilla Godlo umfundisi-ntsapho we Zibalo ne Nzululwazi e Mconco Senior Primary School. Ndicela ukuba uthathe inxaxheba kuphando kwi zifundo zam zakwi Dyunivesithi yase Rhodes. Uphando lwam ndizakulwenza eMconco Senior Primary School, lunxulumene nokuphanda umdla wabafundi ukuzama ukuphuhlisa kokufundiswa kweNzululwazi kwibanga lesixhenxe. Kolu phando ndizakuzama ukudibanisa ulwazi nenkcubeko efumaneka eluntwini nasekuhlaleni jikelele xa kufundiswa ngokwenziwa nokutshiswa kwezitena zodaka.

Oluphando luzakuthatha izigaba ezithathu. Sigxile kakhulu ukufundisa nokucacisela abafundi notitshala weNzululwazi ukuba luthinina ulwazi lwemveli ngokwenziwa nokutshiswa kwezitena zodaka. Injongo ephambili yoluphando kukujonga ukuba kungakwazi na ukuhlanganiswa ulwazi lwemveli neNzululwazi yase Ntshona, ukuzama ukukhulisa umdla wabafundi kwezeNzululwazi. Ndiyazithoba ndikwakucela kanjaqo ukuba uzokusifundisa, ngolwazi lwemveli ngokwenziwa nokutshiswa kwezitena zodaka. Uphando lwam ndilucwangcisele ukulenza ngoJune.

Ndakuvuyiswa yinxaxheba yakho koluphando. Imithetho ye Dyunivesithi ke ayibopheleli abathathi nxaxheba lonto ithetha ukuba banako ukurhoxa nanini na xa befuna njalo. Ndiyakuqinisekisa nakanjalo ukuba ulwazi olufumaneke koluphando aluyikunikwa nabanina ngaphandle kwemvume yakho. Ukanti, igama lakho aliyikuchazwa esidlangalaleni ngaphandle kwemvume yakho. Siye ke safumanisa ukuba masenze oluphando lokuba sazi ukuba yintoni eyenza umdla nendlela abacinga ngayo abantwana xa beyinxalenye kusenziwa uphando nzulu kwizifundo zeNzululwazi ingakumbi kwindlela yokwenziwa kwezitena zodaka emakaya.

Ukuba unombuzo malunga noluphando, nceda utsalele umxeba kum kolu cingo 0782481037, godlolp@gmail.com, okanye iingqonyela endiphantsi kwazo uProf. Kenneth M. Ngcoza kulomxeba 046 603 7269, k.ngcoza@ru.ac.za okwiSebe lwezeMfundo kwi Dyunivesithi yase Rhodes, okanye uGqirha Chrispen Mutanho, chrispenmutanho@gmail.com

Ncincilili!!!

Ndiyakucela kananjalo ukuba uncede uzalise esi siqendu silandelayo

Mna Mnumzana ……………………………………………………….. (igama lakho)

Ndiyavuma ☐ OKANYE Andivumi ☐ (Khetha ngokufaka X) ukuthatha inxaxheba koluphando.

Tyikitya …………………………………………………..

Inombolo yomnxeba …………………………………………….

Ozithobileyo
Lindiwe Godlo

Rhodes University, Research Office, Ethics

Ethics Coordinator: ethics-commitee@ru.ac.za
Telephone: +27 (0) 46 603 7727 f: +27 (0) 86 616 7707Room 220, Main Admin Building, Drostdy Road, Grahamstown, 6139

Appendix B5(A): Letter to the Parent(s)/Guardian(s)

Enquiries: Ms. Godlo L.P.
Cell number: 0782481037

Dear Sir/Madam
RE: Participation in research on the integration of local indigenous knowledge when teaching the topic conservation of heat energy in Grade 7 Natural Sciences class.

I am Lindiwe Priscilla Godlo (student number: 17G6603) a part- time student doing Masters in Science Education with Rhodes University, South Africa and a teacher at Mconco Senior Primary School. I am a Natural Sciences and Mathematics teacher at Mconco Senior Primary School. I hereby humbly request your permission to conduct a research study with your child who is studying at Mconco Senior Primary School. I intend to conduct the study in June 2023.

The focus of the study is using the traditional brick making to support Grade 7 Natural Sciences learners from a rural school to make sense of the topic conservation of heat energy. Kindly be informed that participation in this study is voluntary. It is therefore the right of the parent(s) to decide whether his/her child should participate or not. Also, participants are free to withdraw at any time as they wish to do so. The identity and views of participants will be treated with high degree of confidentiality and anonymity, and the data that will be collected will not be used for other purposes apart from this study.

If you have any questions about the research, please feel free to contact me at 0782481037, email address (godlolp@gmail.com) or my supervisor Prof. Kenneth Ngcoza, email address (k.ngcoza@ru.ac.za) and Dr Chrispen Mutanho, (chrispenmutanho@gmail.com).
Lastly, if you agree for your child to participate in this research, please complete the consent form below.

I..(full name of parent/ guardian, hereby confirm that I understand the contents of this document and the nature of the research. I hereby give permission to..(name of the child) to participate in the study.

Yours Sincerely
Lindiwe Priscilla Godlo

Rhodes University, Research Office, Ethics
Ethics Coordinator: ethics-commitee@ru.ac.za
Telephone: +27 (0) 46 603 7727 f: +27 (0) 86 616 7707Room 220, Main Admin Building, Drostdy Road, Grahamstown, 6139

Appendix B5(B): Xhosa Translation

Imibuzo: Ms Godlo L.P.

Umnxeba: 0782481037

Mzali obekekileyo,

Igama lam ngu Lindiwe Priscilla Godlo umfundisi-ntsapho kweNzululwazi neZibalo eMconco Senior Primary School. Ndicela ukuba uvumele umntwana wakho ukuba abeyinxalenye kuphando olunxulumene nezifundo zam zakwiDynivesiti yase Rhodes.Uphando lwam ndizakulwenza eMconco Senior Primary School. Oluphando lunxulumene nokuphanda ukuba umdla wabafundi ungakhula okanye udodabale kusini na xa kufundiswa eZenzululwazi kwibanga lesixhenxe kudityaniswa ulwazi nenkcubeko efumaneka eluntwini nasekuhlaleni ngokubanzi xa kufundiswa ngokwenziwa nokutshiswa kwezitena zodaka kugcinwa ubushushu. Oluphando luzakugxila kakhulu ekufundiseni nokucacisela abafundi notitshala weNzululwazi ukuba luthini ulwazi lwemveli ngezitena zodaka nokugcina ubushushu xa zisenziwa. Injongo ephambili yoluphando kukufumanisa ukuba kunakho kusini na ukuhlanganiswa kolwazi lwemveli neZenzululwazi yase Ntshona, ukuzama ukukhulisa umdla wabafundi kweZenzululwazi.Ndiyazithoba ndikwakucela ukuba uvumele umntwana wakho abeyinxalenye yoluphando. Uphando lwam ndilucwangcisele ukulenza ngo June.

Ndakuvuyiswa yimvume yakho koluphando. Imithetho yeDyunivesiti ke ayibabopheleli abathathi nxaxheba, lonto ithetha ukuba banakho ukurhoxa nangaliphina ixesha befuna. Ndiyakuqinisekisa nakanjalo ukuba ulwazi olufumaneke koluphando aluyikunikwa nabanina ngaphandle kwemvume yakho. Ukanti, igama lomntwana wakho aliyikuchazwa esidlangalaleni ngaphandle kwemvume yakho. Siye ke safumanisa ukuba masenze oluphando lokuba sazi ukuba yintoni eyenza umdla nendlela abacinga ngayo abantwana xa beyinxalenye kusenziwa uphando nzulu kwizifundo zeNzululwazi ingakumbi ngofundo lokwenziwa kwezitena zodaka nogcino bushushu.

Ukuba unombuzo malunga noluphando, nceda uqhagamshelane nam kulomnxeba, 0782481037,email address (godlolp@gmail.com) okanye iingqonyela endiphantsi kwazo uProf. Kenneth Ngcoza (k.ngcoza@ru.ac.za) (046-6037269) okwiSebe lwezeMfundo eRhodes Dyunivesiti, kwakunye no Gqirha Chripen Mutahno (chrispenmotanho@gmail.com).

Ndibamba ngazo zozibini

Ndiyakucela kwakhona ukuba uncede uzalise esisiqendu silandelayo.

Mna Mzali/Mmeli...(igama lomzali okanye ummeli womntwana),
ka..(igama lomntwana)

Ndiyavuma ☐ Andivumi (khetha ngokufakela ☐ X) kwibokisi

Tyikitya...Inombolo yomnxeba...

Ozithobileyo

Lindiwe Priscilla Godlo

Rhodes University, Research Office, Ethics
Ethics Coordinator: ethics-commitee@ru.ac.za
Telephone: +27 (0) 46 603 7727 f: +27 (0) 86 616 7707Room 220, Main Admin Building, Drostdy Road, Grahamstown, 6139

Appendix B6(A): Letter to the Learner

Enquiries: Ms Godlo L.P.

Cell number: 0782481037

Dear …………………………………………… (Learner Name)

Re: **Participation in research on the integration of the local indigenous knowledge when teaching the topic conservation of heat energy in Grade 7 Natural Sciences class.**

I am Lindiwe Priscilla Godlo, a part-time student doing Masters in Science Education at Rhodes University, South Africa. I am Natural Sciences and Mathematics teacher at Mconco Senior Primary School. I hereby humbly request your permission for me to conduct a research study with you as my co-researcher, during teaching and learning of the topic conservation of heat energy. The study will explore using the traditional brick making with a view to contextualise and enhance learning of the topic conservation of heat energy and the Grade 7 Natural Sciences learners will be co-researchers in this study. They will be required to (a) collect data from community members, (b) present in class, (c) interact with four community members who will be presenting about the traditional brick making, and these activities will be observed and videotaped. I will videotape and interview the learners and the community members. A written consent will be sought from the parents or guardians of the learners' and the learners themselves. I will also work with a Grade 5 Natural Sciences teacher to observe the four community elders presenting the Indigenous technology of traditional brick making. I plan to conduct the study in June 2023.

The focus of the study is to explore how the use of the traditional brick making can support Grade 7 Natural Sciences learners to make sense of the topic conservation of heat energy. I would like to assure you that, should I be granted permission, the research ethics will apply throughout the process of the study. Kindly be informed that participation in this study is voluntary. It is therefore your right to decide whether you wish to participate or not. Also participants are free to withdraw at any time of the study as they wish to do. The data that will be collected will not be used for other purposes apart from the study. Please note: Extra support and activities such as worksheets, video lessons and other relevant teaching materials will be made available for all those learners who do not wish to be part of this research and they will not be disadvantaged in any way.

If you have any question about the research, please feel free to contact me at 0782481037, (godlolp@gmail.com) or my supervisors Prof. Kenneth M. Ngcoza at (k.ngcoza@ru.ac.za) and Dr Chrispen Mutanho at (chrispenmutanho@gmai.com).Lastly, if you agree or do not agree to participate in this research, please complete the consent form below.

Yours sincerely

Lindiwe Priscilla Godlo

Appendix B(B): Child participant's assent form

INFORMED CONSENT DECLARATION
(Child participant)

Project Title: Making sense of the topic conservation of heat energy: Using traditional brick making in a Grade 7 Natural Sciences class

Researcher's name: Lindiwe Priscilla Godlo

Name of participant: ____

1. Has the researcher explained what s/he will be doing and wants you to do?

YES	NO

2. Has the researcher explained why s/he wants you to take part?

YES	NO

3. Do you understand what the research wants to do?

YES	NO

4. Do you know if anything good or bad can happen to you during the research?

YES	NO

5. Do you know that your name and what you say will be kept a secret from other people?

YES	NO

6. Did you ask the researcher any questions about the research?

YES	NO

7. Has the researcher answered all your questions?

YES	NO

8. Do you understand that you can refuse to participate if you do not want to take part and that nothing will happen to you if you refuse?

YES	NO

9. Do you understand that you may pull out of the study at any time if you no longer want to continue?

YES	NO

10. Do you know who to talk to if you are worried or have any other questions to ask?

YES	NO

11. Has anyone forced or put pressure on you to take part in this research?

YES	NO

12. Are you willing to take part in the research?

YES	NO

______________________________ ________________________

Signature of Child

Rhodes University, Research Office, Ethics
Ethics Coordinator: ethics-commitee@ru.ac.za
Telephone: +27 (0) 46 603 7727 f: +27 (0) 86 616 7707Room 220, Main Admin Building, Drostdy Road, Grahamstown, 6139

Appendix B6(C): Xhosa Translation

Mfundi obekekileyo ………………………………………. (Igama lomfundi)

Igama lam ngu Lindiwe Priscilla Godlo umfundisi-ntsapho we Nzululwazi eMconco Senior Primary School. Ndicela imvume yakho yokuba ubeyinxalenye kuphando kwi zifundo zam zakwi Dyunivesithi yase Rhodes. Uphando lwam ndizakulwenza eMconco Senior Primary School, lunxulumene nokuphanda ukukhulisa umdla wabafundi xa kufundiswa iNzululwazi kwibanga lesixhenxe. Kolu phando kuzakudityaniswa ulwazi nenkcubeko olufumaneka eluntwini nasekuhlaleni jikelele xa kufundiswa ngokwenziwa kwezitena zodaka nogcino bushushu.

Oluphando luzakuthatha izigaba ezintathu. Sigxile kakhulu ukufundisa nokucacisela abafundi notitshala weNzululwazi ukuba luthinina ulwazi lwemveli ngokwenziwa kwezitena zodaka nokugcinwa kobushushu. Injongo ephambili yoluphando kukujonga ukuba kungakwazi na ukuhlanganiswa ulwazi lwemveli neNzululwazi yase Ntsona, ukuzama ukukhulisa umdla wabafundi kwezeNzululwazi. Ndiyazithoba ndikwakucela kanjaqo ukuba ubeyinxalenye yoluphando. Uphando lwam ndilucwangcisele ukulenza ngoJune.

Ndakuvuyiswa yimvume yakho koluphando. Imithetho ye Dyunivesithi ke ayibopheleli abathathi nxaxheba lonto ithetha ukuba banako ukurhoxa nanini na xa befuna njalo. Ndiyakuqinisekisa nakanjalo ukuba ulwazi olufumaneke koluphando aluyikunikwa nabanina ngaphandle kwemvume yakho. Ukanti, igama lakho aliyikuchazwa esidlangalaleni ngaphandle kwemvume yakho. Ukuba uyavuma eyakho indima iyakuquka, (a) ukufilisha imibuzo yophando, (b) uyokufuna ulwazi kubantu abadala ekuhlaleni olungqamene noluphando, (c) wabelane nabanye abafundi eklasini ngophando lwakho, kwakhona (d) ubeyinxalenye yabafundi abazakufundiswa ziingcali zasekuhlaleni ngolwazi lwemveli olunxulumene noluphando, uzibuzele imibuzo kubo. Siye ke safumanisa ukuba masenze oluphando lokuba sazi ukuba yintoni eyenza umdla nendlela abacinga ngayo abantwana xa beyinxalenye kusenziwa uphando nzulu kwizifundo zeNzululwazi ingakumbi malunga nokwenziwa kwezitena zodaka nokugcinwa kobushushu.

Ukuba unombuzo malunga noluphando, nceda utsalele umxeba kum kolu cingo 0782481037, (godlolp@gmail.com), okanye iingqonyela endiphantsi kwazo u Prof. Kenneth M. Ngcoza kulomnxeba 046 603 7269, (k.ngcoza@ru.ac.za) okwiSebe lwezeMfundo kwi Dyunivesithi yase Rhodes, okanye uGqirha Chrispen Mutanho, (chrispenmutanho@gmail.com).

Ngcingcilili!!!

Ndiyakucela kananjalo ukuba uncede uzalise esi siqendu silandelayo

Ozithobileyo

Lindiwe Godlo

INFORMED CONSENT DECLARATION

(Child participant)

Isihloko sophando : Ufundo ngogcino bushushu: Kusetyenzisiwa ulwazi nenkcubeko ngokwenziwa kwezitena zodaka kwizifundo zeNzululwazi kwibanga lesixhenxe.

Igama lomphandi : Ms Lindiwe Priscilla Godlo

Igama lomthathi-nxaxheba ……….……………………………………

1. Ingaba umphandi ukucacisele yonke into azokuyenza kwakunye nafuna wena uyenze?

EWE	HAYI

2. Ingaba umphandi ukucacisele na ukuba kutheni efuna wena uthathe inxaxheba?

EWE	HAYI

3. Uyayiqonda na into ezanywa ekwenziwa ngoluphando?

EWE	HAYI

4. Ucinga ukuba ingakhona into entle okanye embi engathi ikwahlele ngelixesha loluphando?

EWE HAYI

5. Uyayazi ukuba igama lakho nezinto ozozitsho koluphando azizokuboniswa abanye abantu?

EWE HAYI

6. Umbuzile umphandi imibuzo nayiphi ngoluphando?

EWE HAYI

7. Ingaba umphandi uyiphendule yonke imibuzo yakho?

EWE HAYI

8. Uyaqonda ukuba ungangavumi ukuthabatha inxaxheba koluphando ukuba uyafuna, kwaye akukho nto izakwehlela ukuba akuvumanga?

EWE HAYI

9. Uyaqonda ukuba ungayeka ukuthabatha inxaxheba koluphando nanini na xa uziva ungafuni ukuqhubeka?

EWE HAYI

10. Uyazazi ukuba ungathetha nabani xa uziva ukhathazekile okanye unemibuzo ngoluphando?

EWE HAYI

11. Ukhona umntu okunyanzelisa ngokuthabatha inxaxheba koluphando?

EWE	HAYI

12. Uyavuma ukuthabatha inxaxheba koluphando?

EWE	HAYI

___________________________ ______________________

Utyikityo lomfundi **Umhla**

Rhodes University, Research Office, Ethics
Ethics Coordinator: ethics-commitee@ru.ac.za
Telephone: +27 (0) 46 603 7727 f: +27 (0) 86 616 7707Room 220, Main Admin Building,
Drostdy Road, Grahamstown, 6139

Appendix C: Time Frame of Study

Table 1: Proposed time frame for this study

DATE	ACTIVITY
January–March 2022	Refining research topic, literature, writing research proposal.
April 2022	Writing the draft research proposal.
April–May 2022	Submission of the first draft research proposal.
June–August 2022	Submission of the second draft research proposal.
January–February 2023	Submission of final research proposal.
February–March 2023	Writing draft literature review, ethics application and consent letters.
March 2023	Submission of the final research proposal to the EHDC. Designing data-gathering tools.
March–May 2023	Draft chapters 1-4 write up.
June–July 2023	Data collection and analysis.
August–September 2023	Data presentation and write up.
September–October 2023	Working on draft thesis.
October 2023	Submission of final full thesis to supervisors and editing.
November–December 2023	Submission of final full thesis for examination.

Appendix D: Data Collection Methods

Table 2: Shows the tools, methods and purpose for the gathering of information

Stage	**Method to be used to gather data**	**Purpose**	**Research question**
Stage 1	Focus group interview	To find out how learners find learning the topic of conservation of heat energy, Establish how learners found the experiences of having the community members presenting to them.	1& 3
Stage 2	Group Activity	To determine learners' individual prior-knowledge, To find information from the community about making fire.	2
Stage 3	Participatory and consolidation	To find out the influence of integrating IK in teaching, Mediation of learning using traditional brick making to make sense of the topic of conservation of heat energy and Using a module that integrates IK in the topic of conservation of heat energy in class.	2 &3
Stage 4	Learners' journal reflections .	To find out the influence of the practical demonstration by the community members and the lesson module that integrates IK in the teaching of science. .	2 &3

Appendix E: Focus Group Interview Schedule

1. Could you please tell why your group chose you to represent them in the focus group?
2. What makes you want to learn science or not?
3. How do you find learning the concepts involved in the topic of conservation of heat energy?
4. How are the concepts learnt in this topic relevant to your everyday life?
5. What traditional practices at your home or community related to conserving heat energy do you know of?
6. How best would you like the topic of conservation of heat energy to be taught and learnt? Why?
7. Is there anything else that you would like to share with me?

Appendix F: Group Activity Questions

a) How do we make fire at home and why do we make it?
b) What stories are told at home when you sit around fire?
c) How do these stories relate to the science learnt at school?
d) Why are traditional huts made with clay bricks?
e) What relevance do you think this has in science, in particular in the topic of conservation of heat energy?

Appendix G: Observation Schedule (Adapted from Nikodemus, 2017)

Observation Date …………………………Name of the teacher: ………………………

Subject: …………………………………... Number of participants: ……………………

Lesson Topic: ……………………………. Observer: …………………………………….

Social interaction	**Remarks**
The participation of learners during presentation by the community members	
The interaction of learners with one another	
The interaction of learners with the community members	
How community members take learners' views	
How learners are motivated in the presentation	
learners' courage to respond to their peers' thoughts and discussions	
Language	**Remarks**
The use of mother tongue and how it impacts on participation	
How learners' everyday experiences and ways of talking and knowing expressed during the presentation by the community members	
Learners' engagement and sense-making	**Remarks**
The involvement of learners in active learning	
How community members are sharing information or knowledge	

Learners' openness and interest in the presentation	
Learners' questions invite thinking	
Learners exploring concepts and ideas emerging from the practical demonstration	
Learners' interpretations of concepts and ideas emerging from the practical demonstration	
Learners construct clear scientific explanations from the demonstration	
Learners sense-making shifts or (not) as a result of the practical demonstration	

Appendix H: Interview Questions

The researcher is interested to find out the effect of integrating indigenous knowledge (IK) when teaching the topic of conservation of heat energy.

Researcher: Tell me about your experiences of learning conservation of heat energy using a lesson module that integrates IK?

Learner:

Researcher: What do you think are the reasons for your experiences that you have just mentioned?

Learner:

Researcher: What have you learnt from the presentation by the community members?

Learner:

Researcher: What were the most interesting things that emerged from the presentation (if any)?

Learner:

Researcher: How do you think the things that you have just mentioned are related to the topic of conservation of heat energy?

Learner:

Researcher: Is there anything that you would like to suggest that you think might improve the learning of science?

Learner:

Appendix I: Journal Reflections

Instruction: Answer all the following questions

1. What have you learnt from the lesson module presented?
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2. What have you learnt from the community members' presentations?
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3. In what ways did the presentation change (or not) your view about learning science? Give reason for your answer
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4. What have you enjoyed in these presentations?
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5. What have you <u>not</u> enjoyed in these presentations?
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6. In what ways do you feel the presentation has afforded you (or not) an opportunity to have a better understanding of conservation of heat energy or not? Please explain.
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7. What are your views on the integration of IK in science teaching? Please explain.

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Appendix J: Sharing Circle Interview Transcriptions

Title

Making sense of the topic of conservation of heat energy: Using traditional brick making in a Grade 7 Natural Sciences class in a rural school.

Colour codes for sub-themes

turquoise: sense-making; bright-green: conceptual understanding made easier; yellow: IK integration; blue: attitudes towards science learning; dark-yellow: social interactions afforded argumentations; grey: out-of-school learning; pink: use of easily accessible cultural tools; teal: no shift in sense-making; red: application of concepts in real-life situations

Sharing circles interview transcriptions

How do Grade 7 Natural Sciences learners' argument and sense-making shift (or not) as a result of the practical demonstration of the Indigenous technology of brick making by the indigenous knowledge custodians and by using a module that integrates learners' local indigenous knowledge in this topic?

1. **Nikufumanise kunjani ukufunda isifundo ngokugcinwa kobushushu ngokuthi kudityaniswe nolwazi lwasemakhaya?**
   Tell me about your experiences of learning conservation of heat energy using a lesson module that integrates IK?

   L1MB (MamBhele): Yenze kwalula ukuva indlela esifundiswe ngayo kuba bendingayazi ukuba umlilo lo esiwenza emakhaya yonke imihla uhlobene nezifundo zescience.
   Understanding conservation of heat energy was made easier using the module that integrates IK in the topic, I did not know that making fire that we do at home every day was related to science.
   L2DU (Duma): Ndibe nomdla kakhulu yindlela esetyenzisiweyo ukusifundisa le *topic*, ekhaya sihlala ezindlini zodaka ezithi xa kushushu ziphole xa kubanda zibe shushu.

Bendingayazi ukuba kungenxa yokuba izinto ezenziwe ngazo zi *insulators.* Kwakhona ebusika sinxiba iimpahla ezishushu sombathe neengubo ukuze sibe shushu naleyo bendingayazi ukuba yi *insulation.*

The method that was used was so interesting, at home we live in mud huts and we know that when it is hot they are cool and when it is cold they are warm. I did not know it is because they are made of insulators. Also, in winter we wear warm clothes and cover ourselves with blankets to make us warm, I did not know that this is called insulation at school.

L3MX (MamXesibe): Ndikuve kumnandi kuba ilesson isebenzise ukwenziwa komlilo lo esiwenzayo emakhaya sipheka ngawo siwubasele nokuba kubeshushu indlu yonke.

I enjoyed the lesson because it made use of fire making that we use at home to cook and warm our houses.

L4MZ (MaZulu): Ndikufumanise kumnandi ukufunda ngendlela yokugcinwa kobushushu ngolu hlobo besifundiswa ngalo. Lonto indenze ndaqondisisa. Umzekelo bendingayazi ukuba xa uhleli ecaleni komlilo eziko ubushushu buza kuwe nge *radiation*, xa ubeke imbiza emlilweni ubushushu busuka emlilweni buye embizeni nge*conduction*.

To me, it was fun learning conservation of heat energy using the method that the teacher used. This improved my understanding of the topic. For example, I was not aware that when I sit around the fire place at home, heat is transferred to me through radiation and when I cook with the pot heat is transferred to the pot through conduction.

L5T (Tolo): Ibinomdla kakhulu indlela esifundiswe ngayo kudityaniswa ulwazi lwasemakhaya ne science. Enye into endiyithandileyo bekulula ukubuza imibuzo singoyiki, sisebenza kunye nabanye abantwana sincedisana yonke imibuzo ibiphenduleka lula.

The lesson was so interesting, it integrated our local knowledge in science. Another thing that I liked was that asking questions was easy, in a non-threatening environment, working as a group, helping each other. All questions were easy to answer.

L6DL (Dlamini): Ndiyivuyele le ndlela yokufunda kuba nathi isenze sanenxaxheba ekufundeni kwethu sisebenzisana, xa omnye engaqondi ecaciselwa ngabanye abavileyo.

I enjoyed the lesson module, we were actively involved in the lesson, co-operated with each other, those who understood the lesson helped to make others understand as well.

2. **Zintoni ezona zinto zazinomdla ngexesha oomama besifundisa ngokwenziwa kwezitena zodaka**
   What were the most interesting things that emerged from the presentations by the indigenous knowledge custodians?

   L1MB (MamBhele): Eyona nto yanditsala umdla kukubona ukuba xa kusenziwa izitena zodaka kudityaniswa umhlaba nothuthu lwamalahle ukuze ziqine izitena emva koko kuhluzwe lo mxube udityaniswe namanzi.

   It was interesting to see how the bricks were made by mixing soil and coal ashes to make them strong, the mixture was sieved and mixed with water.

   L2DU (Duma): Kukubona ukuba kusetyenziswa isihluzo socingo esi sisisebenzisayo nathi ekhaya ukuhluza isanti xa sifuna ukohlula amatye esantini kuba emakhulu.

   To see that they use a sieve made of wire that we also use at home to seperate larger particles of sand from smaller particles.

   L3MX (MamXesibe): Ndifunde ukuba xa sele zigqityiwe ukwenziwa izitena ngumfolomu uyazikhupha azibeke elangeni ukuze zome nto leyo exhomekeke kwimozulu. Kwaye ndifunde ukuba nathi sikwazi ukuzenzela izitena siyeke ukuzithenga.

   I learnt that once the brick maker has finished making the bricks, she takes them out of the brick block and dry them in the sun, this depends on weather conditions. I have also learnt that we can make bricks for ourselves instead of buying them.

   L4MZ (MaZulu): Omnye woomama usicacisele esibonisa kananjalo ukuba xa besenza umlilo wokutshisa izitena basebenzisa iinkuni namalahle, apo baqale bafake iinkuni ezincinci uze xa sele uvutha umlilo bafake ezinkulu bagalele amalahle. Phambi kokuba babase baqale bazilungelelanise izitena ukuze kushiyeke izithuba phakathi kwazi ezizokwazi ukuhambisa umlilo kuzo zonke apha eontini.

   One of the mothers explained and demonstrated to us how fire is made in the oven in preparation to burn the bricks. She showed us that they first use small pieces of wood to kindle the fire, once its burning, they add logs and coal. Before making fire, bricks are arranged such that there are spaces in between them to allow heat to be transferred to the whole oven.

   L5T(Tolo): Eyona nto eye yanomdla kukubona ukuba ionti iyombathiswa ngodaka ukuze igcine ubushushu zizokwazi ukutsha kakuhle izitena ngaphakathi.

What was interesting to me, was to see that the oven was covered with a layer of clay mud to conserve heat inside so that the bricks burn properly.

L6DL (Dlamini): Ndiye ndaqaphela ukuba xa kubaswa umlilo uqala ezantsi apha eontini unyuke ngezithuba eziphakathi kwezitena ize njengokuba ionti imbathisiwe ngodaka kushiywe izithuba ezincinane zizongenisa umoya wokuvthisa umlilo ngaphakathi iintsuku ezisixhenxe. Emva kweentsuku ezisixhenxe iyakhululwa idyasi ukwenzela ukuba ionti iphole kuzosuswa izitena.

I noticed that fire is started at the bottom of the oven then moves up through the spaces between the bricks. Then as the oven is covered with a layer of clay mud, small spaces are left outside the oven to allow air to burn the oven for seven days. After seven days the cover is removed to allow the oven to cool down before removing the bricks.

3. **Ezi zinto zikwenzele umdla xa kwenziwa izitena ucinga ukuba zidibana njani nokufundwa ngokugcinwa kobushushu?**
   How do you think that the things you have just mentioned are related to conservation of heat energy?

L1MB (MamBhele): Iyadibana nezifundo ze *science* kuba okwakubasa umlilo nokumbathisa izitena ndizidibanisa *ne heat energy* kunye ne *insulators* esifundiswayo ngazo kwi science ukuba ziyabugcina ubushushu.

They are related to science. For example, making fire relates to heat energy and covering the oven with layer of clay mud relates to insulators which we learn about them in science that they conserve heat energy.

L2DU (Duma): Xa kutshiswa izitena kushiywa izithuba phakathi kwazo ukuze umlilo uthungeleke kuzo zonke izitena ngaphakathi kwionti. Kanti kwi *science* siyazi ukuba xa ubushushu busuka kwenye indawo busiya kwenye yi *heat transfer.*

When bricks are burnt, heat is transferred in the spaces between them, we know in science that when heat moves it is being transferred.

L3MX (MamXesibe): Izitena ziyabugcina ubushushu xa zombathiswe ngodaka kuba alibudlulisi ubushushu, lo nto yenze ukuba ionti ihlale ishushu zonke eza ntsuku zisixhenxe.

Mud bricks conserve heat when they are covered with a layer of clay mud because it does not allow heat to pass through as it is one of the good insulators, that kept the oven hot for the whole seven days.

L4MZ (MaZulu): Ukumbathisa izitena ngodaka kwenzelwa ukuba ubushushu bungaphumi kuhlale kushushu eontini, sithi lo nto yi*heat gain* paya kwiscience. Ukanti xa zingambathiswanga buzophuma zingatshi kakuhle izitena kuzokwenzeka i*heat loss.* Imingxuma emincinane evulweyo ecaleni eontini yenzelwa ukuze kungene umoya wokuvuthisa ngaphakathi kwi onti.

Covering the bricks with clay mud was done to keep the oven hot, this is what we call heat gain and if they were not covered heat was going to be lost and bricks would not burn properly. Small openings left on the sides of the oven allowed air to burn the oven because oxygen supports burning.

L5T (Tolo): Emva kokuba izitena zikhutshiwe ngumfolomu zibekwa elangeni ukuze zifumane ubushushu belanga nge *radiation.*

After raw bricks have been taken out of the brick block by the brick maker, they are laid on the ground to dry in the sun where heat will be transferred through radiation.

L6DL (Dlamini): Emva kweentsuku ezisixhenxe, ionti ishushu kakhulu lonto ithetha ukuba ifumene ubushushu kodwa emva koko kufuneka idyasi isuswe ukuze ubushushu buphume iinstsuku ezintathu kuzosuswa izitena.

After seven days the oven is too hot, which means it has gained heat but after that the covering of mud has to be removed so that heat is lost and the oven becomes cool again for three days before bricks are removed.

4. **Ingaba ikhona enye into eningayicebisa ukuzama ukuphucula ukufundwa kwezifundo zeNzululwazi?**
   Is there anything you would like to suggest that you think might improve the learning of science?

L1MB (MamBhele): Ndibone ukuba lento esiyenzayo emakhaya iyadibana ne science apha esikolweni noxa kuqala bendingayiqondi lonto. Ke ngoko ndingakuvuyela ukubona kudityaniswa ulwazi lwethu lwase makhaya xa sifundiswa iscience sifumane nolunye ulwazi emakhaya.

I have noticed that what we do at home is related to science learnt here at school. For example at home we make fire and we also sieve things. I would suggest that we connect what we learn in class with our local knowledge and get more information from the community.

L2DU (Duma): Ndicinga ukuba singanikezwa ithuba lokuzikhangelela ngokwethu ulwazi ngokuthi senze *practical activities* futhi sifune ulwazi emakhaya sigqibe siludibanise nescience sibone ukuba ingaba ingasinceda na lonto.

I think if we can be given an opportunity to explore for ourselves by doing practical activities and find more knowledge from home, then combine this knowledge with science to see if this works well for us.

L3MX (MamXesibe): Mna ndicinga ukuba singenza ireflections emva kwe lesson nganye efundisiweyo ukuze utitshala wethu aqonde ukuba sive ndawoni saphosakala phi. Ndinqwenela ukuba bonke ootitshala bethu basebenzise olu hlobo lokwenza nakwezabo izifundo.

To me, if we can reflect after each and every lesson taught so that the teacher can know what we have understood or not in the lesson. I wish other teachers can use this strategy too in their lessons.

L4MZ (MaZulu): Ndiyithandile lento yokwenzelwa idemonstrations ngabantu abanolwazi ngemveli yethu, lo nto indenze ndaqonda kakuhle. Ndingakuvuyela ukubona senzelwa ezi demonstations ngabantu abanolwazi ngemveli yethu sizokwazi ukudibanisa olu lwazi kwiscience.

. I enjoyed the demonstrations by the indigenous knowledge custodians who are more knowledgeable in our culture, it has made my understanding of science better and easier. I would appreciate it if more of these demonstrations can be organised so that we integrate this knowledge in science

L5T (Tolo): Ukuba singadibanisa ulwazi lwethu esiza nalo esikolweni, lo nto ingenza sikwazi ukuziqonda kakuhle iconcepts esidibana nazo kwi science khona sizokwazi ukuzisebenzisa ekuphileni kwethu.

If we can integrate our prior knowledge in science, that can give us a better understanding of the science concepts learnt at school and can help us apply them in our real-life situations.

L6DL (Dlamini): Ndiyithandile indlela esifundiswe ngayo isifundo sokugcinwa kobushushu eclassini apho kuye kwadityaniswa ulwazi lomlilo esiwuqhelileyo ekhaya kwi science. Lonto indenze ndakwazi ukudibanisa iconcepts ezinjenge heat transfer, radiation, conduction kolu lwazi lomlilo. Kungoko ndingavuyela ukubona sifundiswa ngoluhlobo nezinye ititshala zisenza ngolu hlobo. Umzekelo ngoku besiye eziteneni ndibonile ukuba nezinye izifundo singazifundiswa ngolwahlobo ezinje ngeZibalo ngexesha oomama bebesibonisa ukuba bazibala kanjani izitena, bayibala kanjani imali abayenzileyo nabayichithileyo.

I liked the lesson module that integrated IK in science where fire making which we are familiar with at home, was used to teach science concepts. Through this method I was able to link these concepts with fire making and made sense of them, such as heat transfer, radiation and conduction. I would like to see other teachers use the same method. For example, during the practical demonstrations by the indigenous knowledge custodians, I could see that other subjects such as Mathematics can be taught using brick making process when they demonstrated to us how they count the number of bricks made, calculate the profit and expenditure of the money they made from the selling of bricks.

Appendix K: Learners' Journal Reflections Colour-coded

Questions	L1JR	L2JR	L3JR	L4JR	L5JR	L6JR	L7JR	L8JR
1.What have learnt from the lesson module presented?	I learnt from the lesson how heat energy can be transferred	I learnt concepts such as radiation,conduction, convection, heat gain and heat loss	I learnt a lot about heat transfer, I now know that when I put my hands closer to the fire heat will be radiated to my hands	I learnt how heat is transferred and how heat energy is conserved	I learnt that when I sit around fire, heat energy is radiated to me	I learnt that insulators do not conduct heat and that they are good at keeping heat energy	I have learnt more about heat transfer , I know that when I put an iron pot on fire heat will be conducted from fire to the pot	I learnt that in making fire there is science
2. What have you learnt from the IKCs presentation?	I have learnt that when making bricks, there is science involved because concepts such as heat transfer emerged	Learnt that when bricks are burnt they store heat energy	I learnt that brick making process includes science that we are taught at school	I learnt that clay mud conserves heat energy	Learnt that when making brick different material sare mixed and sieved such as soil, coal residue and water	I learnt that the IKCs make and sell bricks to buy food in their homes and take their children to school	Bricks store heat, when we use them to build our houses they keep them warm	The IKCs count the bricks after they have finished making them using what we call 'area' in Maths then sell them and use their profit to buy coal
3. In what ways did the presentation change or not your view about learning science. Give	It changed my view because I had little knowledge of heat transfer before but now I	I like the way science was taught, it gave me a better understanding	I found out that science is fun and easy to understand	It made me like science more and drying brick in the sun made me understand	I enjoyed learning science when our knowledge from home	Process of brick making taught me how bricks are	Using knowledge from home in science made me love and	I found out that I like science and it is easy for me to understand it

reasons for your answer	understand better			radiation better	was involved	made and when I am old I will make my own bricks without buying them	enjoy science	
4. what have you enjoyed in these presentations?	Arguing, asking questions, working in groups helped me to understand some of the concepts, such as insulation	Visiting the IKCs to see how bricks are made and they conserve heat energy	Integrating our knowledge in science changed my view of learning science, I like it more	Those mothers explained everything to us clearly and asked us questions when we were not asking them.	The presentations helped me understand conservation of heat energy better	Really seeing science being demonstrated helped me to understand better	Knowing that mud bricks keep heat energy and this helps us to understand insulators	I enjoyed going out of the class to see how bricks are made and conserve heat energy. I now understand conservation of heat energy better
5.What have you not enjoyed in these presentations	There is nothing I did not enjoy. I enjoyed to see the brick making process	There is nothing because I gained more knowledge	I enjoyed everything	I enjoyed everything that I saw	Nothing that I did not enjoy in this lesson	I understood the presentstion clearly	I enjoyed the presentation	I have enjoyed the presentation but still cannot understand clearly conservation of heat energy
6. In what ways do you feel the presentatio	I understand the topic better	It has made me to understand the topic clearly	I understand the topic more now	The methods used to teach conservat	The topic still does not	This afforded me an oppor	I understand the topic a little bit	The presentation from *'oomama'* (the

n has afforded you or not an opportunity to have a better understanding of conservation of heat energy or not? Please explain	now because at home we make fire to warm ourselves and now in science we also learn that fire transfers heat to us that makes us warm	because our teacher used examples of things we do at home and we were actively involved in the lesson doing presentations	because it was explained using different ways including taking us to where bricks are made by the community	ion of heat energy made me more curious to learn science	make sense to me, if more can be done to make me understand	tunity to understand that heat from fire is heat transfer in science	but not that much clear	mothers) of traditional brick making and lesson by our teacher improved my understanding of the topic
7. What are your views on the integration of IK in science teaching? Expain	I like the way our teacher taught us this lesson, she used things that we also know	My view is that IK can be used in science because mostly the things we do at home also appear in science and here they have names	To me it is a good thing because science is more understandable when we are taught this way	I like it, it uses the knowledge I already have.	I must say I like the way this lesson was taught in a way that science relates to what we already know.	It makes understanding of science easier.	When integrating IK in science that can help us to do what we learn in science at home	It helps us to understand science clearly when our knowledge from home is connected to science