



The role of ethnomathematics in the cultural life of AmaNdebele women at Ekosini village in Mpumalanga Province

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ABSTRACT

Ethnomathematics embraces the mathematical ideas, concepts, and strategies used, or simply incorporated in the cultural practices or activities of different ethnic groups in society. Since each cultural group has its own specific way of doing mathematics and mathematizing their realities, these associations frequently represent a given cultural system, particularly the manner in which they evaluate and utilize numbers, geometric forms and relationships, measured or ordered objects in their own environment.

Against this background, this study investigated the role of ethnomathematics in the cultural life of AmaNdebele women at Ekosini village in Mpumalanga Province. This study was three-fold. The first was to explore the feminine cultural expression of ethnomathematics in the cultural life of AmaNdebele women. The second was to investigate the mechanisms used by AmaNdebele women in transmitting ethnomathematical knowledge. The third was to explore how Ndebele art sustains the livelihoods of AmaNdebele women. Using the eZiko Sipheka Sisophula Theory and the Cultural Creativity Theory to underpin this study, findings show that Ndebele women are custodians of Ndebele art, which is well seated within mathematical ideas and concepts. Ethnomathematics is utilized as a tool to express the identity of AmaNdebele.

The African indigenous philosophies that are discussed in this study guided the researcher to conduct an in-depth study that utilized the appropriate methods for an indigenous research. Thus, this study utilized indigenous research methods to investigate the role of ethnomathematics in the cultural life of AmaNdebele women at Ekosini village in the Mpumalanga Province. The participants who took part in this study were twenty-two in total (with Dr Esther Mahlangu being a key participant in the first data chapter and the third data chapter). However, they were grouped according to the objectives of this study, which have formed the data chapters.

The first data chapter of this study utilized an exploratory research design. An indigenous relational approach and indigenous research paradigm was adopted in all data chapters. Using an expert purposive sampling procedure, six participants were sampled. Data analysis was performed through a thematic analysis, where various themes and an emerging theme were identified. The findings suggest that AmaNdebele women use mathematical ideas and concepts to construct their art. In

most cases, they depend on their imaginations for measurements and estimations. Furthermore, they have their own techniques in crafting their art and also prefer using unique styles in order to achieve the desired designs. The findings also show that Ndebele art originates from the cosmos and is represented through the symmetrical and geometric shapes. However, such knowledge was lost in the past. The art of Ndebele people does not only show mathematical ideas and concepts but also has cultural significance.

The second data chapter utilized an ethnographic research design. A convenient sampling procedure was used to identify five participants in Ekosini village, who took part in a focus group interview. A thematic data analysis was also used to generate themes from the data. The findings of this chapter show that AmaNdebele women use different mechanisms to transfer ethnomathematical knowledge. There is also a purpose why AmaNdebele women transmit this knowledge. The results of this chapter reveals that there are taboos that play a vital role in knowledge transmission among AmaNdebele women. These taboos are part of customary laws that are established to maintain order in the Ndebele nation.

The last data chapter utilized an exploratory research design. The sample size consisted of twelve entrepreneurs from Ndebele art school who availed themselves. Two data analysis processes were utilized for this chapter. Firstly, the data was analysed using the descriptive analysis process. Second, a thematic analysis was used to analyse data from open-ended questions. The tool that was used for this study was tested in Pretoria, Marabastad where most AmaNdebele women sell their artefacts. The findings of this chapter show that AmaNdebele women generate income from selling their artefacts, which is used in different ways to sustain their lives. Furthermore, Dr Esther Mahlangu, who is of Ndebele ethnic group, was a key participant and was also used as an example. From this, the findings revealed that AmaNdebele women are using their indigenous knowledge for job and wealth creation. This aligns well with the IKS policy of 2004, which supports the commercialization and utilization of IK for wealth creation and supports the role women play in IK promotion and preservation.

In conclusion, AmaNdebele women are gatekeepers of Ndebele art, which is a visual articulation of ethnomathematical ideas and concepts. They use different mechanisms

to transfer ethnomathematical knowledge. AmaNdebele women are breadwinners of their household who generate income from selling this art. Therefore, Ndebele ethnomathematics serves as a cultural identity besides being used to sustain livelihoods. Recommendations for implementation and further research are also provided in this study.

Key words: Ethnomathematics, Indigenous Knowledge Systems, AmaNdebele, artefacts, women, livelihoods, Ekosini village.

DEDICATION

This work is dedicated to Dr Esther Mahlangu, our Ndebele icon, who made known to the world, Ndebele beadwork and mural art. I also dedicate this work to all the AmaNdebele women who are working hard to preserve this knowledge. Furthermore, I dedicate this dissertation to *amakhosi wekhethu*, Ndzundza and Manala Kingdoms. As your child, I humbly ask that we unite as the Ndebele nation and honour the legacy of our King Musi who wanted the Ndebele nation to be one. Let us continue to preserve our culture because it is our pride and identity.

DECLARATION

I, Monicca Thulisile Bhuda declare that the dissertation hereby submitted for the degree of Master in Indigenous Knowledge Systems at the North-West University is my own original and independent research work. The dissertation was carried out under the supervision of Dr. T. Saurombe and Prof. S. A. Materechera. I have, not previously submitted this dissertation or any part of it, for any degree or examination at another Faculty or University. The research work reported in this dissertation does not contain any person's data, pictures, graphs or other information unless specifically acknowledged as being sourced from those persons.

Signed at North West, Mafikeng

Date: 4/03/2019

Monicca Thulisile Bhuda (Candidate)

Signature 

As the candidate's supervisors, we agree to the submission of this dissertation.

Signed:  **Date: 5/3/2019**

Dr. T. Saurombe (Supervisor)

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Prof. S.A. Materechera (Co-Supervisor)

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LIST OF ABBREVIATIONS AND ACRONYMS

IK	Indigenous Knowledge
IKS	Indigenous Knowledge Systems
NIKSO	National Indigenous Knowledge Systems Office
UNESCO	United Nations Educational, Scientific and Cultural Organisation
DST	Department of Science and Technology
UJ	University of Johannesburg
DUT	Durban University of Technology
NWU	North-West University
FAST	Faculty of Agriculture, Science and Technology
FNAS	Faculty of Natural and Agricultural Science
FRC	Faculty Research Committee
HDRC	Higher Degrees Research Committee
USA	United States of America

CONFERENCE PRESENTATIONS, NEWSPAPER ARTICLES AND TELEVISION INTERVIEWS EMANATING FROM THE STUDY

Sections of this study have been presented and featured in different platforms as follow:

Bhuda, M.T & Saurombe, T. 2018. The inclusion of Indigenous knowledge within the CAPS curriculum: A decolonizing ethnomathematical perspective. Paper presented at the African Century International African Writers conference, 07th November 2018, Pretoria, Gauteng province, South Africa.

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Bhuda, M.T .2018. Ndebele geometry [personal TV interview]. SABC studios in Johannesburg.

Bhuda, M.T .2018. The decolonization of education System: An ethnomathematics perspective [personal TV interview]. SABC studios in Johannesburg

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North West University. 2018. NWU student studies ethno-mathematics in Ndebele art and beadwork. *The ulbum*, 27 June.

<http://pressoffice.mg.co.za/northwestuniversity/PressRelease.php?StoryID=284310>. Date of access: 30 June.2018

Toreran, E. 2018. Counting on Beadwork. *PressReader- Afro Voice*.7, 28 July

CHAPTER 1: INTRODUCTION TO THE STUDY

1.1 Background

Ethnomathematics can be described as a way in which people from a particular culture use their mathematical ideas and concepts for dealing with relational and spatial aspects of their lives (Borba & Skovsmose, 1997; Mosimege, 2012; Mawere, 2014). In the same token, Orey (2000) stated that the way people view mathematics in their cultures validates and affirms all people's experience of mathematics because it demonstrates that mathematical thinking is inherent to their lives. Within this context, D'Ambrosio (2006) argued that in an ethnomathematical perspective, mathematical thinking is developed in different cultures in accordance to common problems that are encountered within a cultural context.

In Africa, the rich history of ethnomathematics is clearly visible in-house designs, pottery, hair styles, rock paintings, textile technologies, architecture styles and settlement patterns. Eglash (1997) explains that in African cultures, there are two main types of geometry, which are part of the traditions and way of life of African people, namely: fractal and symmetrical geometry. Fractal geometry is mostly found in architecture and dwelling patterns; hairstyles and textiles whereas symmetrical geometry is mostly visible in beadwork, mural art, carved items and some in textiles. Ethnomathematics in Africa for a very long time has been the main aspect that describes the cultural identity of indigenous people within the continent. The connections between culture and mathematics are well established and are firmly rooted in the history of African culture (Oliver, 1971; Denyer, 1978; Bourdier & Trinh, 1985; Eglash, 1997). According to Levy (1990), it is in Africa, that people created abilities in glass making, pottery, metallurgy, weaving, carpentry, leatherwork, and stonework.

All artistic endeavors in Africa are divided by gender. It is a common practice in Africa for women to work with clay, beads, pottery and other natural substances to paint exterior walls while men focus on collecting wood to make sculptures or work with architecture (Semali & Kincheloe, 1999). Eglash (1997) argues that cultural expression in the form of ethnomathematics shows that African women have knowledge of basic and advanced mathematics, which they have managed to preserve and passed down

from one generation to another in an oral manner, through participation, experiments, observations and other forms of knowledge transmission practiced by diverse African cultures.

When it comes to African culture, there are traditional taboos, which are the main source of guiding principles regulating and directing the behavior of individuals and the community (Guidoni, 1987). Africans believe that there is a motivation for abiding by normative principals that are instructions from the ancestors, gods and God. As Ose (2006: 44) notes, “the Africans’ cultic code of ethics, written or verbal, serve as a point of reference in determining traditional law-breakers and in the adjudication of ensuing cases at the traditional courts and shrines. Those found guilty of serious moral or legal violations are made to undergo ritual cleansing as a means of moral or ontological purification and transformation”. Therefore, customary laws that African people, for a very long-time, have been abiding by, have managed to preserve and protect the indigenous knowledge in their cultures.

The indigenous knowledge of ethnomathematics in Africa explains the relationship Africans have with their environment, cosmos, the living, non-living, and with each other. African worldviews and beliefs have contributed in how they perceive reality. With ancestors, gods and God the main center, indigenous people of Africa believe that the mathematical ideas in their cultures are influenced and guided by the spiritual domain (Semali & Kincheloe, 1999). Thus, the knowledge of ethnomathematics is perceived as holistic.

Over the years, it has been discovered by scholars that Africans use mathematical ideas and concepts as part of their cultures. Thus, a global interest on investigating the role and significance of mathematical ideas and concepts in African cultures is needed (Gerdes, 1990; 2001; Eglash, 1999; 2005; Laridon, Mosimege & Mogari, 2005; Mosimege, 2012; Mawere, 2014; 2015). Therefore, ethnomathematics represents a methodology for progressing research and analysis of the procedures that transmit, diffuse, and organize mathematical knowledge (ideas, processes, and practices) that derive cultural contexts through history. This context empowered the improvement of the six critical dimensions of the ethnomathematics program: Cognitive, Conceptual, Educational, Epistemological, Historical, and Political. These dimensions are

interrelated and a main aim which is to analyze sociocultural roots of mathematical knowledge (Rosa & Orey, 2016).

1.2 Rationale for the study

For a long time African people have been using mathematical concepts and ideas as a way of survival and solving problems. However, this knowledge is tacit and has been transmitted orally, through observations, experiments, participations and other indigenous ways of preserving and transmitting knowledge. This study sought to document the indigenous knowledge of the AmaNdebele people in order to preserve it and for this knowledge to be accessible to AmaNdebele and people interested in knowing about the Ndebele culture. Within academia, the researcher hopes that this study will serve as a point of reference by other scholars who have an interest in African Ethnomathematics, indigenous studies and research.

1.3 Problem statement

Despite the growing interest in Ndebele art, there is limited literature which focuses on the mathematical concepts and ideas embedded in this art and such requires a need for further research. For instance, scholars such as Van Warmelo (1930), Schapera (1937), Weiss, (1963), Becker (1979), Levinsohn (1984), Klopper and Nettleton (1987), Levy (1990), Powell (1995) and Mashiyane (2006) previously made attempts in examining various aspects of Ndebele culture. The aspects covered by the above-mentioned scholars, however, have little or no detail about mathematical ideas in the Ndebele art and African mathematics at large. Instead, they looked at Ndebele culture focusing mainly on the history of the AmaNdebele people, the ritual ceremonies of AmaNdebele and the cultural significance of beaded attire and mural art.

In addition, in the existing research on the Ndebele culture, little has been said about the role that women play in transmitting the knowledge of mathematical ideas and concepts to the younger generation. Furthermore, the current existing literature shows that very few scholars acknowledge Ndebele women as mathematicians who have mastered the skill of using mathematical ideas and concepts in their art without having had any formal education (Mashiyane, 2006).

Furthermore, scholars like Mashiyane (2006), and Levy (1990) have made fair attempts by investigating how Ndebele women, over the years, have managed to sustain their livelihoods using art. However, there is need for further research in terms of investigating the current economic status of Ndebele artists and how ethnomathematical artistic works have developed/improved their livelihoods. For a very long time, non-indigenous scholars such as Weiss (1963) and Becker (1979) have used their worldviews to interpret the knowledge of the Ndebele people. In return, they have misinterpreted and misrepresented the cultural significance of Ndebele art and also have mis-written important terms used in this art. This has tended to degrade the indigenous knowledge of the Ndebele people and mislead other scholars interested in the same field. In view of such errors and gaps, there is a need for further research on the role of ethnomathematics within the indigenous cultural life of AmaNdebele women and the Ndebele cultural landscape in general. Therefore, this study poses the following question: how does the cultural life of AmaNdebele women reveal mathematical concepts and ideas?

1.4 Aim and objectives of the study

This study aimed to investigate the role of ethnomathematics within the cultural life of AmaNdebele women at Ekosini village in the Mpumalanga Province. The objectives of the study were to:

1. Explore the feminine cultural expression of ethnomathematics in the cultural life of AmaNdebele women.
2. Investigate the mechanisms used by Ndebele women in transmitting ethnomathematical knowledge.
3. Explore how Ndebele art sustains the livelihoods of AmaNdebele women.

The objectives of this study were guided by the following research questions:

1. What is the role of ethnomathematics in the cultural life of Amandebele women of Mpumalanga Province?
2. What are the mathematical ideas and concepts used by Ndebele women in their cultural expression?

3. How are mathematical ideas and concepts used by Ndebele women in their cultural expression?
4. Where do women acquire the knowledge of mathematical ideas and concepts?
5. How does ethnomathematical knowledge transmission take place?
6. How is the knowledge of mathematical ideas and concepts in the Ndebele art preserved and passed on?
7. How does Ndebele art together with mathematical ideas and concepts help in sustaining the livelihoods of AmaNdebele women?

1.5 Significance of the study

The researcher wanted to reveal how Ndebele mathematics is embedded in art and how mathematical ideas and concepts in the Ndebele art are translated and transmitted in cultural expressions. It is also anticipated that the study will promote the Ndebele art for the public to be aware that AmaNdebele women are mathematicians who never attended any formal structured school but learned these this knowledge from their ancestors through observations, participation and orally. Since mathematics is an important field used for development, the researcher hopes to develop this indigenous knowledge of the AmaNdebele women so that it can be utilized for innovation and commercialization, which will lead to wealth creation for knowledge holders and the Ndebele nation as a whole.

1.6 Personal orientation of the researcher to the study

The researcher is an AmaNdebele woman who grew up in KwaNdebele in Mpumalanga province. Throughout her life, she has been exposed to Ndebele art and her paternal aunt is an artist specializing in beadwork. Equally, she has had an opportunity to learn about the significance of this art, witnessed the techniques employed, the mathematical ideas and concepts her aunt used in beadwork. She has also, has had an opportunity to see how her aunt sells beaded artifacts in order to generate income. The beadwork of her aunt and knowledge she has acquired over the years about the significance of this art inspired her to do this research as a way of letting the world know that Ndebele art has mathematical ideas and cultural significance. Therefore, an indigenous lense was used to conduct this study. The cultural background of the researcher shows that her reality (ontology) is informed by

indigenous worldviews that perceives the realities of the Ndebele people (epistemology). The researcher as a Ndebele understood some aspects of Ndebele ethnomathematics but without constructing her own knowledge and assumptions, she wanted to investigate how her people perceive, conceive and consider their universe and whether the universe is the focal point through which they see reality, which influences their value systems and attitudinal orientations (African cosmology).

The researcher selected her methodology and axiology based on her indigeniety and that she is doing indigenous knowledge systems studies which intend to decolonize and move away from accustomed methods of conducting research. Therefore, the methods that were used by this researcher for data generation and analysis moved towards research practices that perceive the realities of the AmaNdebele women. The researcher became part of her exploration and indistinguishable from the participants of this research, understanding that the study was conducted 'with' AmaNdebele women and not 'on' AmaNdebele women. The whole research process was a ritual ceremony whereby the scholar was initiated by knowledge holders in order learn knowledge which is hidden to other scholars who are considered "outsiders". The learning process enabled the researcher to discover who she really is (her identity) and where she is going not only as an AmaNdebele woman but also as an indigenous researcher who wants to dedicate all her life to doing African indigenous research.

The researcher wanted to carry a study that honours Ndebele cultural protocols (axiology) and follow the Ubuntu principle with a purpose (teleology) of preserving this knowledge while establishing trust and lasting relationships with the participants (Chilisa, 2012; Hart, 2007; Kovach, 2010). She had to understand that the participants own the knowledge that they were willing to share with her, and they should not feel marginalized in anyway during the research process (Chilisa, 2012; Khupe, 2014; 2017).

1.7 Organization of the study

This study has been organized into seven chapters. Chapter 1 places the study in context by providing the reader with background on African ethnomathematics. The chapter also provides the reader with the rationale for the study, problem statement, aims and objectives that guided the study, the significance of the study and the

personal orientation of the researcher to the study. Chapter 2 provides the reader with the concepts and terms used in this study, the role of ethnomathematics in African cultures and previous studies conducted on Ndebele culture. Chapter 3 looks at the African philosophical underpinnings of the study. Furthermore, the chapter focuses on the conceptual framework of the study, provides the map location of the studied area for the reader and as well as an overview of Mpumalanga Province is also presented. Chapter 4 provides the reader with feminine cultural expression of Ndebele ethnomathematics in the lives of AmaNdebele women. Chapter 5 focuses on the ethnomathematical mechanisms of knowledge transmission amongst AmaNdebele women. Chapter 6 looks at the role of Ndebele art in sustaining the livelihoods of AmaNdebele women. Chapter 7 provides the reader with general discussions, conclusions and recommendations.

CHAPTER 2: THE ROLE OF ETHNOMATHEMATICS IN AFRICAN CULTURES

2.1 Introduction

Scholars in the African continent have shown an ongoing interest in studying Ndebele ethnomathematics to prove that Africans have mathematical ideas and concepts that are embedded in their culture. When conducting a study about AmaNdebele, previously African scholars would not use the term ethnomathematics. They would touch on aspects such as Ndebele culture, geometry, beadwork and mural art. In addition, there has been an interest in investigating the role of beadwork and mural art in the cultural lives of AmaNdebele women. Scholars such as Van Warmelo (1930; Schapera (1937), Weiss (1963), Becker (1979), Levinsohn (1984), Schneider, (1986), Klopper and Nettleton (1988), Levy (1990), Powell (1995), Mashiyane (2006) as well as Van vuuren (2012) to mention only a few, have agreed that AmaNdebele women are the custodians of beadwork and mural art and the knowledge has been transmitted from one generation to another.

The first section of this chapter focuses on the definition of ethnomathematics and its importance in the lives of indigenous people. In this chapter as well, the reality of the existing knowledge about the phenomenon (ethnomathematics) in the African cultures will be discussed to show that mathematical ideas and concepts are embedded in African cultures. The second section of this chapter takes a detour to expose the shortcomings of studies on perception of ethnomathematics in the cultural life of the AmaNdebele.

2.2 Definition of important terms and concepts used in the study

Indigenous knowledge (IK): This is the cumulative body of strategies, practices, techniques, tools, intellectual resources, and explanations accumulated over time in a particular locality, without the interference and impositions of external hegemonic forces, shared from one generation to another. “IK is stored in people’ s memories and activities and it is expressed in stories, songs, folklore, proverbs, dance, myths, cultural values, beliefs, rituals, community laws, local language, taxonomy, agricultural practice, equipment, materials, plant species, and animal breeds” (Grenier, 1998: 2).

Indigenous Knowledge Systems (IKS): These are ways for (relational) knowing and living created within indigenous communities from native to a certain geographical area. Indigenous knowledge systems are “accumulative, representing generation of experience, careful observation, participations and trial and error experiments. All members of the community have indigenous knowledge and contribute to IK processes: elders, women, men and children (Grenier, 1998:1; Ntuli, 2002).

AmaNdebele: AmaNdebele is a general name used for all Ndebele speaking people in both Zimbabwe and South Africa who belong to the Nguni grouping and are originally from the Bantu speaking group (Mahlangu, 2010; Jackson, 1969).

Culture: “The set of attitudes, values, beliefs, and behaviors shared by a group of people, but different for each individual, communicated from one generation to the next” (Matsumoto, 1996: 16).

Ethnomathematics: Powell (1997) described ethnomathematics as a manner by which individuals from a specific culture utilize mathematical thoughts and ideas for managing the quantitative, social, and spatial aspects of their lives. This way of viewing mathematics validates and asserts all individuals' involvement of mathematics since it shows that mathematical reasoning is inbred to their lives.

Documentation: Documentation is a set of documents that can be provided on paper, online, digital or analog media. It is an act of recording information, collecting and organizing documents (Moody, Slocumb, Berg & Jackson, 2004).

Livelihood: According to Tanner, Lewis, Wrathall, D., Bronen, Cradock-Henry, Huq, Lawless, Nawrotzki, Prasad, Rahman and Alaniz (2015), a livelihood encompasses individuals' abilities, resources, income and activities required to anchor the necessities of life.

Symbolism: Symbolism is the practice or art of using an object or a word to represent an abstract idea. An action, person, place, word, or object can all have a symbolic meaning (Keyton, 2011).

Communication: Murphy, Hildebrandt and Thomas (1997) stated that communication is a procedure of transmitting and accepting verbal and non-verbal messages. It is viewed as viable when it accomplishes the desired action or reaction from the receiver.

Spirituality: Spirituality identifies with the extension or development of aspects of consciousness such as physical, emotional, intuitional and moral. that leads towards greater perfection, goodness and wholeness is therefore spiritual. It the experience of the extraordinary, or the nature of transcendence, something that invites, yet does not require, religious convictions (Cobb & Robshaw, 1998; Goddard, 2000; Bento, 2000).

Entrepreneurship: According to Moroz and Hindle (2012), entrepreneurship is the capacity and willingness to develop, organize and manage a business wander alongside any of its dangers in order to make a profit.

Environment: Kalavathy (2004) stated that an environment is a complex set of numerous factors, which surrounds man and in addition the living beings.

Women: According to Mason (1986), women are female humans who are adults. However, the term can also be used for female humans, regardless of age.

Cultural expressions: “Those expressions that result from the creativity of individuals, groups and societies, and that have cultural content” (UNESCO, 2018).

Policies: Policies can be defined as regulations, procedures, laws, administrative action or voluntary practices of governments and other institutions (Torjman, 2005).

Mathematics: Mathematics is the science that deals with the logic of shape, space, change and quantity (Hersh & Ekeland, 1997).

Concept: A concept can be defined as a thought or abstract idea (Holmberg & Mathews, 1994)

Idea: An idea is a thought or suggestion construed as mental representational image of some object with an aim of taking action (Lovejoy, 2017).

2.3 Introduction to ethnomathematics

Ethnomathematics is a term that was first coined and defined by D'Ambrosio in 1977 to allude to mathematical concepts embedded in cultural practices and recognizes that all cultures and all people create unique methods and sophisticated explications to comprehend and to transform their own realities. The way of viewing mathematics validates and asserts all individuals' involvement of mathematics since it shows that

mathematical reasoning is inbred in their lives (Nkopodi and Mosimege, 2009). The term was coined in order to explain the mathematical ideas and concepts in culture (Mawere, 2012). However, the term requires a dynamic interpretation since it depicts concepts that are themselves neither rigid nor singular-namely, ethno and mathematics. The term ethno portrays "all of the ingredients that make up the cultural identity of a group: language, codes, values, jargon, beliefs, food and dress, habits, and physical traits'. Ethnomathematics communicates a "broad view of mathematics which includes arithmetic, classifying, ordering, inferring, and modeling" (D'Ambrosio 1987:2-3).

Africa has a rich cultural diversity that can be clearly seen in the wide range of house designs, baskets, textiles, wooden objects, decorations, settlements, pottery and enclosure shapes (Denyer 1978; Bourdier & Trinh 1985; Guidoni 1987; Eglash 1997). There is unity and harmony within this diversity, and it can be seen in the importance of the artistic and geometrical exploration of symmetrical and fractal forms and patterns (Gerdes, 1990). According to Gerdes (1990), Africans have always been masters of counting and such skill was carried out through mental calculations. Africans counting skills is visible in their art, rituals and daily activities (Solomon, 1997; Wenzel, 1972).

Culture is not static, it changes according to seasons and this can be seen through geometric shapes and decorations that change according to seasons and they mark changes in the family composition or be chosen for special ceremonies (Wenzel 1972; Courtney-Clarke, 1986; Gerdes 2001, 1995). According to Gerdes (1990), as people have been migrating from one place to another, some traditional African cultural ideas (including mathematical ideas) were shaped and reshaped by the environment, experience or knowledge in other cultural spheres.

2.3.1. The role of Ethnomathematics in African architecture

It is no secret that the Egyptians have the greatest knowledge of advanced mathematics in the entire North Africa. Egyptian art is made up of the harmonisation of nature and geometric regularity. According to Reimer and Rossi (2016), the combination of geometric regularity and keen observation of nature is characteristic of all Egyptian arts. Everything had to be represented from its most natural characteristic angle. The ancient Egyptian monuments, for example, include architectural elements

that have been highly recognized in history (Katz, 2007). The Egyptian pyramids were constructed because of kings that wanted to become immortal. According to Gerdes (1998), Egypt's Pharaohs wanted to become gods in the afterlife and to prepare for the next world, so they erected temples to the gods and massive pyramid tombs for themselves filled with all the things each ruler would need to guide and sustain himself in the next world.

Reimer and Rossi (2016) pointed out that the shape of Egyptian pyramids is thought to speak to the primordial mound from which the Egyptians believed the earth was made of. The shape of a pyramid is believed to be illustrative of the descending rays of the sun, and most pyramids were made to look clean with an exceptionally reflective white limestone, so as to give them a splendid appearance when seen from a distance. The great Egyptian pyramids are a polyhedron for which the base is a polygon and all lateral faces are triangles and consist of an estimated 2.3 million rectangular blocks which most believe to have been transported from nearby quarries (Reimer & Rossi, 2016).

In West Africa, likewise, mathematics has been applied in the daily culture of the Frafra, a voltaic people residing in north-eastern Ghana, which consists of three culturally and linguistically related ethnic groups: Gurensi, Tallensi, and Nabdam (Zaslavsky, 1994; 1999). The Frafra dwelling comprises of various round structures or rooms joined by high outside walls and by both high and low inside walls. Commonly, the ground plan of a small compound is round, yet as it develops, it turns out to be progressively ovoid. A compound extends and contracts with the family unit and clearly constitutes a spatial impression of the particular family social association at any given time (Awedoba, 2005; Odeyale & Adekunle, 2008).

According to Lentz and Nugent (2000), the Frafra artists use the free hand embroiling on wall painting. Before a wall is painted, it is plastered with a combination of clay, cow dung and water. In agreement with Lentz and Nugent (2000), and according to Bodomo (1994), the red pigment is produced using mud, black from a pounded stone, and white from a delicate chalk-like stone. Both the outside and inside walls of Frafra structures are intricately painted with red, white, and dark geometric motifs encased in registers outlined by a series of painted dark lines. These three colours and the kinds of motifs used to enhance Frafra walls relate specifically to the painted

decoration of voltaic masks of the indigenous people residing in Burkina Faso. The colors white, black, and especially red are viewed by the Frafra as aspects of the Earth. According to Sow, Adaawen & Scheffran (2014), alongside the ancestors, the Earth is a critical regulating power that keeps the religious and social system in adjust. The process of painting the walls include using a small broom to a wall with red brown. The black and white are applied using a frayed brush or a feather. After painting, the walls are allowed to dry, then later carefully polished with a stone. At long last, a varnish-like fixative is applied so as to keep the pigment from washing away in the rainy season.

The Frafra wall painting is to a great extent non-figurative, rectilinear, and symmetrical (Bodomo, 1994). The most widely recognized ornamental plan is the repetition of a single motif or pattern within a horizontal or sometimes vertical register. Every now and again, the wall is partitioned into two horizontal registers isolated by a limited band or by a specific motif called yidoor, comprising of a series of painted and incised parallel lines. Taking everything into account, there are around seventeen generally perceived and regularly utilized motifs. However, among the Frafra of northern Ghana, there is an acknowledgment of creative capacity and in addition a dominance of technique and style (Bodomo, 1994; Sow, Adaawen & Scheffran, 2014). Frafra women utilize these wall designs as a way of communicating with the community about their social status and the status of the male compound proprietor.

Still in West Africa, the northern parts of Cameroon, making a beeline for Lake Chad along the Logone River, have enormous rectangular fractal residences of the city of Logone-Birni belonging to the Kotoko nation. The residences were made on clay and the biggest of these structures, in the upper center, which is the castle of the king, or "Miarre" (Eglash & Odumosu, 2005). According to Eglash (1999), Parashar & Bandyopadhyay (2014), each complex is created by a procedure regularly called "architecture by accretion," Thus, in this situation, adding rectangular enclosures to pre-existing rectangles. Since new enclosures often incorporate the walls of two or more of the old ones, walled in areas have a tendency to get bigger and bigger as you go outward from the center. The final product is the complex of rectangular shapes within rectangular shapes. Since this architecture can be depicted as far as self-comparable scaling, it makes utilization of a similar pattern at a few distinct scales.

Eglash (1999) elaborated by stating that the purpose behind choosing scaling rectangles as a symbol of supreme authority turns out to be clear when one looks at the passage that one must take to visit the Miarre. The entry as a whole is a rectangular winding. Each time a person enters a littler scale, s/he is required to carry on more respectfully. When one arrives at the position of authority, he/she is shoeless and speaks in an exceptionally cultural manner. As a result, the fractal scaling of the architecture is not just the consequence of oblivious social dynamics; it is a subject of abstract portrayal and even a practical procedure applied to social positioning (Eglash, 1999; Parashar and Bandyopadhyay, 2014).

In Southern Africa, the Ba-ila settlements of Southern Zambia display fractal attributes whereby they show rings within rings. The Ba-ila village has about 250 huts, which are mostly built on the edge of a circle of 400 yards in diameter (Eglash, 1999). Inside this circle, there is a subsidiary one occupied by the chief, his family, and livestock. The settlements are made up of smaller rings, which are livestock pens (corals). Also, those are comprised of smaller rings which are single cylindrical houses and storage spaces, it is a ring of rings of rings. Toward the back of the village is a small village; that of the king's extended family. At the back of every coral is the family living quarters and at the back of each house is the secret sacrificial place which is the alter (Eglash, & Odumosu, 2005). As a philosopher would say, the king's family ring is to the entire settlement just as the alter is to the house. As observed by Smith and Dale (1968: 113), "this is viewed as a repeating functional role between various scales inside the settlement. The kings' connection to his people is depicted by the word *kulela*, a word that means nurse and cherish because he seen as the father of the community. A similar word is connected to a mother caring for her child. This relationship is echoed throughout family and spiritual ties at all scales and is basically mapped through self-similar architecture".

Fontein (2016) mentions that in Southern Africa, there is a sophisticated mathematical architectural construction that can be seen from the walls of Great Zimbabwe. The stone constructions of Great Zimbabwe can be categorized into roughly three areas: The Hill Ruin (on a rocky hilltop), the Great Enclosure, and the Valley Ruins (Amankwah-Ayeh, 1995). The early builders of Great Zimbabwe laid stones of different sizes together to form balanced walls. In the mid-14th century, more refined builders trimmed and coordinated stones to shape even rows and built decorative bands into

the walls. During the second stage, in the 14th century, Great Zimbabwe's developers delivered their best walls, utilizing stones that had been painstakingly trimmed to fit conveniently together and laying them in even courses, some of the time setting them in decorative patterns, for example, zig-zags or chevrons, a V-shaped design.

Researchers such as Sinclair, Ekblom and Wood (2012) have identified that Great Zimbabwe had a Great enclosure that was a temple. There was a temple, the residence of the King's wives, or a private community set aside for members of the royal court or other elite citizens. Eglash (1999) has proposed that the Great Enclosure may likewise have been a school where young women experienced training and rituals to prepare them for commencement into grown-up society. He constructs this suggestion with respect to the way that some African cultures continue to maintain the tradition of initiation school even in the present times.

Current archaeological evidence indicates that, up to the late 1800s the Nguni people of Southern Africa's settlements and patterns were very similar (Mhlaba, 2009). Their dwellings were built in the form of a thatched dome and were set in a circle about a central cattle byre. Traditionally, the dwellings of the Nguni people were built in the shape of an open fan with a substantial circular space containing the dairy cattle byre and the get-together place for the men being situated at its centre. This shows that the Nguni people have a mathematical thinking and belief system that plays a vital role in their daily lives.

In the Ndebele nation, such a settlement was influenced by the fact that polygamy was highly encouraged as it was one way of guaranteeing posterity and a form of wealth. Therefore, the setting homesteads were designed to accommodate large families (Cobbing, 1976). The dwelling of the first wife of the senior man was situated at the head of the settlement, on axis with the fundamental entry to the central space. Different wives of the senior man were then allotted homes on either side of the primary wife, on a left-and-right basis in alternating order of status (Cobbing, 1976; Magubane, 1998). The dwellings of his brothers or different individuals from his retinue, were located on the other hand to one side and right of his house, in descending order of status. Likewise, Magubane (1998) elaborated that where such men had polygamous families, their own homes were additionally organized by an internal left-and-right ordering. Married male children were typically allocated abodes

behind that of their mother, and they too took after a left-and-right ordering. The pattern of the Nguni people unlike that of the Ba-ila does not show any evidence of fractals. However, it provides a clear understanding on how the Nguni have been using geometry to construct their dwellings.

Likewise, Courtney-Clarke (1986) argued that it ought to be noticed that by the 1940s, most Ndebele settlements had changed to a geometric linear pattern. The homes of individual relatives were as yet spread out as per their status in a left-and-right hierarchy, however the residence currently followed the land's lines of contour, an arrangement which improved utilization of their cultivating resources.

2.3.2 Mathematics embedded in African masks

According to Eglash (1999), West Africa is well known by traditional masks that are used for spiritual purposes, including rituals and other traditional ceremonies. The Dogon people of Mali, for instance, believe highly in ancestral worship. They are well known for wearing masks for different ceremonies. According to Queiroz (2012), the Kananga masks worn by the Dogon's form geometric patterns and these masks represent the first human beings and are normally made by carvers of the Awa (cosmos) society. The masks are worn during the Dama dancing ceremonies and the Dogon believe that the Dama dance creates a bridge and connection with the supernatural world.

According to Lane (1994), the Dogon have three distinctive styles of sculpture namely; masks which are incorporating recessed rectangles, the ancestor sculptures which are carved in geometric style which are also used for architectural supports, and lastly the freestanding figures made in a cylindrical style. This resonates with Van Beek and Banga (1992), who note that the Kanaga mask is created from the wood of a local baobab tree. In addition to the wood for the mask, the pigments used to color the mask are derived from local plants. The mask is made from a single block of wood. Several carving tools are used to create the basic shape and they give the mask more details. After the mask is crafted, it is painted with pigments. The traditional colors of the mask are white, black and sometimes red. The Kanaga masks are about a height of 36 ½ inches (in. 93cm) (Van Beek & Banga, 1992).

Among the Voltaic people, including the Bwa, Nuna, Winiaama, and Mossi, masks bear geometric examples in red, white and black that are symbols in the language of the spirits, an initiatory language in which these individuals turn out to be more proficient with increasing age (Petridis, 2008). The patterns are joined on masks to speak to the prohibitions, rules for appropriate conduct of life, and necessities of the spirits the masks represent (Kasfir, 1990). According to Petridis (2008) the colours of the mask costumes along with the patterns refer to the spirits. The color red is associated with danger, especially in the form of spirits from the bush, which are almost always thought to be red. Masks are covered with complex compositions of triangles, rectangles, crescents, dentate patterns, and other geometric shapes, which are carved or pyro engraved, and then colored red, black and white using natural vegetable or mineral pigments. Furthermore, McNaughton (1979; 1991) highlights that amongst the voltaic people, masks are carved by specialists from smith clans. Performances are done by families that own the masks and young men of each family wear the masks of their fathers. Masks are also worn during burials, funerals and other ceremonies.

The Bamileke people of Cameroon wear long faced masks which are named after an elephant. The masks symbolize leaders, at least, their respected deputies or messengers (Malaquais, 1997). The social orders that use these masks in fact act as agents of chiefs' control and as formal royal emissaries. Ndjio (2009) highlighted that elephant societies that originated in Bamileke and spread somewhere else in the Grasslands comprised of three graded positions attained by wealth. As Northern (1975) reminds us, "these elephant masks, signifying kingship and riches, were worn by the powerful individuals from the Kuosi regulatory society, which included individuals from royalty, wealthy title holders, and ranking warriors of the Bandjoun kingdom of western Cameroon". Elephant masks contain cloth panels and hoods woven from plantain fiber over raffia. On this foundation, colorful beads are sewn in geometric patterns (Forni, 2016).

Such masks are frequently worn with robes of dark woven fiber secured with small fiber knobs or indigo and white tie-dyed "royal" cloth. "The robes contrast incredibly with the maskers' bright red legs, dyed with camwood. Costumes additionally incorporate beaded vests with wide belts and leopard pelts attached at the back. Since a chief possesses or controls the masking society, the two leopards and elephants are well-suited metaphors for symbolic impersonation" (Brain & Pollock, 1971:100-104).

2.3.3 Evidence of mathematics in African Textiles

Africa has a rich history of textile production which have different roles in various cultures (Eglash, 1999). The textiles of Africa show how different ethnic groups incorporated mathematics in their cultural lives. For instance, evidence of symmetrical geometry can be seen on the Kente cloth of Ghana that is associated with the Asante King and which is a cloth made only for the Kings. According to Boateng (2011) the colours of the cloth has strong symbolic meanings which were honoured for generations. Originally, the Kente cloth had only black and white colours. At a later stage, dyes were developed from the natural environment, blue was obtained from the indigo plant, red from dried cam wood, brown from Indian tamarind, and green from boiled spinach leaves. According to Marberry and Zagon (1995), colors convey mood, such that dark shades are associated with grief and used for mourning ceremonies, while lighter shades are associated with happiness. Ofori-Ansah (1993) argued that the symbolic significance of Kente is located in the motifs (the elephant signifies kingship, the scorpion bitterness).

The Kente cloth is characterized by shapes which are created by the technique of loom weaving. It is easier to weave geometric than organic shapes, therefore rectangles, diamonds, zig-zags, and squares are predominant. According to Kent (1971), colours and tones interact along their straight edges, creating optical vibrations as the eye attempts to accommodate constantly changing visual stimuli. However, weavers do not consciously apply the scientific color theory established by the color wheel but tend to work with abrupt contrasts of tone and hue (Ross, and Adedze, 1998). The process of weaving involves the crossing of a row of parallel threads called the warp whereby the threads run vertically and with another row called weft whereby threads run horizontally (Schneider, 1987). The colors of the cloth each hold symbolism: gold is for status/serenity; yellow symbolizes fertility; green symbolizes renewal; blue symbolizes pure spirit/harmony; red symbolizes passion; and black symbolizes the union with ancestors/spiritual awareness.

The Kente cloth designs change, with the distinctive designs, colors and patterns, each having their own extraordinary meanings and stories. For instance, the Obaakofoo Mmu Man pattern symbolizes democratic rule; Emaa Da, the novel

creativity and knowledge from experience; and Sika Fre Mogya, the duty to impart money related success to one's relations (Kent, 1971).

Hale (1970) stated that a horizontal loom, developed with wood, comprises of an arrangement of two, four or six heddles (loops for holding thread), which are utilized for isolating and directing the warp threads. This statement was further supported by Solomon (1997) by pointing that these are connected to treadles (foot pedals) with pulleys that have spools of thread embedded in them. The pulleys can be utilized to move the warp threads separate. As the weaver separates the warp threads, he utilizes a shuttle (a little wooden gadget conveying a bobbin, or little spool of thread) to embed the weft threads between them. These different parts of the loom, similar to the themes in the cloth, all have symbolic importance and accorded a great deal of respect (Musgrove, 2001).

The Akwete cloth is a fabric which is woven by the Igbo women of Nigeria in the Akwete area near Aba state. According to Chuku (2004), the Akwete cloth is referred to as “Akwa Miri” which means the cloth or towel of the water. Akwete cloth comes in different colours and designs. However, Kriger and Thomson (2007) argued that the common are the patterns of red and black designs, interwoven in geometric patterns such as triangles, V-shapes and diamonds on the white background which are preferred by Igbo men. The Akwete cloths, woven from sisal-hemp fibres are of a coarse kind, utilized by masqueraders, and by warriors as headgears, while those produced using raffia fibres are utilized on religious events like the Ozo titleship, and for mourning by women (Akinwumi, 2008; Nwauche, 2017).

Borgatti (1983) noted that traditionally, the raw cotton fibres that surround and protect cotton seeds do undergo some processes before use, namely: First, is the ginning process, where the cotton seeds are removed from the fibres by rolling a rod over the cotton ball. Second, in the bowing process, this involves making cotton fibres fluffy by flicking the string of a small bow against them until they look like cotton wool (Okonjo, 1975). Third, in the spinning process, this is done by pulling the fibres into threads. The processing of the cotton fibres from the cotton seeds is not the same with that of the raffia fibres. Raffia is the fibre from the fresh leaf of the palm tree. Nwauche (2017) mentioned that the process of extracting fibre from the thorny raffia palm frond demands a special skill by the woman weaver. The weaver firstly starts from the tip,

the distal end by splitting it, and then gently pulls down to the inflorescence (Borgatti, 1983).

The Igbo women of Nigeria also weave an *Ukara* dyed indigo cloth which is made of plain cotton but transformed into a ritual object when *nsibidi* symbols are inscribed onto it through indigo dyeing (Aronson, 1982). *Nsibidi* is a body of ideographic, geometric, figurative, concept, narrative, abstract, and gestural signs deployed by the Ekpe society as a form of coded communication (Ajibade, Ekpe & Bassey, 2012). The *Ukara* cloth is worn as personal wrappers during initiations and at other social events or gatherings, and it distinguishes Ekpe members. Battestini (1991) composed that covering, concealing, and protecting the bodies of Ekpe members, functions as a physical metaphor for the ideological secrecy that the Ekpe society carefully constructs and guards. The symbols in *Ukara* cloth are arranged in a grid, giving the cloths an orderly, symmetrical quality that is often reinforced by repeated patterns (Adams, 2003).

According to Battestini (1991), Olumati and Mgbemere-Emukah (2016), the process of creating this luxuriously symbolic fabric is laborious. Although utilized solely by individuals from Ekpe, *Ukara* is produced by a sub-group in a village of the Ezillo community in Ebonyi state of the Igbo area in South-Eastern Nigeria (Anderson & Peek, 2002). Each *Ukara* is very individualized and clearly created to be worn by a particular Ekpe member or to mark a specific Ekpe lodge. Leib and Romano (1984) further mentioned that the Ekpe individuals ask for *nsibidi* designs of personal or communal significance. The design is left to the attentiveness of the Ezillo makers, who are not Ekpe individuals and don't know the meanings of *nsibidi*. These specialists sew the white cloths with raffia thread so parts of the ukara (in a pattern of *nsibidi* symbols) won't be uncovered during the coloring procedure. The cloth is then dipped in indigo dye and hung to dry. At the point when the threads are cut, the *nsibidi* design stands (Anderson & Peek, 2002).

The Bambara tribe of Mali in East Africa have been producing the *bògòlanfini* (mudcloth) for centuries. *Bògòlanfini* is a handmade Malian cotton fabric traditionally dyed with fermented mud. In traditional Malian culture, *bògòlanfini* is worn by hunters, serving as camouflage, as ritual protection and as an identification of status (Imperato & Traoré, 2006). According to McNaughton (1979), women are wrapped by *bògòlanfini*

after their introduction into womanhood (which include female circumcision) and instantly after childbirth, as the cloth is believed to have the power to absorb the dangerous forces discharged under such conditions. According to Akrofi, Ocran, and Acquaye (2016), *bògòlanfini* patterns are geometric in nature (triangular, square zig-zag, precious stone and V-shapes) and rich in cultural importance, alluding to recorded occasions, (for example, a celebrated fight between a Malian warrior and the French), crocodiles (huge in Bambara mythology) or different items, mythological ideas or proverbs. Since around 1980, *Bògòlanfini* has turned into a symbol of Malian cultural identity (Kuren & Sierra, 2017).

Again, Oyange-Ngando (2018) stated that in East Africa, the Massai people of Kenya and Tanzania, are producers of a symbolic cloth worn by men known as the *shuka*. Traditionally, the most preferred colours by the Massai for the *shuka* are red and blue (Thompson & Cornet, 1981). The geometric designs visible on the *shuka* are rectangle and square. Fabric is normally woven on a loom, a device that holds the warp threads set up while filling threads are woven through them. According to Spear and Waller (1993), for Maasai, red is the primary colour and is viewed as sacred. They wear *shuka* which is red in colour to protect themselves against predators. It represents blood symbolizing bravery, solidarity, unity and the mind blowing challenges the Maasai confront every day (Mann & Spoerry, 1974). Blue, on the other hand, represents sky and embraces the Maasai belief in Nkai (God). According to history, the *shuka* cloth emerged when fabric that were used as means of payment during the slave trade, which landed in East Africa, were subjected to dying using black, blue and red natural dyes that were obtained from Madagascar. (Thompson & Cornet, 1981). However, these claims are not 100% authentic and scholarly proven. Thus, the origin of the Massai *shuka* cloth remains mystery and a much disputed topic.

2.3.4 Evidence of ethnomathematics in African basketry

African basketry is a dynamic art, modified by social changes and molded by both natural and economic factors. Traditionally, shapes and weaves were resolved to a great extent by the utilizations for what the bins were expected. Traditional fibers utilized in basketry include illala palm, sisal leaves and fiber, raffia (African bamboo), fibrous tree and plant roots, for example, makenge, vines, leaves (banana and fan palm), cane, bark wood and papyrus (Egash, 1999; Gerdes, 1990).

In East Africa, particularly Uganda, there are two kinds of vegetative fiber that are used to make coiled baskets, one for the inward coil and another for the wrapping of the coils. As observed by Lasage, Aerts, Mutiso and De Vries (2008), the baskets are woven from raffia or papyrus wrapped and sewed around a coil of banana leaf stems. Grass is regularly used for the core of the coils. A basket can be circular, oval, square or conical, now and again even multi chambered. Ndangalasi (2005) noted that it can have an open bowl, be a plate or a pannier, and demonstrate a foot, a cover, a handle or an extra appendage for hanging. The design of the basket is made by weaving with various colours.

Baranga (2007) further mentioned that dyes are obtained from natural sources like roots, barks, fruits, leaves, mud, dung or different combinations of the above (Ndangalasi, 2005). Patterning can be as ornamental bands or geometric shapes; lozenges, triangles, diamonds, star or flower shapes, zig-zags, swirls or chequer board motifs (Ndangalasi, Bitariho & Dovie, 2007). Before the real weaving can take place, the fiber must be readied which as indicated by the character of the twine which can be to a great degree an extensive process. This is especially so if there is a need for it to be colored and in addition made pliant. As a fiber, for example, sisal should be stripped, cleaned and spun by hand, a procedure which can take up to 16 hours for a medium size basket (Ndangalasi *et al.*, 2007). The baskets are used to carry maize from the fields.

Amongst the Tutsi people of Rwanda, basket related tasks are distributed according to gender. The responsibility of men is to build dwellings, fences, granaries and other large-scale fiber-based structures (Adekunle, 2007). Plants, for example, bamboo, grass, stick, reed, raffia, and banana leaves constituted the raw materials of most Tutsi fiber artifacts (Celis, 1970). To create the characteristic geometric patterns that graphically decorated these fibers, Tutsi basketry producers artfully adjust natural black and red pigments with the natural pale gold of the grass (Van Haute, 2008). Black dye was acquired from the dark sap from boiling banana flowers. The red dye is comparably separated from the root and seeds of the *urukamgi* plant. Be that as it may, works made after the 1930s frequently present a more extensive scope of colours from dyes procured through importation. Specialized tools are utilized for the making of basketry works. The more specialized tools included the iron lancet *uruhindu*, utilized for cutting and piercing; a small knife, *umshyo*; and *urwabya*, a small

stoneware vase containing water to keep the fibers moist as artefacts (Guo, 2006). The baskets are used for both a utilitarian function and aesthetic beauty.

The Tonga baskets are woven by the BaTonga women of Southern Africa, situated in the Southern Province of Zambia, and in the Binga District of Northern Zimbabwe who are renowned for their basket weaving (Nhemachena, Mano Muwanigwa & Mudombi, 2014; Mawere, 2016). The baskets have a distinctive design with a square base shaping the establishment of the basket. It takes roughly two weeks to finish a basket around 35 cm in diameter. According to Martens (2010), the baskets are produced using the *ilala* palm (*mapokwe* in Tonga), which, although developing freely, is additionally planted by BaTonga women with the end goal of basket making. This re-planting became standard practice in the late 1980s with the opening of the Tonga Craft Center and Binga Community Museum in Binga village of Zimbabwe – a centre financed by the Danish government, which exports thousands of baskets a year (Martens, 2010; Mawere, 2016). This craft center not just keeps the traditional crafts alive (bin making, drum-production, carving, pottery, and beadwork), however keeps the women who are involved alive.

The BaTonga live in a zone inclined to dry season and poverty, and the basket making enables the women to provide for their families. As of late, Tonga basket weavers made an intriguing arrangement of plane patterns (Chikozho, Mubaya, Mawere & Mudenda, 2015). Interestingly, these examples are not the consequence of changes in the weaving. The invention of the plane patterns responds nonetheless, to the intellectual, geometric and artistic pursuit of their creator(s), drawing in the natural attention of different mathematicians (Washburn & Crowe, 2017). Culturally, the baskets were (and still are) utilized for carrying maize or sorghum from the fields and afterward winnowing the grain.

The Batswana women of Botswana and South Africa have long standing history weaving baskets that display zig-zags, triangle and diamonds (Cassidy, Wilk, Kgathi, Bendsen, Ngwenya & Mosepele, 2011). Traditionally, the baskets are used by women to carry food items and other light objects. The baskets are made of the *mokolwane* palm which are cut and boiled in natural earth toned colorings. The shape of the baskets varies according to their function. Due to the slow and intricate work basket weaving requires, a large basket can take up to two weeks to complete (Omari, 2010).

A needle is the primary instrument used to complete the multifaceted weaving. The needle is fundamentally a honed piece of thick wire set in a wooden handle used to pierce a tight coil and insert and afterward wrap the palm in a fashion that results in stunning patterns unique amongst the Batswana (Kgomotso, 2011). Madigele (2016) highlighted that to get the different colours, the material harnessed from the palm trees is pounded and afterward soaked in a boiling solution of natural dyes taken from the bark and roots of different plants. For instance, reds are extracted from the bird plum (*Berchemia discolor*), browns extracted from the magic guarri (*Euclea divinorum*), purples from the indigo dye plant (*indigofera tinctoria* and *arrecta*) and yellows from the red star apple (*Diospyros lyciodes*).

The Batswana basket weavers utilize a strategy called coiling to make their baskets. The process influencing a coil basket can take several weeks before finishing. Basket weavers utilize a thick bundle of palm fiber, grass or vine to start the inner coil (Lenao & Basupi, 2016). The following stage is to penetrate a small hole into the coil and start wrapping strips of palm around the core of the basket (Kgomotso, 2011). This procedure is rehashed until the point when the basket achieves the desired size. They at that point make different designs by weaving strips of dyed palm into the basket pattern.

As noted by Nettleton (2010), in the Zulu culture, basket weaving is mainly a female craft taught by older women in a family to young girls, sometimes as young as age five and this is passed from one generation to another. Zulu women utilize all-natural materials, including palm leaves, to make the baskets (Chahine & Kinuthia, 2013). The results of grass and ilala palm weaving (such things as sleeping mats) and basketry are related with the widest possible range of activities through a Zulu's lifetime, touching virtually every domestic, social, and religious function.

These baskets are a confirmation of the expertise of the Zulu artists and their resourcefulness for utilizing indigenous plants (Chahine & Kinuthia, 2013). Traditionally, Zulu women weave their baskets utilizing age-old, respected techniques that are passed on from mother to child. The patterns, each with their own importance, change from decorative bands to intricate triangles, diamonds, zig-zags, and checkerboard motifs. Weida (2014) stated that the baskets are created by using grass and *Ilala* palm. The beautiful geometric examples frequently use in the various colours

are created by dyeing the Ilala palm with natural colours. The ochre colour is produced by utilizing *umqandande* fruit, black is created by utilizing *isiszimane* roots and lilac is made utilizing *umphekambedu* leaves (Wemegah, 2014). More recently, the diverse shades of brown are created by submerging tin cans into water and utilizing the rust coloured water to dye the Ilala palm fronds. Today, there is a palette of more than 20 colours accessible to weavers. The geometric designs and patterns utilized on the baskets are symbolic, for instance the diamond shape alludes to femininity, and the triangles imply masculinity and the zig-zag lines allude to the squadrons of war (Chahine & Kinuthia, 2013).

2.3.5 Evidence of Mathematical ideas among the beadwork of African cultures and colour symbolism

The utilization of beads in Africa can be followed back no less than 12,000 years (Waweru & Matheka, 2013). The oldest known beads have been found in the Kalahari Desert, Sudan and Libya. The earliest beads were made of eggshell, dirt, twigs, stones, ivory and bone. Glass beads were presented later by traders from Europe, India and the Middle East (Nyambura; Nyamache; Waweru & Matheka, 2013). Beads are utilized in different parts of Africa as adornment or works of art. In some African economies they previously served as currency (Xia, 2014; Pole, 2010; Nyambura, Campus, Nyamache & Nyabisi, 2012). As adornment, they are important in identifying and defending the status of an individual. This section of the study centers around ethnomathematics in beadwork by taking a gander at how Africans incorporated mathematics in their beadwork that has cultural significance (Hitchcock, 2012).

East Africa is known for its artistic beadwork. Beads are generally used to decorate the human body for different purposes such as representation of marital status, age and accomplishments. According to Thompson and Cornet (1981), this could also be seen in the colours and patterns. The beads are incorporated into clothing and hairstyles or used as accessories. The Maasai women of Tanzania and Kenya are responsible for beadwork in their culture which is worn by both genders (Thompson & Cornet, 1981). Their passion for beadwork can be seen in their daily lives as they adorn themselves with beadwork daily. Hodgson (2011) argued that some beadwork displays geometric patterns, and some as plain beads with no meaning. However, the Massai avoid symmetry in their beadwork and seem to feel an innate need to create

an equalization from various elements (Coast, 2001). Single rows of beads are strung from headbands and hung across the cheeks, attracting attention to the face (Bruner & Kirshenblatt-Gimblett, 1994).

The Maasai used natural materials such as clay, wood, bone, and copper to make their beads before they had contact with Europeans in the 19th century and it was then they were introduced to glass beads (Carey, 1986; Spear & Waller, 1993). Symbolism in the colour of the beads is based on existing Maasai beliefs about the natural world. As captured by Venkatasamy and Vadicherla (2016), colours symbolise the following: red: bravery, unity, blood, White: peace, purity, Health, Blue: energy, the sky, Orange: Hospitality, Yellow: hospitality, Green: health, land, Black: the people (Bignante, 2010). Symbolism can also be based on existing Maasai beliefs about the natural world remains valid today (D'amant, 2015). Blue represents sky and embraces the Maasai belief in *Nkai* (God). Green represents grass, a sacred element revered since it nourishes the cattle that play such a central role in the cycle of traditional Maasai and Samburu life. Red and white are the life-sustaining colors. Red represents the blood of the cattle, and white stands for their milk (Lazzari & Schlesier, 2011). The beads of the Maasai enabled them to spell out the essential beliefs and elements of life in the dress-code and personal adornment.

Alternatively, the Samburu people of North-central Kenya are closely related to the Maasai but also distinct from them. As noted by Simpson & Waweru (2012), the culture of the Samburu people is defined by their beadwork. The word Samburu means butterflies, and it was given to them by other tribes because layers of bead-covered jewelry, face painting and fascinating colourful dresses (Simpson & Waweru, 2012). Holtzman, Englund, Fratkin, Schlee and Spencer (2004) highlighted that beading plays an important role in the Samburu community. It used for identity, and beautification, and women always wear beads when attending events to symbolize their status in the community. Nyambura, Nyamache, Waweru and Matheka (2013) wrote that the status of women in the Samburu tribe is seen in the complexity of their accessories, the patterns involved and the sophistication of colours. For Fratkin (2011), the patterns in the Samburu beadwork, specifically the neck pieces include both symmetrical and fractal geometry. It is fascinating to see the combination of these designs in one artistic piece. Most groups will rather distinguish them for different purposes, but the Samburu women prefer the combination of both to express their culture (Fratkin, 2011). Beads

are also considered secret and they are used for different stages of life (at birth, initiation, marriage and death).

The common colours used in beadwork and textiles of the Samburu group are red: signifies danger, ferocity, bravery, strength, and unity; blue: represents the sky which also represents water for the cows. Green: is important because it represents the land which grows food for the cattle to eat (Labelle, 2005). Green also represents the health of the Samburu people. Yellow: suggests hospitality because it is the color of the animal skins on guest beds, White: represents purity because it represents milk which comes from a cow (Brantley & Casey, 2000). Cows are considered a pure and holy animal. Black: represents the color of the people, but more importantly the hardships we all go through in life (Nyambura, Nyamache, Waweru & Matheka, 2013).

In Southern Africa, there are the Nguni ethnic groups which consist of the Xhosa, Zulu, Ndebele and Swati people situated in South Africa who migrated from the large Bantu group. These ethnic groups have knowledge of geometry which is embedded in their arts and crafts. In the Xhosa culture, mathematics lies in the counting of beads to form certain shapes. Beadwork is used for traditional dresses and accessories (Putter, 2012). Girls are responsible for helping their mothers make articles, they also make articles for their boyfriends, their fathers, siblings and themselves. They were permitted to borrow and wear these pieces from time to time (Hamalwa, 2012). However, Nettleton (2013) argues that beading is a craft which is practiced by women to express their taste in art such as ornaments and clothes decoration. Girls who cannot bead are seen as incompetent and failures. The knowledge of beadwork has been passed from one generation to another, specifically from mothers to daughters (Mokoena, 2015). Since girls' bead for themselves, their boyfriend and help their mothers' bead for their fathers, they are able to become innovative and create ideas. Such ideas can be seen in the colour coding as these girls are very careful with how they place their beads and which patterns are created after the finished product (Van Wyk, 2003).

Before the introduction of glass beads the Xhosa made beads from natural materials, such as ostrich egg shell, which was chipped and ground to the approximate size, bored and polished before being strung (Van Wyk, 2003). Metal beads were also made since they are polished well and were durable. As beads took a long time to make,

they were scarce and highly valued. Other ornamentation consisted of animal teeth and horn. Bone, ivory, slats of sandalwood, tambotie and other woods, seeds and roots of plants as well as shells (Mokoena, 2015), were strung on fibre and animal sinews to make necklaces, bracelets, belts and anklets. Tufts of animal hair, pieces of animal skin, feathers and small horns were added for decoration. In addition to the above, grass ornaments, newly woven each season, were also worn. These original materials which were used as ornamentation did not disappear with the introduction of glass beads but were used together with beads (Boucher, Weeks & Putter: 2012).

Mkhwanazi (2013) mentioned that most beadwork is done in cold winter months when the workload is lighter, and the harvest is in. In the Xhosa culture, this is a good time for ceremonies such as weddings and initiation. Therefore, beadwork is seen in such ceremonies and people are allowed to compete on which beadwork is more sophisticated and beautiful. The patterns which are commonly used in the beadwork include chevron, circles, zig-zags, lozenges, triangles, V-shape and straight lines both vertical and horizontal to create meanings and messages (Rozani, 2013).

Colours in the Xhosa beadwork have cultural significance and meaning. White in Xhosa beadwork is associated with spiritual purity, red with royalty, yellow fertility and green new life. Both men and women are exposed to this beadwork (Rozani & Goduka, 2017). Traditionally, in Xhosa culture a person's social status and identity is communicated through their beadwork. Social meanings were established through the utilization of patterns and colour to mark a person's age, gender, marital status, social role and social rank (Boucher, Weeks & Putter, 2012).

The Zulu women who are responsible for cultural creativity in this ethnic group have a unique style of beadwork (Zungu, 2000). What makes Zulu beadwork unique is the code by which specific colours are chosen and consolidated in different approaches to creating messages that are woven into decorative geometrical designs and shapes (Xulu, 2002). Zulu beadwork with its colours frame an intricate system of communication which is given completely to the expression of thoughts, feelings and facts related to behaviour and relations between the genders. As observed by Marschall (2003), Zulu beadwork is outlined and produced solely by women, yet is worn by both genders and the beadwork worn by men is received from women.

In this way, beaded items can be utilized to encourage communication between unrelated men and women, which keeps them away from the distress of starting direct discussion on the sensitive subject of individual relations (Gatfield, 2014). Men usually wear beadwork to indicate the involvement with women they intend to marry. According to Xulu (2002), this implies that mothers, sisters and daughters do not give their sons, siblings or fathers beaded endowments, owing to the incestuous implications of such gifts. The language of Zulu beads is deceptively straightforward. It traditionally uses one fundamental geometric figure, the triangle, and investigations of the craft show that a maximum of seven colours is utilized (Zungu, 2000). To translate beadwork such as the Zulu love letter also known as *incwadi* which is a wrist beaded bangle that one must know how to interpret both with the geometric and colour symbolism. To the extent the geometric symbolism is concerned, the three corners of the triangle represent the father, mother and child (Govender, 2002).

As a fundamental unit of design, the triangle may be utilized inverted (apex pointing downward). Levinson and Levinson (1979) note that, this means the unfulfilled or unmarried man; or be situated with the apex pointing upwards, implying the unfulfilled or unmarried woman; or be joined with another triangle along the base to frame a diamond (or stylised egg, a widespread ripeness image) to represent the complete or married woman; or be joined to another triangle with apexes meeting in an hourglass shape, to symbolize the total or married man (Govender, 2002).

In the Zulu culture, there are colour meanings, although it must be understood that there are numerous subtle variations that frequently rely upon the specific shade of a given colour, or its mix with other colours (Ibid). Zungu (2000) argued that it should likewise be remembered that each colour has both positive and negative implications, depending upon the specific situation. Black indicates sadness, disappointments or loneliness. However, in a specific setting black can likewise symbolize marriage or convey reassurance. Blue, depending upon the shade, can symbolize the sky or the ocean; or even dedication.

In a negative setting, blue can symbolize hostility (Mthethwa, 1988). Green symbolizes grass and dairy cattle, or local happiness; however, it can also symbolize love, sickness and jealousy. Pink can signify a shy recommendation of poverty, particularly of inability to pay lobola (the bride-price paid to her parents from the soon to be

husband). It can, likewise, signify high birth or a vow/promise. Red symbolizes strong feelings and physical love, yet it can also mean blood, heartache, outrage or impatience (Schoeman, 1968; Mthethwa, 1988; Wickler & Seibt, 1995; Xulu, 2002; Biyela, 2013). White proposes virtue, otherworldly love and good fortunes. It has no negative implications. Yellow symbolizes riches and fertility. However, it can also mean estrangement and hate. The Zulu beads were made of materials ranging from the bones or the shell of an ostrich egg, to stones, seeds and metal. Due to colonization, the Zulu bead material changed to glass beads which are still used even today (Biyela, 2013).

2.3.6 Evidence of mathematical ideas in African rock and carved art

The rock art of East Africa (which includes Kenya, Tanzania, Uganda, Ethiopia and the horn of Africa) is very diverse and scattered with the richest concentrations of art occurring in central Tanzania. The earliest art was done by hunter-gatherers who were the only inhabitants up to around 5,000 years ago (Thompson & Cornet, 1981). Moreover, Whitley (2009, 2011) highlighted that the art itself is not homogenous but it consists of painting and carving. Southern Ethiopia contains a lot of engravings and carvings but a very few paintings. Examples of engravings include grave-markers (stelae) decorated with swords, faces, and geometric designs (Sauvet, Layton, Lenssen-Erz, Taçon & Włodarczyk, 2009). Whitley (2009) noted that the rich history of Kenya can be seen in the rock art which ranges from a thousand years. In western Kenya in the Suba District, Mfangano Island in Lake Victoria, there are two rock art painting sites Mawanga Cave and Kwitone shelter contain the red and white geometric symbols.

African artists always had the intelligence and skills of creating paints, preparing surfaces, making brushes and other tools, drawing, etching, carving, painting, and the sense of perspective and of movement, long before artists in other continents had developed those skills (Garfinkel, Austin, Earle & Williams, 2009). Whitley (2011) stated that for carving, granite stones and metal were used by blacksmiths for rock art. For painting, brushes were made from bird feathers stuck into thin reeds, or from animal hair. The lines of painting from both bird feathers and animal hair were distinguishable according to their thin and thickness (Sauvet *et al.*, 2009). Objects like sticks and soft elastic work were used to measure the engravings or paintings made

on rocks. The most common shades of paint that were used by Africans are red ochre pigment, yellow ochre, white paint from white clay or bird dropping, black from charcoal, manganese oxide or cow dung.

The discovery of an engraved ochre pieces shows that there are about 100 000 years old at Blombos Cave, Western Cape, South Africa shows that the Sothern Africans were the first to invent the concept of symbolic behavior, symbolic thought and symbolic logic (Zulu, 2015). Some archaeologists such as Watts (1999), McBrearty and Brooks (2000), Henshilwood (2005) and Henshilwood, d'Errico, Yates, Jacobs, Tribolo, Duller, Mercier, Sealy, Valladas, Watts and Wintle (2002) argue that 'symbolically mediated behaviour' emerged in Africa and link its origins with Homo sapiens (e.g., Watts, 1999, 2009; McBrearty & Brooks, 2000; Henshilwood *et al.*, 2002, Vanhaeren, d'Errico, Van Niekerk, Henshilwood, & Erasmus, 2013).

Powerful categories of evidence for symbolically mediated behaviour, variously described as 'modern' or 'cognitively modern' human behavior, are geometric or iconographic representations were discovered in the Blombos cave (Henshilwood, Marean, Chase, Davidson, Gamble, Holliday, Klein, Mc Brearty, Zilhão, 2003). Henshilwood, d'Errico and Watts (2009) contend that the engraved geometrical patterns on the ochres imply the presence of modern syntactical language, and that modern human behaviour must therefore have emerged much earlier. Geometric patterns on the ochre pieces incorporate cross-hatched designs, branching lines, parallel lines and right angles (Henshilwood, 2005).

In the 1970s during the excavations of Border Cave, a small piece of a baboon fibula known as Lebombo bone was discovered marked with 29 clearly characterized notches, and, at 37,000 years of age, it ranks with the oldest established mathematical objects known (Bangura, 2011). Apostolou, and Crumbley (2008) define the Lebombo bone as a bone tool made of a baboon fibula with chiseled markings found in the Lebombo Mountains situated between South Africa and Swaziland. It is guessed to have been utilized for tracking menstrual cycles, since it has 29 marks on it and it is still used by Bushmen clans in Namibia and it could also be used as a measuring stick by early Africans (Stray, 2007). Strannegård, Amirghasemi and Ulfsbäcker (2013) mentioned that this tool older than the Ishango bone of Congo which will be discussed shortly in this study. The utilization of baboon bones as mathematical devices has

been consistent in many African cultures, suggesting that Africans held the baboon as sacred and related creature with the moon, mathematics and time (Ion, 2013).

Alternatively, in the Congo, Ishango which is a dark brown length of bone, the fibula of a baboon, with a sharp piece of quartz affixed to one end, perhaps for engraving was discovered (Fauvel, & Gray, 1987). Pletser (2012) pointed out that Ishango bone was first thought to be a tally stick, as it has a series of what has been deciphered as tally marks carved in three columns running the length of the instrument. However, it has been recommended that the scratches may have been to make a better grip on the handle or for some other non- mathematical reason (Sy & Tinker, 2006). "The left column can be divided in 4 groups, with each group possessing 19, 17, 13, and 11 notches. The sum of these being 60. Those are the 4 successive prime numbers between 10 and 20. This constitutes a quad of prime numbers. The central column is divided in groups of 8. By an approximate count, one can find (in the parenthesis, is the maximum number): 7 (8), 5 (7), 5 (9), 10, 8 (14), 4 (6), 6, 3. The minimal sum is 48, while the maximal sum is 63. The right column is divided into 4 groups, where each group has 9, 19, 21, and 11 notches. The sum of these 4 numbers is 60" (African heritage, 2013:1).

Scientists have demonstrated that the groupings of notches on the bone are indicative of a mathematical understanding, which goes beyond ordinary counting (Pletser, 2012). In fact, most believe that the notches follow a mathematical succession. The notches have been translated as an ancient calculator, or a lunar calendar, or a prehistoric barcode (Yellen, 1998; Kellermeier, 2006).

2.3.7 The evidence of mathematics in African hairstyles and the cultural significance

Eglash (1999) conducted a study on African fractals. One of his discoveries is that Africans have been utilizing fractals to make beautiful and intricate hairstyles for a very long time, braiding iterations of the same form. Just like when influencing a fractal, braid designers repeat the same shape while moving, rotating, reflecting, and shrinking it. Among the Yoruba people of southwestern Nigeria, the head (called ori) is given an exceptionally position and especially in the females, the hair is thought to be the crown of women beauty.

Throughout the years, the rich cultural values of the Yoruba people have come up with different delightful and stunning hairstyles (Johnson, 2013). According to Bach (2002), these hairstyles are not only for beautification. They additionally serve different purposes, and these can be religious, as a symbol of identity, age, political power, ceremonies, occupation or even to reflect the mindset of a woman. It can also symbolise the marital status of a woman. Ipako Elede in the Yoruban language alludes to the occiput of a pig. In Ipako Elede, the styling begins from the back, but everything eventually ends at the front (Johnson, 2013).

When scaling the braids, the non-linear contours of the head are followed. There is a fundamental center model that the Onidiri (beautician) takes after repeating the units in a stunning form of fractal geometry. Onsesoo is the individual on whose head the style is being made. In addition, the head is believed to be the seat of the spirit, therefore the Onsesoo is forbidden to price the amount charged while the Onidiri is expected to avoid food while working (Otopame & Mexicana, 2005)

2.3.8 The mathematics embedded in African divination

As it was stated before, Eglash (1999) conducted a study on African fractals. In Chapter 7 under the heading on numerical systems, he delineated how divination priests of the Bamana individuals in Dakar, Senegal West Africa, calculate fortunes utilizing a recursively generated binary system. Eglash clarified that diviners utilize base-two arithmetic, much the same as the 1 and 0 in digital circuits and bring each output of the arithmetic technique back in as the following input. This creates a series of symbols that the priest at that point translates as the clients's fortune. This system is similar to a kind of irregular number generation in computing, Eglash stated, and the Bamana's procedure can deliver more than 65,000 numbers before the sequence repeats (ibid,1999).

Eglash (1999) in Chapter 7 further speaks of the Ifa divination system which started in West Africa, uses an arrangement of binary Mathematics to retrieve answers to life's inquiries and answers to life's problems. Ifa is a 256 robust binary system in light of 16 principal odu elements – every coefficient of original 8 odu markings takes binary states of zeros or ones; bringing about 16 principal odu elements (Abimbola, 2016). In Ifa divination, the coefficient 2 is geometrically fractalized into 256, which can additionally be fractalized to assemble more perplexing coefficients or sub-hierarchies

of Odu components (Clarke, 1939). The Odu elements of Ifa divination system speak to all activities and results in the universe, whose prime coefficients decide everything that exists or that could reverse engineer the creation accordingly. According to Abimbola (2016), with the Ifa priest (Babalawo) as a domain master, he is appointed with the interpretation of Ifa structure and patterns. Since one Odu needs to develop out of conceivable 256 Odu elements, the probability of having or showing one Odu is plainly $1/256$ (Tedlock, 2001).

According to Eglash (1997), computers utilizes byte or bit to represent data. Eight bits speaks to a byte and four bits represents a nibble. Like computers, Ifa has a device named opele, which is a divining chain comprising two arms made of 8 dots both on the left side and right side. Ifa literary corpus comprises of 256 conceivable outcomes called odu and each odu contains pointless stories called ese (Opeola, 1986). The binary number framed from the arrangement or combination of zeros and ones in computer science can be compared to an odu ifa in ifa divination. Along these lines, Computer Science takes its origin point from Ifa (Alamu & Aworinde, 2013)

2.4 The significance of women in African art and culture expression

As stated in Chapter 1, African endeavours are divided according to gender (cf.1.1.1). This has been a customary practice that has been followed and honoured for generations. Cultures in West Africa communicate with spiritual realms using sculptures, masks, and other artistic form. These articles are further used to manipulate, control accessible spirits. According to Ellis (2007), for many years, the role of women in cultural expression was ignored with the possible explanations that Western researchers had a mindset that cultural expression was a duty of men in return, so they relied on males as key informants to give details on cultural expression and thus were blind to the female sphere (Ellis, 2007).

Aronson (1991) argued that art objects such as pottery, basketry, and calabash decoration, frequently crafted by women, which were deemed to be of less value and hence disregarded. Women's specialties were additionally ignored on the grounds that they have a tendency to be less noticeable to outsiders than are men. According to Pelton (1980), women confine much of their activity, including their crafts, to the household arena, which is regularly separate from general public space of the

compound. Men's art, by contrast, are more public and, on account of masquerades, more sensational in their introduction and in this way more available for study than women's (Mirzoeff, 2014).

In contrast, Eglash (1999) argued that when it comes to cultural expression, women in Africa are the most preferred artists and are chosen by the gods to carry such artistic works because they are believed to be the voices of the gods, they represent purity, they are responsible for reproduction and bring fortunes. In North Africa, traditionally, symbols and signs are found in all artistic pieces such as pottery, textiles, jewelry, leather works, amulets and tattoos (Phillips, 1996). According to Steiner (1994), Alageria's Kabyle women are responsible for painting on pottery and upon the walls of their village homes. Many of their shapes and symbols have a resemblance of Neolithic pottery found in the region. They are believed to carry healing qualities or to embody magical attributes that protect from all evil, these signs and symbols assume new forms and meanings to the present art (Brand, 1998). By combining signs with stylizing traditional symbols, present artists tap the unconscious to create abstract work that combines the past and present (Kasfir, 1998; 2007).

In the ancient Egyptian civilization, there existed the concept of harmony and balance in all aspects of life (Emery, 1961). This ideal was exercised mostly by the Pharaoh who was a mediator between people and the gods. Egyptian art, architecture and religious practices exhibited a perfect symmetry of balance and such was seen in the gender roles throughout the history of ancient Egyptian civilization (Robins, 1993). According to Katz (2007), women in ancient Egypt were seen as equals of men in every area except occupations. The respect given to women in ancient Egypt is evident in every aspect of religious beliefs and social customs. The gods in Egypt were both male and female, and each had their own important roles and expertise (Aldred, 1984).

According to Reimer and Rossi (2016), women could be scribes and also priests usually of a cult with a feminine deity. For example, the priests of Isis were female and male. Women were believed to have powerful powers and were able to connect with the gods of after life (Busby, 1992). Artistic work was brought to them by locals in order to perform rituals or pray for any ceremony that involves spiritual purposes (Robins, 1993). Due to women being priests, they had authority to perform rituals or prayer for

the Pharaohs and connect to the gods of after life in order to accept the dead pharaohs and make them rulers in after life (Katz, 2007).

In Ivory Coast in West Africa, in the Senufo ethnic group, both men and women play their roles when it comes to artistic works (Richter, 1980). For every male art, a female partner exists. For instance, blacksmith's spouses are experts in ritual basketry while brasscasters' wives are potters (Glaze, 1986; 1993). There is concurrence of two separate yet complementary arenas of power, one controlled by men and the other by women, each practicing authority within various social domains. Perinbam (1980) stated that Poro, which is the men's sacred society, is in charge of keeping up social and political order, though Sandogo, a predominantly women's divination society, is more concerned with order and progression along kingship lines. Each got its capacity from higher powers, however controlling those powers through various categories of art. For instance, masks fall within the male area sculpture form is a female region (Perinbam, 1980).

Complementarity between the two power circles implied that men could work as diviners and women as members in Poro occasions (Aronson, 1982). Grossman and Bonnell (2009) added that women's interest derived from the Senufo belief that women possess clairvoyant powers empowering them to communicate best with the spirits. Due to these powers, they serve as spiritual advisors and even have a place with the Poro society itself (Tonkin, 2014). Also, their profound spiritual powers could give them command over the utilization of sculptures. According to Glaze (1993), Sande diviners (fundamentally women) are in charge of arranging Poro sculptures on the altar as dictated by the spirits with whom they are in communication with. Along these lines, while Senufo men carve the Poro-related sculpture, it is the women who comprehended its placement and subsequently how to expand its communicative potential. Likewise, representations of admired women upgraded the effectiveness of Poro sculpture. It tends to be inferred that the Senufo ethnic group perceives a female arena of power and art delivered by women as complements to those of men (Vlach, 1990).

Also, in West Africa, there are arts associated with women's initiation rituals which also include various kinds of body and facial coverings in perishable materials (Ogundipe-Leslie, 1994). The custom of face painting is ordinarily practiced in Sande and related women's initiation societies found throughout Liberia and Sierra Leone. As noted

before, Sande is the female counterpart of men's Poro, and, strikingly enough, both utilize the women's face-painting art during liminal stages in their initiation process (Phillips, 1978). They spread white clay in facet painting as an illustration for an unbaked pot, inferring some examination in its incomplete state to initiates who have yet to become adults (Aronson, 1991). In light of the fact that women make pots and work with clay, it is enticing to recommend that the initiates turn into the clay containers that women symbolically mold into grown-up beings, similarly, as they mold their offspring in real life (Reinhardt, 1979).

As a procedure, wooden masks are not featured in rituals done during women's initiation because their production tends to be under the control of men (Aronson, 1991). One exception is the wooden type utilized in Sande or Bundu (Bondo) initiation rituals among the Mende and neighboring ethnic groups specifically in Liberia and Sierra Leone (Kasfir, 1998). Phillips (2015) notes that, the Bundu wooden masked spirit (called Soweï or Sowò) dances in the presence of female initiates as a way of guiding and model during their bush education. In its youthful female form, its symbolic connections, and its graceful dance movements, the masked spirit represents the highest articulation of female balance, legitimacy, perfection, and power (Reinhardt, 1979). Nevertheless, it is such an inquisitive exception for women to utilize a male-carved wooden mask in their initiation that numerous researchers have tried to clarify it (Azeez, 2010). Hence, as indicated by the myth of the Gola people of Sierra Leone, wooden masking was at one time the privilege of women; men replicated it in order to make their Poro tradition with its own arrangement of masks, and now currently, both masking societies exist side by side (Stoller, 2005).

In Mali among the Bamana ethnic group, most female created initiation art falls within the classification of body expressions and covering (Sheldon, 2017). There are mud materials that young girls must wear to shield themselves from the spiritual powers (Nya) released after clitoral removal. By the goodness of the powerfully charged symbolism, derived mainly from value differentiates in the design, the cloth assimilates the spirit in order to keep it from dangerously returning a young girl's body during the healing critical period (Bjälkander; Bangura; Leigh; Berggren; Bergström & Almroth, 2012). In the meantime, it protects others from the potential sorcery associated with her unhealed wounds. This is one of the best researches made on women initiation that has a strong connection with the art they produce (Sheldon, 2017).

Berns's (1993) study of the Ga'anda in Nigeria deserves to be acknowledged. Berns (1993) clarifies that marriage, prearranged in Ga'anda society, is something Ga'anda women foresee and work towards in the early stages of childhood (Aronson, 1991). At the age of six, women apply scarification in a step by step process until they reach puberty stage. Each stage of the application is punctuated by endorsed rituals, for example, bride wealth payment (Rubin, 1998; Vaughan, 2007). Keefer (2013) observed that some of the designs symbolize essential stages in the young girl's development process. Keefer added that for instance, the first scar is placed close to her navel to highlight her childbearing potential. The full communicative effect of these markings is felt toward the end of years of agonizing and extensive ritual planning (Berns, 1993). In addition to the fact that they are material and considered aesthetically satisfying, yet they additionally, mark her identity as a grown-up woman with the majority of its social connotations in Ga'anda society (Squillante, 2012).

2.5 Taboos involved in cultural expression

A taboo in numerous cultures is an impression of religion herein essentially characterized as belief in, worship of or submission to a supernatural power or powers viewed as divine or to have control of human destiny (Baxter & Wilmot, 1985). In addition, taboos are expressive of anthropological proof about a society, and religion or belief system is one anthropological component which taboo uncovers. In most African literacy texts, a people's belief system is clear in their taboo, and adherence to, and prohibitions for transgressors of those taboos (Ayisi, 1992).

Some fascinating research on sexual division of work originates from studies of blacksmithing. According to Rasmussen (1995) blacksmiths work by a strict arrangement of tenets aimed at maintaining control of their process. In addition, these guidelines prevail with regards to keeping outsiders, including women, from learning the insights and secrets of their profession. Biological factors are utilized to build an ideological justification for this rejection. Herbert (1984) takes note of blacksmiths, who follow up on every single accessible power to guarantee safety in their profession taboo menstruating women with the fear that their cycle will contaminate the iron purifying process.

Aronson (1991) stated that the *Shai* potters of Ghana prohibited non-*Shai* women and all men from intervening in their profession, in an effort of being the only ones profiting

from that industry. They believe that anyone other than them who wants to enter their protection will experience the rage from gods which causes incurable diseases (Tandoh, Bredwa-Mensah, Dampare, Akaho, and Nyarko, 2009). Also, *Ikombe Kisi* potters of Tanzania which are women claim sole ownership of pot production and have complex taboos such as death and madness to those who are outsiders, trying to capitalize on them (Waane, 1976).

The Baoulé, the Senoufo and the Dan peoples have skills of carving and each culture produces different types of wooden masks. The masks of the people of Ivory Coast represent animals in caricature, depict deities and souls of the departed. The masks are believed to hold great spiritual powers which can badly harm anyone other than specially trained persons who attempt to wear or possess them (Xia, 2014; Pole, 2010; Nyambura, Campus, Nyamache & Nyabisi, 2012).

Ileke is a bead of the Yoruba people used for the *yeye osun* which is sacred and can also be used and worn as other beads by chiefs (Raji & Ajadi, 2013). However, Ibigbami (1993) highlighted that Kings are forbidden to wear *Ileke* when they have sexual intercourse with their wives. It is believed that such an act can bring them bad luck and scattering of the kingdom. Also, the oba crowns are equally secret and which the reigning *Ooni*/king is not allowed to wear one for more than two hours. History indicates that the reigning *Ooni* is forbidden to look inside the crown as that can result in him dying and joining his ancestors (Thompson, 1970).

2.6 Attempts by early scholars in documenting the Ndebele culture

To the best of the researcher's knowledge, there were no works done on the concept of ethnomathematics during the period the present researcher reviewed literature for this study. Therefore, for this study, the reviews/ gaps are established from the scholars who investigated Ndebele culture.

2.6.1 Researchers from the 1900s to present who conducted studies on the Ndebele culture

Van Warmelo (1930), the government ethnologist of the Union of South Africa, is one of the early scholars who wrote about the Ndebele people. Such was done in a publication which appeared in 1930 entitled "*Transvaal Ndebele Texts*". This study

was important based on the following reasons: Firstly, the main structure was based on the findings of Van Warmelo while working with the Manala Ndebele group. Secondly, it included the translation of the Ndebele vernacular texts recorded by participants in the field. Thirdly, it is one of the first ethnographies that captured the Ndebele people and their culture. This work includes photographs that captured mainly women in their traditional attire. Van Warmelo has done in-depth research about Ndebele people that can be referenced from where he continually described the Ndebele as an artistic people. In his work, he broadly explains the Ndebele beadwork and mural art.

Although the Ndebele beadwork and mural art are often mentioned in his work, the scholar has failed to highlight important aspects on the Ndebele beadwork and mural art. Firstly, the scholar failed to research deeply about what gave birth to the Ndebele beadwork and mural art which is known today. Secondly, the scholar failed to research deeply on the importance and meaning of colour in the Ndebele beadwork and mural art. Lastly, his study lacks discussions on the levels of knowledge transmission and the role women play in transmitting the knowledge to other women. It is such short comings that the researcher of this current study hopes to address.

Walton (1956) published a book entitled "*African Village*", which recorded years of work in the field conducted by his wife, art historian and archeologist. During the 1940s and '50s, Walton researched and published parts of African Village, a study which focused on construction of structures and organization of Native "huts". He used both the archeological and arthistorical approach, and was derived from broad work in the field, where he took measurements of sites. This work includes Ndebele mural art, where it was classified as wall panel decoration. The work of Walton also includes photographs he took from the field where women were constructing the walls before painting which he referred to as "*lelapa*" walls (Fig.5). In one of the photographs, there is a woman standing by a wall, looking downwards with her hair shaved in distinctive geometric pattern, with small tufts of curly hair. She is wearing beaded hoops around her waist and three large beaded bracelets, each with a different colour. Boyd (2017) who examined this work compared the colours in the beadwork of the women in one photograph to that which was taken by Van Warmelo in 1928 and observed the changing of style and colour in beadwork. The findings of the scholar indicate that Ndebele women in a photograph by Van Warmelo (1928) preferred solid white beads

whereas the photograph taken by Walton in 1956 shows Ndebele women wearing beadwork that reflect multi-colours. Therefore, this shows that over a period, Ndebele women shifted from utilizing one colour (white) to preferring multi-colours in beadwork.

However, there is a misleading word used by Walton, which cannot be ignored. The word is "*lelapa*," which does not exist in the Ndebele language. What the historian wanted to refer to is *iboda langekhaya* which in English means the home walls. The word *lelapa* is Sotho word for home or family. It is such misinterpretations that misleads other scholars interested in similar field. It is for this reason that Ndebele people have to conduct a study about their own culture to correct previous errors that were made by other scholars which are non-Ndebele.

Meiring (1955) wrote an article on the Ndebele history. In the article, the scholar has used a Eurocentric perspective regarding the war the Ndzundza Ndebele lost to the Dutch speaking Boers. In his article, he refers to the 1849-1883 Mapoch war as a minor episode the Ndebele encountered in their history. His version of the outcomes after the war are simplistic and lack content. What he only highlights is that the Ndebele became the labourers of the white farmers after they lost the war, ignoring how the war transformed the culture of the Ndebele people. It is such gaps this researcher hopes to address by conducting a study with the Ndebele people, using research methodologies that accommodate indigenous people which will be discussed in chapter three.

The earliest research on the Ndebele relates to the Manala group more than the Ndzundza group. Van Warmelo (1937) observed that "the Southern group (of the Ndebele) today comprises of a single senior tribe, the Manala, and a junior tribe, the Ndzundza ..." (p. 53). However, Van Warmelo (1937) does not provide enough evidence of such claims. The fact that early researchers focus mostly on Manala Ndebele, does not necessary mean that they were the only group who had expertise in beadwork. It should be noted that the Manala settlements were situated in a place called Wallmansthal which is closer to Pretoria and the convenience of looking at a group living close to an urban area may have partly determined the direction of early studies.

On the other hand, in support of the Manala Ndebele group and its dominance, Weiss (1963), in her dissertation, claimed that the beadwork did originate with this group

(1963:43). Her information appears to have been based on comments by informants in the field, although she does not provide specific details, nor could her informants say precisely when the beadwork was first produced” (1963:43). Since the Manala group were situated close to Pretoria, it is possible that some of the beadwork did develop from this group because their geographical location at that time placed them closer to trade routes and urban white settlements in the 19th century. However, beads would have been obtained throughout the Transvaal from trading stores, which means the Ndzundza already had access to beads by the 1920s and 1930s, and probably even earlier.

However, it is not easy to identify the extent to which Manala and Ndzundza beadwork may have differed, if at all. It should be highlighted that oral history suggests that the Ndzundza were the earliest people to have access to beads that in a short period displayed geometric designs which influenced their wall painting after the Mapoch (Mabhogo) war with the Dutch speaking Boers in the 19th century. The lack of documentation makes it difficult to determine when the Ndzundza began making beadwork but history fully supports that the Ndzundza are the masters of geometric art amongst the Ndebele. Explaining the history of these groups is not part of the scope of this study. However, to make the reader understand and to correct previous studies, mathematical concepts and ideas in the Ndebele culture belong to the Ndzundza Ndebele group.

Becker (1979) is a linguistic and historian who traveled across South Africa and documented all what he has encountered with the South African indigenous people in a book published in 1979 entitled “*Inland Tribes of Southern Africa*” a fieldwork-meets-coffee-table-book. In his discussion of the Ndebele, Becker also focused on their beadwork and wrote “the Ndebele woman’s passion for personal adornment and her skill in bead craft are rivalled in southern Africa only by her Zulu and Xhosa counterparts. However, nowhere south of the Zambezi river is there a larger range of ornaments worn by women than among the Manala, and indeed the Ndzundza sections of this tiny and somewhat scattered tribal group” (Becker, 1979:75).

In the above paragraph, the scholar acknowledges the Ndebele women on their beadwork. Furthermore, Becker (1979) discusses the important beads worn by women all over the body. However, in his study, he does not give a holistic perspective on

how beadwork is interlinked with spirituality, communication and symbolism. He also does not discuss the mathematics (geometry) in the Ndebele beadwork and what could have possibly influenced it.

The book shows a photograph of a Ndzundza village known as KwaMsiza which was named after King Msiza II. Becker mistakenly notes that the Manala group are the genuine mural painters. His arguments are based on the arguments that he met King Msiza wearing European clothing. Furthermore, he took a photograph of Msiza wearing an attire for traditional herbalists and included just that image in his work, overlooking taking photographs of other people, primarily women who are constantly wearing their beaded attire. The photograph of King Msiza in his attire, which is the only one in his book according to Becker (1979) offers an image of Ndebele villages as being divorced from developments in the rest of urban South Africa.

However, Becker must be acknowledged for his contribution on the Ndebele colours. He mentioned the importance of colour in the Ndebele beadwork. He actually discovered that colours have meaning such that women are not free to use any colours but must use colours that the gods (abezimu) instructed them to use.

Levinsohn (1984) conducted a study about the fading cultures in Africa. She wrote specifically about the dying art and of the ongoing 'acculturated' arts. However, according to Levinsohn, the two form separate categories and such can be seen when she wrote that "their cultural and value traditions in flux, (tribal artists) incorporate this dynamic (of acculturation) within their artistic expression, creating a visual panoply intriguing in its history at the same time that its evolution endangers the traditions themselves" (:p. 135).

On the Ndebele beadwork and mural art in particular, the scholar wrote that "both forms possess significant cultural, ceremonial and decorative aspects that are now changing at a pace that endangers their continued existence" (1984:113). Nevertheless, such statements made by Levinsohn are incorrect, as the changing of culture does not specifically mean it will fade but means that it can develop, survive and grow. According to Spencer-Oatey (2008), culture is not static, but that it is dynamic and complex. Culture is fluid which means it is forever changing and developing. The Ndebele culture over the years has changed based on the environment and other external factors such as losing the war to the Dutch speaking

Boars. Ndebele beadwork and mural art had undergone periods of changes. These periods will be fully discussed in Chapter 4. However, it is crucial to highlight that the Ndebele culture has been attracting scholars in the past few years based on its continues changes as compared to the 19th century.

Commenting on Levinsohn (1984), Kloppe and Nettleton (1988:39) pointed out that “no real understanding of the dynamics of time depth informs her discussion of arts ‘in transition’. In order to study arts ‘in transition’, one must assume that they are changing in relation to what they used to be. Now this in itself makes or follows a common, but clearly erroneous, assumption in African Art studies, and that is that traditional societies are stagnant, synchronic in their perception of time and not ever in ‘transition’ until they clash with Western culture. Virtually all recent studies reject this notion altogether, yet Levinsohn does not even appear to have considered these issues”

Levinsohn further discussed the changes in the style of the beads. Her consideration can be identified as underdeveloped and misleading. The scholar has contradicted herself on several occasions where firstly she claims that “white beads predominate in the complete bridal costume” (1984:117) implying that this has always been the case. Secondly, she contradicts her first statement by stating that “designs vary as the older examples seem to be predominantly white and less patterned than those of more recent creations” (1984:120). Furthermore, she argues in a simple manner that “Westernization’s effects are evident in newer designs which are geometric, often three-dimensional in effect, and include triangles, rectangles, parallelograms, diamonds, arcs and wavy lines, and may include alphabetic lettering which the people absorb from vehicle number plates or architectural studies” (Ibid). From what the scholar has stated, there is a confusion in her work, and on how and when the change in style of Ndebele beadwork commenced.

Also, there are misinterpretations and errors in her work. For example, the caption for her Fig. 89 (1984:114) is inaccurate. The scholar identifies the “long strips” of beadwork which is worn to hang down the sides of the women’s faces and symbolize tears as *siyaya*, when in fact they are called *umlingakobe*. This error can be seen again in another text (1984:116). The same word ‘*siyaya*’ that the scholar used was repeated again as a wedding veil which was for the first time utilized correctly (1984:120).

However, it should be highlighted that the term *siyaya* used by the scholar is incorrect and does not exist in the Ndebele language. Instead, Levinsohn (1984) was supposed to use the term *Isiyaya* which is part of the Ndebele vocabulary. In Levinsohn (1984) study, miss writing continuously occur and some can be identified on pages such as (1984:114-116). Such errors can mislead other scholars who are interested in studying the Ndebele art and degrades the culture of AmaNdebele.

Schneider (1986) wrote a PhD thesis entitled “*Paint Pride and Politics: Aesthetic and Meaning in Transvaal Ndebele Wall Art*”. This is work based on field work conducted between 1976 and 1978, also, on follow-up trips somewhere in the range of 1979 and 1984 (Schneider, 1986: 12). In the book, Schneider makes a historical range to show that Ndebele art arises from traumatic experiences the people encountered. To this impact, she led surveys alongside a tasteful qualities test, and a statistical analysis of linguistic terms for colour depiction in IsiNdebele. Her work is intensive, and she touches base at the sound end that Ndebele art is a dynamic ethnic art.

She further looked at the errors made by *Becker's Inland Tribes of Southern Africa* (mentioned above). In her discussion, she identified that Becker was mistaken when he claimed that the Manala Ndebele are the true custodians of mural art. To back her arguments, she provided a history of the Ndzundza Ndebele, drawing examples from the KwaMsiza settlements. In the 20th century, Schneider's work is one of the least PhD-level work that has been conducted about the mural art of the Ndzundza Ndebele. This work was researched and written at the same time as Courtney-Clarke's (1986) photo book with the title “*Ndebele: the art of an African Tribe*”, which includes photos, taken by Schneider, of some of the same homesteads that Courtney-Clarke visited.

In 1990, Levy completed her master's degree thesis entitled: *Continuities and Changes in Ndebele Beadworks*, c. 1883 to the Present. Her work is based on the reviews of the literature of the AmaNdebele, making examples from Fourie, Kuper, Weiss, Warmelo, and Meiring, amongst others. Levy argues that researchers need to use photographic material to support their arguments of changes and continuities within the Ndebele beadwork. Her research is crucial because she looks at the photographic project of Courtney-Clarke (1986) and it is reviewed throughout the first chapter of her work (Levy, 1990: 38). She has made fruitful statements relating to the art market for native arts in South Africa which she has observed as well as her

criticism of Becker's *Ndebele: Art of an African Tribe* which is valid. The observations of Levy on the art market for indigenous arts in South Africa are critical, a topic she treats broadly in the third chapter (Levy, 1990:96-125). Levy has made key observations about the art market and argued that white gallery owners exploit the craft made by native African women.

Just like many scholars who did not pay attention to the miss writing of terms, her work shows an error where she writes that "when a young girl reaches puberty, she wears an *isiphephetu* (Figs.5, 6, 31), which announces that she is of marriageable" age (1990:47). The word "*isiphephethu*" does not exist in the Ndebele vocabulary. The item referred to above is known as (*iphephethu*) in IsiNdebele. Another miss-writing she has made is seen where she writes that "The *umnyanyo* is the ritual for girls, which, unlike the boys' *wela*, is not collective but takes place within each girl's individual home" (1990:47). The term *umnyanyo* is not a Ndebele word. Analyzing what she explained in the sentence where she mentioned the term *umnayanyo*, the term correctly written is *umnyanya* which can refer to a Ndebele ritual ceremony. Such errors provide enough evidence that Levy did not see a need to make a follow up on her study in order to seek assurance that she used the correct Ndebele terms to back her findings and arguments.

Another miss writing of terms was found in the journal article of an Anthropologist and Archaeologist, Van Vuuren (2012) entitled "*Iconic bodies: Ndebele women in ritual context*". In this article, Van Vuuren has provided a table (Figure 9) which is for female age categories and dress codes. In this table, there is a blog for category terminology in IsiNdebele where the scholar wrote all the Ndebele terms. In this blog, Van Vuuren (2012) wrote the following words which are all misspelled; *umdranyana*, *Umdazana*, *umalokzana* and *umakhohthi*. The terms stated by Van Vuuren (2012) are non existant in the Ndebele terminology/language. The correct terms that the scholar was supposed to use are *umndrazanyana*, *umndrazana*, *umalukazana* and *umakoti*. Such mistakes discredit the Ndebele culture and show disrespect of the scholar towards the Ndebele language as a whole.

According to Mashiyane (2006), when it comes to academia, there are research findings which are considered as shortcomings of which most can be caused by language barrier. In addition, most indigenous languages are not used in academia

and often transcribed and translated to a suitable academic language. This has been supported by Powell, (1995: 9) as part of the preface to his book when he stated that “... the commonly used words are often not the academically sanctioned ones; in many cases they have been transcribed in the first instance by non-Ndebele-speaking researchers, and differ substantially from those sanctioned by the language expert”. It is then important for the non-Ndebele scholars to get assistance from Ndebele art custodians to assist with interpretations, pronunciations and spellings before they publish or submit their work for consideration for publication.

However, Powell (1995) contradicted what he suggested. In his book entitled “*Ndebele: A people and their art*” referring to what he calls “lirhabi” wrote that “This apron of beaded tassels may be worn by both boys and girls” (Powell, 1995: 127). He did not do justice in his research on the aspect of Ndebele attire and gender. He referred to what is called “*irhabi*” as an apron of beaded tassels that may be worn by both girls and boys. Gender in Ndebele is a very serious matter and it is an inconceivable thought that boys could be dressed as girls. Such would be an insult not only to the child but to the entire Ndebele nation. The “irhabi” is strictly for young women’ toddlers only. Boys wear both on the front part and back part some triangular skin patches.

Powell (1995) continued to discuss Ndebele beads and mural art in his book. He had a section where he discussed the periods of beads from the time the Europeans were in the midst of the AmaNdebele. According to Powell (1995), it was during this time when the Ndebele started producing beadwork on a larger scale. In this chapter/section, Powell described the periods of Ndebele beads and how they have developed. The scholar then estimated the origin of Ndebele beads which have been in the late 19th century (1883) when the Ndzundza Ndebele group was defeated by the Dutch speaking Boers at the Mabhoko caves (mispronounced by whites as Mapoch’s caves). According to Powell (1995), there is a high possibility for the Ndebele beadwork to have existed earlier than 1883 since the Ndebele originated from a larger group of the Bantu people.

Furthemore, Powell described how each period was characterised by its own dominant colour and style. This work is similar to that of Mashiyane (2006) where he described the different periods of AmaNdebele as marked by colours (p.102-111). Powell’s

colourful pictures accompany his discussion in order to make his view point. In his discussion, he highlighted that the 1950s period, was followed closely by what he calls the “contemporary beading party style”, which are the present-day plastic substitutes of the original Ndebele attire. Powell (1995) must be acknowledged for his analysis on Ndebele beadwork. However, it cannot be ignored that his descriptions on Ndebele beadwork worn by women is brief and does not give in-depth information for those who are not familiar with the Ndebele culture.

Josey (2004) submitted her PhD thesis entitled “*The Ndebele of South Africa and their Intellectual Property Rights*”. Josey draws her philosophical and dissident position from the work crafted by Walter Rodney and his economic theories of the deliberate underdevelopment of Africa by Europeans. She conducted her primary interviews with Dr. Esther Mahlangu in Maryland on the occasion of an exhibition in Washington D.C. and conducted an additional interview at her home in South Africa. However, the empirical data of her study depends on limited fieldwork. Josey must be applauded for her attempts in connecting the Native American intellectual property law and the protection of the indigenous knowledge of the Ndebele. Nevertheless, her work only depends on the interviews she conducted with Dr. Mahlangu. She did not make attempts to find more participants to validate her data. Rather, she made conclusions based on the interviews she conducted with only one participant.

Josey claims that Dr. Esther Mahlangu was approached by an unnamed French party to not only buy artwork from her but to buy the rights to reproduce all of her work. She claims that the artists agreed to the unfavourable terms because she was vulnerable, had no personnel to represent her and she had financial needs. Her thesis does not show any compassion to Esther or proper research on issues regarding intellectual property in South Africa. Instead, as an American scholar, she has centered her discussions on what Americans encounter and the intellectual property law of America. She has not taken any steps to investigate the South African intellectual property, making her thesis unreliable and showing degrading treatment to Dr. Esther Mahlangu. Moreover, the work proves an absence of meticulousness with respect to ethnographic details and historical context. Her recommendations to Ndebele women and their representatives to regain control over their intellectual property rights show up withdrawn from on-the-ground realities in South Africa. The author appears to cite

too few concrete instances of exploitation of Ndebele intellectual property rights to support her arguments, the directives in the study appear to be excessively general.

Mashiyane (2006) conducted a PhD study with a topic entitled “*Beadwork - its Cultural and Linguistic Significance among the South African Ndebele People*”. In his study, Chapter 4 is dedicated to the Ndebele designs, shapes and colours. He gives full details on the period of beadwork, the dominant colours on the beadwork and designs. With the in-depth information he has provided, Mashiyane (2006) has however failed to identify the meaning of the Ndebele shapes and their possible origin. Even though scholars like Schneider (1985) and Levy (1990) argue that the recent Ndebele designs/shapes have been highly influenced by modernization, it was necessary for Mashiyane to investigate the meaning of shapes found in beadwork and mural art. In Chapter 3 of the very same study, Mashiyane (2006) does an outstanding work where he fully discusses the preparation and processing of beadwork ornaments where he acknowledges Ndebele women as mathematicians who have shared their skills from one generation to another.

Mashiyane (2006) also touched on the aspect of gender in bead handling. While discussing gender aspects, Mashiyane (2006) wrote that “the next remarkable stage in the life of a Ndebele female is when she enters her teens. The point of demarcation is when the young lady observes her menstrual period for the first time known in Ndebele as *ukuthomba*. To mark her coming of age, the young lady’s parents organize a big ritualistic event for her called *iqude*. The way this ceremony is organized may differ from one region to another and also whether the family is of royal origin or of a commoner” (Mashiyane, 2006: 54-55). *Ukuthomba* in the Ndebele culture is a secret ritual for girls that lasts a couple of weeks, then shortly followed by *iqude* which is a ritual ceremony that is followed by the *umhlubulo* ceremony where a girl makes a public appearance for the first time as an initiate. However, Mashiyane contradicts himself and disagrees that the secret rituals and religion have never been a part of the Ndebele art. Even though it is sacred knowledge of what young girls wear in the process of *ukuthomba*, during *umhlubulo*, she wears her beaded attire which shows that she has arrived at the next stage of her life. The levels of this process indicate that secret rituals are interlinked with the beadwork.

Otherwise, Mashiyane (2006) should be applauded for his contribution regarding Ndebele beadwork. In Chapter 5, which focuses on eco- socio and cultural values of beads, he provides detailed discussions on how Ndebele women survive because of their beadwork. Similar information has been provided by Levy (1990) who wrote that "...the beadwork has always been a dynamic art form, with developments taking place over the years within, and for, the group itself. At the same time, the commercial demand for Ndebele beadwork is not new, as women have been selling their art to a 'tourist' public since at least the 1950s, if not earlier. Over the last few years, the market has expanded considerably..." (Levy, 1990:97).

Still on Mashiyane's work, the scholar did not venture into trying to explain the role of mathematical ideas and concepts in the cultural life of AmaNdebele women. Rather, he wrote a sweeping statement which stated that "The geometric shapes themselves play a very important role of expressing ideas and feelings of the Ndebele nation as a whole" (Mashiyane, 2006:120). Such statements lack context and need to be further elaborated in order for scholars interested in Ndebele beadwork to understand and have full insights. However, in the 21st century, Mashiyane's work is so far the best for this study. In-depth, his study has looked at mathematical ideas and concepts applied by women in making beaded artefacts and therefore he should be acknowledged for his contributions.

Concluding remarks

This chapter has provided evidence that African people have always used mathematical ideas and concepts as part of their cultures. The studies that were reviewed in this chapter on Ndebele culture did not give details on Ndebele ethnomathematics. Even though some have mentioned that geometry is embedded in Ndebele art, most studies only provided 'sweeping' statements on mathematical ideas and concepts in the Ndebele art. The role of women in Ndebele art was acknowledged in most studies reviewed in this chapter. However, the process of which the indigenous knowledge of Ndebele art is transmitted and preserved was overlooked. Other studies reviewed showed that researchers misinterpret concepts and other important Ndebele cultural aspects. After establishing these gaps, the next chapter presents the African philosophical underpinnings of this study.

CHAPTER 3: AFRICAN INDIGENOUS PHILOSOPHICAL UNDERPINNINGS OF THE STUDY

3.1 Introduction

For a considerable length of time, Western knowledge has been broadly scattered from the point of creation to different places and different occasions. The process of colonization with its political and ideological triumph was instrumental in not just impelling Western knowledge on both worldwide and temporal scales, but also in preventing the dissemination of other different knowledges (Khupe, 2014). Knowledge is something everybody has (Studley, 1998), thus the depiction of knowledge and philosophies as, for example, 'indigenous African' (Higgs, 2008). Higgs mentions the distinctions in strategies among African and Western philosophy, which he clarifies results from the Western quest for philosophical discourse for the wellbeing of its own, instead of African philosophy that is utilized to address specific social issues. Van Eijck and Roth (2007) share comparative perspectives and propose the thought of the degree to which knowledge is valuable to a community, as a more reliable measure of its legitimacy. Pertinence and usefulness are the main considerations in the non-Western philosophical discourse where utility is at the fore in knowledge formation (Khupe, 2014).

This study is underpinned by African indigenous philosophies based on the reasons that African cultures have unique philosophical beliefs and values which constitute the way of living and doing. Using indigenous methodologies in research by indigenous scholars protects and advance the knowledge of indigenous people from being misrepresented, fragmented, mystification, commodification, and simplification (DeLoria, 1995; Sue & Sue, 1990; Grenier, 1998; Mihesuah, 1998; Nakata, 1998; Bishop, 1999; Smith, 2000; Fixico, 2003; Mawere, 2014; 2015). Indigenous research methodologies are necessary to reframe, rename and reclaim the research processes so that indigenous people have control of what they see as cultural identities, emancipate the voices that have been hidden in the shadows, and recognize Indigenous realities (Steinhauer, 2002).

This section of the study provides discussions on indigenous philosophies by other indigenous scholars in order to justify the importance of underpinning this study on indigenous philosophies.

3.2 Indigenous philosophical underpinnings of the study

This study is underpinned by indigenous African worldviews, indigenous research methodologies and South African policies that promote indigenous knowledge systems (The IKS Policy of 2004; The Arts and Culture policy of 2002; National Language Policy of 2003 and the IKS Bill of 2016). The conceptual framework, theories that guided this research, study area and overview of Mpumalanga Province are also presented in this chapter.

3.2.1 African indigenous worldviews

There appears to be many scholars who have different views on indigenous worldviews (Fitznor, 1998; Gill, 2002; Rice, 2005). McKenzie and Morrisette (2003) clarified that indigenous worldviews developed because of the relationships people have with the environment, the cosmos, the living and non-living. They identified six metaphysical beliefs of indigenous peoples that have formed this relationship:

All things exist according to the principle of survival; the act of survival pulses with the natural energy and cycles of the earth; this energy is part of some grand design; all things have a role to perform to ensure balance and harmony and the overall well-being of life; all things are an extension of the grand design, and, as such, contain the same essence as the source from which it flows; and this essence is understood as spirit, which links all things to each other and to Creation. (McKenzie & Morrisette, 2003:259)

Seven principles of indigenous worldviews have been outlined by Simpson (2000). For Simpson, firstly, knowledge is a holistic, cyclic, and relies upon the relationships and connections with living and non-living beings and entities. Secondly, there are numerous truths, and these truths are reliant upon individual encounters. Thirdly, everything is alive. Fourthly, everything is equivalent. Fifth, the land is sacred. Sixth, the connection among individuals and the spiritual world is vital. Seventh, people are least critical in the world.

It is obvious to the researcher that these and other different discussions on indigenous worldviews feature a solid focus on individuals and entities coming together and support each other in their relationships. This has been described as a relational worldview (Graham, 2002). The main emphasis of relational worldview is spirituality, communalism and deferential individualism. Weaver (2001) notes that communalism is when a community is connected by familial relations and the families' commitment to it. Respectful individualism is when an individual is in a place where s/he enjoys extraordinary freedom in self-articulation since it is perceived by the society that individuals take into account and act on the necessities of the community instead of acting on self-interest alone (Gross, 2003). Interestingly, relational worldview is one major aspect that makes up indigenous people's knowledge.

The African notion of Ubuntu communicates this well, and Mbiti's (1969:141) articulation, "I am because we are; and since we are, therefore I am", is a befitting depiction of this connection between the individual and the rest of the community in an African setting. According to Ubuntu, the individual is seen essentially in relation to other people. Therefore, Ubuntu is the "wellspring from which activities and dispositions stream" (Kamwangamalu, 1999:27). The accentuation on relationships and association in the African setting does not end at a social dimension but rather reaches out to the physical and spiritual realms (Odora-Hoppers, 2005). Thus, Tutu (1999) defined this connection and relationship, as "I am a human being because I belong."

In Africa, philosophy is embedded in Ubuntu which is a term utilized to express 'humanness' or 'being human'. Mdluli (1987) certifies the critical understanding that identity emerges out of intersubjective interactions between people, setting accentuation on relationships and advancement of the benefit of society (Venter, 2004). Ubuntu is "...a philosophy that sees human needs, interests and dignity as of fundamental importance and concern" (Higgs, 2008:452). In research, Ubuntu guides scholars to be considerate of the the welfare of others, shown through among others, respect, communalism, consideration, liberality, trustworthiness, generosity thinking about others, and participation for the benefit of everyone (Hamminga, 2005). This will result in building strong relationships with indigenous communities. Ubuntu is an imperative part of the African worldview (Venter, 2004). It underscores collective

solidarity, empowering the understanding of the self primarily in connection to other people, not as 'autonomous' of others (Kamwangamalu, 1999).

3.2.2 Indigenous research methodologies

Indigenous methodologies are elective ways of thinking about the research processes (Akan, 1992; Cajete, 1994, 2000; Crazy Bull, 1997; Abdullah & Stringer, 1997; Bishop, 1999; Semali & Kincheloe, 1999; Smith, 2000; Steinhauer, 2002; Atleo, 2004; Stewart-Harawira, 2005; Hodge & Lester, 2006). They are liquid and dynamic approaches that emphasize circular and cyclical perspectives (Louis, 2007). Their principle aim is to guarantee that research on indigenous issues is refined in a more thoughtful, respectful, and ethically correct manner from an indigenous viewpoint (Ermine, Battiste & Barman, 1995).

This study was carried out by an African indigenous scholar from an African cultural background using an indigenous lense (cf.1.6). The study was underpinned by indigenous methodologies to correct and restore the dignity and hope to the African people who have encountered memorable marginalization and distortion in both research and other scholarly domains (Steinhauer, 2002). In the two cases, African ways for knowing and understanding reality have been questioned or seen as exotic and framed in spiritualism. Beginning around the late 1990s, indigenous researchers such as Chilisa (2012), Kovach (2009) and Smith (2012) started to address Euro-Western thoughts of scholarship and the view of reality as generalized and a single truth (Wautischer, 1998). They further challenged the thoughts of what comprises as knowledge and how to seek for knowledge.

From these basic reflections, a new research paradigm differently known as Indigenous Research Methodologies, Decolonizing Methodologies or Culturally Responsive Methodologies was conceived (Berryman, SooHoo, Nevin, Arani Barrett, Ford, Joy Nodelman, Valenzuela, & Wilson, 2013; Chilisa, 2012; Kovach, 2010; Wilson, 2008). Inside this emergent of research paradigm, the historically held perspectives about what establishes social reality and how individuals come to know it, the nature of knowledge and its sources, and also values and ethics in research are being rethought, critiqued and addressed from the point of view of Indigenous Peoples' worldviews.

In making this case, Wilson's (2008) contention supports the idea that indigenous methodologies are a paradigmatic approach dependent on an indigenous philosophical positioning or epistemology. In this way it is not the method, as such, that is the deciding characteristic of indigenous methodologies, but instead the interplay (the relationship) between the method and paradigm and the degree to which the method, itself, is consistent with an indigenous worldview. From this viewpoint, one could contend that the focal discourse of indigenous methodologies should be a profound centralization of paradigm or worldview (Kovach, 2010).

Goduka, Madolo, Rozani, Notsi, and Talen (2013) contend that for research to be pertinent to, and enhance the quality of life of indigenous participants, it should be established in indigenous worldviews, cultural values and languages. This resonates with Khupe's (2017) contention that language plays a fundamental role in the transmission and preservation of indigenous Knowledge. Therefore, it is the duty of IK researchers to take into consideration these features of IK and to properly align the manners by which they connect with communities, so they are respectful of, and receptive to, sociocultural contexts.

An indigenous research methodology scrutinizes and opposes the idea of a single universal reality as something external that researchers could equitably measure or study and offers new viewpoints to scholarship and research. Kovach (2009) contends that an indigenous research paradigm ought to have four interconnected parts which stream consistently. These, she out-lines as ontology, epistemology, cosmology, axiology and teleology. She noticed that an indigenous ontology perceives multiple realities which exist in relationships and that epistemology comprises of a system of knowledge which is made up of our cultures, in our societies, worldviews, times, histories, spirituality, languages, and in addition the connections people established with that system. The author further contends that indigenous axiology which covers our value systems, standards and ethics, is based upon relational responsibility. In light of this, Kovach posits that the researcher becomes part of his/her research or exploration and indistinguishable from the subjects of that research, the methodology of which should frame a process that holds fast to relational accountability.

Like Kovach, the majority of indigenous researchers hypothesize that indigenous research ought to demonstrate relational accountability interconnectedness,

reciprocity, and assortment of the real world, where both the spiritual and physical domains are interconnected with the ultimate aim of giving acknowledgment to indigenous Knowledge Systems and ways of knowing (Chilisa, 2012; Kovach, 2013; Smith, 2012). According to Khupe (2014), indigenous research reinforces respectful representation, promoting social equity and advocating for self-assurance in research. Other significant components of the indigenous research methodologies are decolonization and shifting away from conventional methods of conducting research. Data generation procedures, analysis and translation in research should move towards research practices that perceive the realities of the marginalized, indigenous epistemic traditions and relationships, and advance cultural responsiveness.

As indicated by Chilisa (2012), decolonization in indigenous research is decolonizing and indigenizing research, as contended by numerous indigenous researchers, should aim at making utilization of indigenous knowledge systems and worldviews. Narratives, and live stories, proverbs, metaphors, melodies, dreams, spirituality and relational accountability should all be utilized as methods to impact the research process (Foley, 2013; Chilisa, 2012; Kovach, 2009; Smith, 2012).

Khupe (2014) contended that decolonizing and indigenizing research does not mean rejecting other Euro-Western methodologies yet, rather it involves being critical and receptive to the cultures under research and advancing their cooperation and ways of knowing in the research process (Chilisa, 2012; Smith, 1999). Berryman *et al.* (2013) further posit that the indigenous methodology, which they allude to as culturally responsive methodology, necessitates that researchers advance cultural responsiveness by utilizing critical, Kaupapa Maori theory, or other theoretical frames that perceive multiples realities, knowledge systems and belief systems, exchange and relational responsibility. Alternatively, Chilisa (2012) stated that indigenous research methodologies are informed by indigenous knowledge systems, eZiko Sipheka Sisophula theory, Indigenous Cultural Creativity theory, critical theory, postcolonial discourse, feminist theories, critical race-specific theories, and neo-Marxist theories.

According to these methodologies, there are socially constructed multiple realities shaped by the set of multiple connections that human beings have with the environment, the cosmos, the living, and the nonliving. In research, an indigenous

research paradigm challenges the shortage thinking and obsessive depictions of the formerly colonized and recreates a body of learning that conveys hope and advances transformation and social change among the historically mistreated. For Chilisa (2012), Hart, (2007), and Kovach (2010) an indigenous knowledge research is guided by the four Rs (responsibility, respect, reciprocity, and rights), These Rs represent:

Relational accountability: all parts of the research process are related; the researcher is accountable to all relations.

Respectful representation: the researcher needs to listen, pay attention, acknowledge, and create space for the voices and knowledge systems of participants and others.

Reciprocal appropriation: the researcher acknowledges the research as appropriation and ensured the participants that there will not be any that benefits accrue to participants and communities as well as researchers.

Rights and regulations: ethical protocols should give colonized and marginalized peoples ownership of the research process and the knowledge produced.

In spite of these common assumptions among most indigenous researchers about what indigenous research methodology is or what indigenous research should aim at doing, there are additionally huge contrasts among researchers. While some indigenous researchers lean towards worldwide indigenous scholarship, others appear to be locally based (Chilisa, 2012; Kovach, 2009; Smith, 2012; Wilson, 2008). Also, these researchers have alternate points of view on how research ought to be led, and in addition who should conduct indigenous research.

Previously, research among indigenous communities has regularly been intertwined with imperialism and colonialism, the greater part of whose methodologies have been condemned as critique of indigenous peoples and their ways of living (Hoppers, 2002; Smith, 1999). Mainstream methodologies generally align with a top-down research paradigm that serves to depict the perspective of the researcher to the detriment of those of the communities that they study (Chilisa, 2012). Indigenous ways for being do not constantly fit this predominant knowledge structure (Louis, 2007). As of late, there has been rising enthusiasm across disciplines (both globally and in South Africa), in the acknowledgment of indigenous knowledge and ways of beings, however there

still must be more unequivocal shifts from the request that depends on the mainstream frameworks (Mclvor, 2010; Hoppers, 2002; Wilson, 2001). Such a move is prompting indigenous research paradigms and which, in the African setting, most researchers prefer to call this paradigm the 'Afrocentric paradigm' (see for example, Mkabela, 2005; Owusu-Ansah and Mji, 2013; Smith, 1999; Wilson, 2001).

The shift towards indigenous research methodologies therefore comes with recognition of the importance of respectful and ethically sound relationships within participating communities (Louis, 2007), resulting in researchers purposively setting out to work in ways that acknowledge participants' traditional teachings and their spiritual connections. An indigenous research paradigm sees relationships as vital to the research process, along these lines knowledge and individuals are not seen as 'objects' (Louis, 2007; Wilson, 2001). Louis (2007) combines four critical principles of indigenous research methodologies.

Firstly, relational accountability portrays the idea that indigenous people groups share about their reliance on everything and everybody around them (Social and physical worlds), casually alluded to as 'all our relations, be it air, water, rocks, trees, animals, insects, human beings, et cetera' (Steinhauer, 2002). In the study field, the researcher is not only in charge of nurturing and maintaining this relationship but is responsible for every one of these relations. Where relationships with participating communities have been properly established, they can last past the duration of the research (Louis, 2007; Mclvor, 2010; Khupe, 2014). Wilson (2001) captures this aptly when he notes that, as a researcher, you are:

... answering to all your relations when you are doing the research. You are not answering questions of validity or reliability or making judgements of better or worse...you are asking how am I fulfilling my role in this relationship? What are my obligations in this relationship? The axiology or morals need to be an integral part of the methodology so that when I am gaining knowledge, I am not just gaining in some abstract pursuit; I am gaining knowledge in order to fulfil my end of the research relationship (Wilson, 2001:177).

According to Khupe (2014), the shift from inquiries of validity and reliability proposed by Wilson (2001) ought not to be translated as rendering research in an indigenous research paradigm as needing in rigour. Rather, when issues of relational

accountability are legitimately taken care of, proper methods will be utilized which will increase the validness and trustworthiness of the research (Anney, 2014).

The second principle is respectful (re)presentation. With regards to this principle, the researcher thinks about how s/he represents herself/himself and community participants, the events and phenomena in the study. Louis (2007) cautions:

Respect is not just about saying 'please' or 'thank you'. It's about listening intently to others' ideas and not insisting that your ideas prevail... It's about displaying characteristics of humility, generosity, and patience with the process and accepting decisions of the Indigenous people in regard to the treatment of any knowledge shared. This is because not all knowledge shared is meant for a general audience (Louis, 2007: 133).

The main priority of indigenous research methodologies is on respectful relationships, which enable researchers to avoid misrepresenting and misinterpreting participants (Khupe, 2014). The researcher has the ethical duty of being wise about what knowledge can be imparted to the general audience.

The third principle is about reciprocal appropriation, which stands for research that is driven by indigenous protocols, contains explicitly delineated objectives, and thinks about the effects of the proposed research (Smith, 1999). This means that it is an ethical duty of the researcher to discuss with the communities on how they are going to benefit from the research. Furthermore, the researcher will need to report back to the community and share the findings after the study is done. Reporting back the findings to the community assists in maintaining and strengthening the relationship the researcher has with participants (McIvor, 2010; Khupe, 2014).

The fourth principle is about Rights and regulation which require an understanding that the study centres on local customary protocols. The community owns the knowledge that they are willing to share with the researcher and they should not feel marginalized in any way during the research process. Also, the researcher must understand that the study is conducted with indigenous people and not conducted on indigenous people. The indigenous communities need to be aware that in case they feel violated or oppressed by the researcher, it is within their rights to withdraw from the research without explaining their reasons to the scholar (Chilisa, 2012; Khupe, 2014). These four principles are presented in Figure 3.1 below:

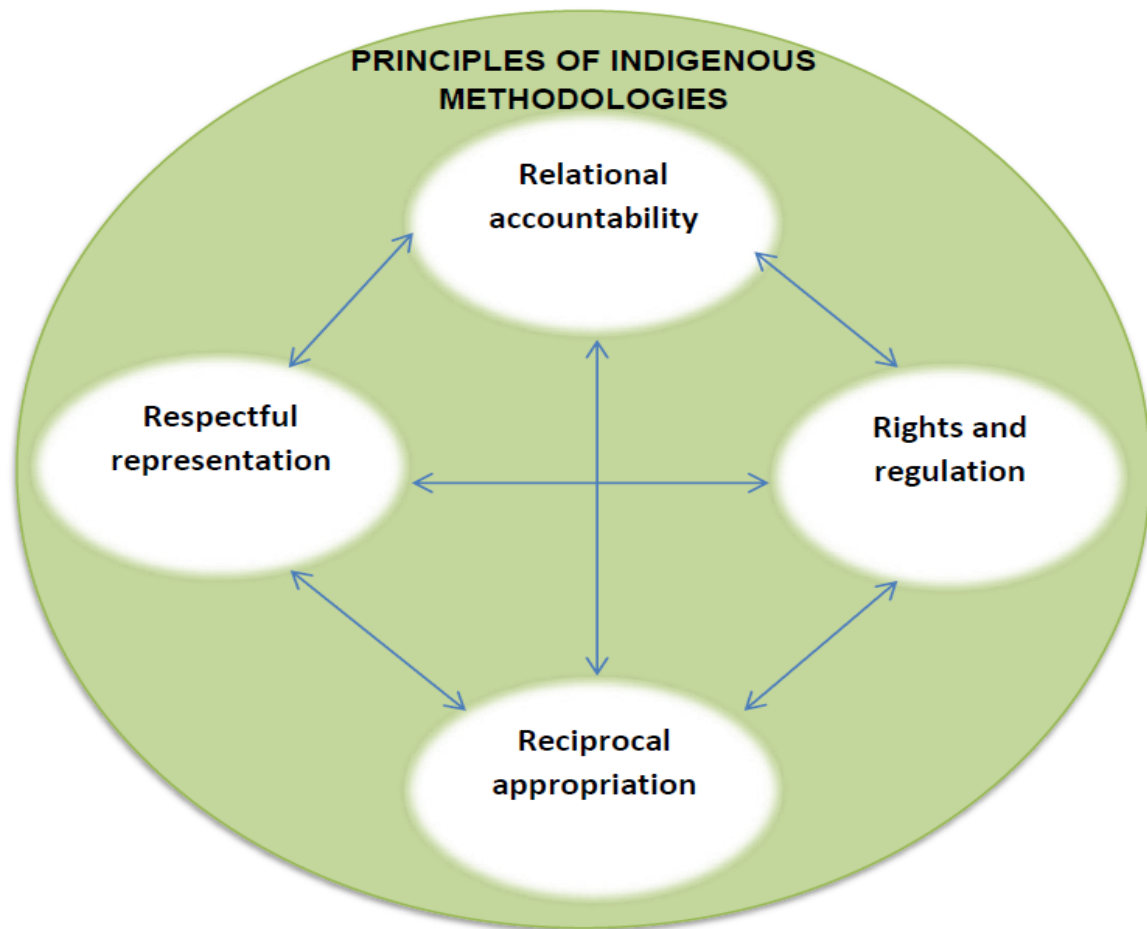


Figure 3.1: Principles of indigenous research methodologies (adapted from Louis, 2007 and Khupe, 2014).

Figure 3.1 illustrates that indigenous research methodologies use a holistic approach within the research process. The principles in this figure influence each other and work together throughout the research process. In order for a study to be carried out in a proper manner, these principles are essential as they guide the research process. Communities have guidelines on how they expect researchers to relate with them. In some communities, these guidelines are written down (Mosimege, 2012; Khupe, 2014), but in others they are not. Therefore, it is an ethical responsibility of the researcher to understand and learn the protocols involved while conducting research with indigenous communities. “The ethics requirements brought about as a result of working in the frameworks of ubuntu and the indigenous research paradigm are rigorous and seem to require even greater researcher accountability than mainstream research” (Khupe, 2014:79).

According to Chilisa (2012), an indigenous research paradigm is associated with the following beliefs:

- **Relational ontology:** Various socially built realities formed by the arrangement of different connections that people have with the environment, the cosmos, the living, and the non-living. Relational ontology speaks to the sense and beliefs of African peoples (Chilisa 2012; Hart, 2010; Kovach, 2010). For instance, fundamental to traditional African idea is the possibility that there are ancestral spirits whose expectations we can know. Ancestral spirits are people who once lived in our physical world. Despite the fact that they are not physically dead, they are as yet equipped for initiating actions on their own. Such actions of theirs have intended results on our physical world. Knowing about their intentions gives grounds to understanding physical occurrences. This asserts that for an African, there is something else entirely to reality than what is within the realm of empirical inquiry (Kovach, 2010).
- **Relational epistemology:** Is informed by the set of multiple relations that one has with the universe (Chilisa 2012; Hart, 2010; Kovach, 2010). African epistemology manages what the African means and comprehends when he makes a knowledge claim. This comprises of how the Africans see or discuss reality (Kovach, 2010). Concerning how Africans see or talk about reality, Asante (2000:02) writes “there are several elements in the mind of Africa that govern how humans behave with regard to reality the practicality of wholism, the prevalence of poly-consciousness, the idea of inclusiveness, the unity of worlds, and the value of personal relationships”. These establish the components of the African mind, they outline the African conception of reality, and they are the premise on which cognitive claims are made by the African.
- **African Cosmology:** Represents the way in which the Afrocentric conception expresses the basic sense of African people and the proportions, meaning, and the workings of the universe and of the natural context of their own reality (Hart, 2010; Kovach, 2010). It is just the manner in which Africans perceive, conceive and consider their universe; the focal point through which they see reality, which influences their value systems and attitudinal orientations (Ijiomah, 2005; Unah, 1995; Chimakonam, 2012; Kanu, 2013; Jaja, 2014). It is the African's search for the significance of life and an “unconscious but natural tendency to arrive at

a unifying base that constitutes a frame of meaning often viewed as terminusa quo (origin), and as terminus ad quem (end). This cosmology is the underlining thought link that holds together the African value system, philosophy of life, social conduct, morality, folklores, myths, rites, rituals, norms, rules, ideas, cognitive mappings and theologies” (Ukpokolo, 2017:30).

- **Relational axiology:** Indigenous people follow protocols that guide the way they should live. They have respect for the living, non living and the spiritual world. Axiology encapsulates the dimension of values, standards, principles and models of morals and ethical quality (Chilisa 2012; Hart, 2010; Kovach, 2010).
- **African teleology:** Alludes to the ultimate purposes that lead African people to follow certain worldviews, protocols, beliefs and reality. African teleology encompasses the belief that ways of living, knowing and doing move towards some purposeful goal (Chabalala, 2018).

Figure 3.2 illustrates the relationship of components which are the basis of an indigenous research paradigm. The components above are a guide on how research has to be conducted with indigenous communities. Also, the components describe the holistic nature of African indigenous knowledge and how knowledge is interlinked. Therefore, an indigenous research paradigm “argues for the reassertion and rebuilding of traditional knowledge from its roots, its fundamental principles” (Garrouette, 2003: 101).

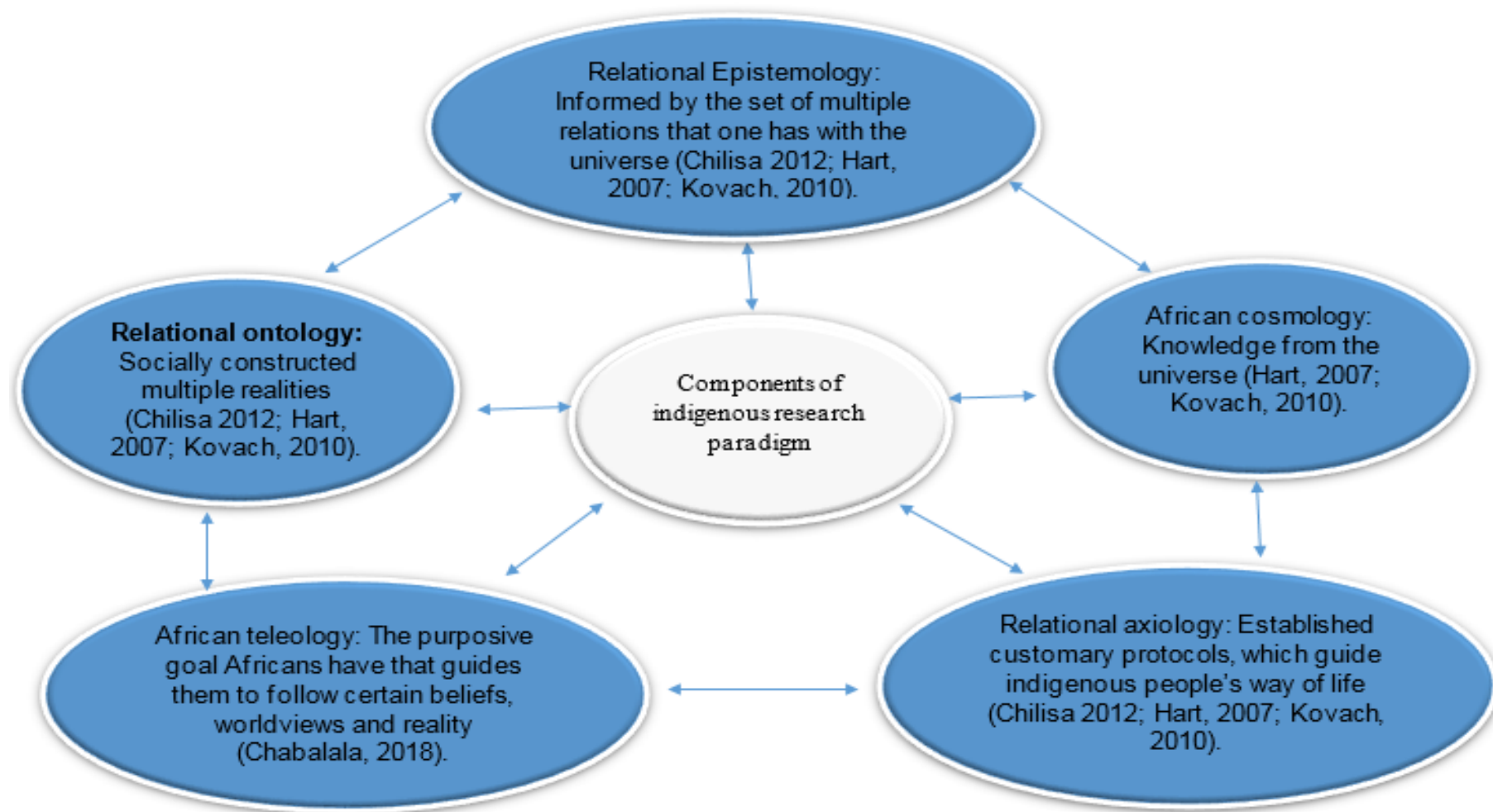


Figure 3.2: Indigenous research paradigm and its components (Source: researcher).

3.2.3 Policy frameworks that guided and enabled the researcher to conduct an indigenous study.

The policies stated below (which are statutory sources) were selected to underpin the study based on the fact that they support indigenous research. The researcher selected certain aspects in these policies that are aligned with this study. Therefore, this study is underpinned by the following policies:

The Arts and Culture Policy of 2002

The Arts and Culture Policy of 2002 supports the ongoing need for the protection, preservation and promotion of South African Arts, Culture and Heritage. Indigenous knowledge systems need to be protected and promoted and should not be allowed to be eroded and replaced by western dogma (Holbrook, 2016). According to Mosimege (2004), heritage must be made attractive to the youth by way of virtual tours or mobile applications. For example, to ensure that it remains relevant to all generations.

The Indigenous Knowledge Systems (IKS) policy of 2004

The South African Indigenous Knowledge Systems (IKS) Policy of 2004 focuses on the importance of underpinning the contribution of Indigenous Knowledge (IK) to the economy, as well as the role of IK in employment and wealth creation. In South Africa, IKS is owned by and provides services to people who are prone to unemployment (National Research Foundation, 2015). Consideration therefore needs to be given to the role that IKS can play in employment creation (Green, 2008). The IKS policy also encourages the participation of women in all levels of IK promotion and innovation. Participation is understood to involve responsibility, trust and co-operation. This means empowerment for women, giving them more autonomy and decision-making power over their own lives and circumstances (Mosimege, 2004; Mosimege, 2007; Domfeh, 2007).

The South African Indigenous Knowledge Systems (IKS) Bill of 2016

This Bill states that it is important to promote public awareness and the understanding of indigenous knowledge for the wider application and development. The National Indigenous Knowledge Systems Office (NIKSO) must create and maintain systems for documenting and recording indigenous knowledge. Where relevant, NIKSO will

facilitate and coordinate indigenous knowledge systems activities related to the commercial of indigenous knowledge products, services and processes (Holbrook, 2016).

According to Pandor (2015), in the case of gaining access to indigenous knowledge systems for the purpose of commercial or industrial application, a benefit-sharing agreement between the community and the third party must be concluded. The benefit of the sharing agreement must contain terms that ensure due reward for such access and guarantee the equitable distribution of any benefits deriving therefrom. NIKSO may assist indigenous communities in concluding benefit-sharing agreements with third parties.

The South African National Language (NL) policy of 2003

The Policy Framework strongly encourages the utilization of the indigenous languages as official languages in order to foster and promote national unity. The National Language Policy of 2003 aims to ensure redress for the previously marginalised official indigenous languages; initiate and sustain a vibrant discourse on multilingualism with all language communities; encourage the learning of other official indigenous languages to promote national unity, and linguistic and cultural diversity. The Policy Framework aims to protect, preserve and promote the indigenous languages of South Africa.

3.3 Conceptual framework of the study

Vaughan (2008) characterizes conceptual framework or conceptualisation of a study as a composed or visual presentation that clarifies either graphically, or in narrative form, the principle things to be studied: the key components, concepts or variables and the presume relationship among them.

AmaNdebele are Indigenous people of Africa who trace their ancestors from the large Bantu group. The South African Ndebele belong to the Nguni ethnic groups which represent approximately two thirds of South African population. The South African Ndebele are categorized into two groups which are AmaNdebele situated in Mpumalanga (Ndzundza and Manala groups) known as the Southern Ndebele and the Ndebele people in Limpopo (BagaLanga and the BagaSeleka groups) known as the Northern Ndebele (Jackson, 1969). In the 19th century, the Southern Ndebele people

of the Ndzundza Kingdom lost a war known as the Mapoch war to the Dutch speaking Boers which started (1849-1883). After they had lost the war, they started communicating using mathematical ideas and concepts in their art (symmetrical geometry), with a belief that it was instruction from God and gods and it was a way of communicating which the colonisers did not understand (Mahlangu, 2016; Levy, 1990).

The symmetrical geometric shapes were initially painted on their walls and shortly started reflecting on their beadwork. These shapes symbolize the struggles and pain the AmaNdebele undergone after they were conquered by the Boers. They also symbolize the spiritual connection AmaNdebele have with their God and gods. The colours that AmaNdebele women use for their beadwork and paintings serve as communication in the Ndebele society. The task to carry this cultural expression was given to women by higher beings (God and gods). AmaNdebele women are ethnomathematicians and custodians, transmitting ethnomathematical knowledge and skills to other women of different age groups as a method of preserving knowledge and also preparing young women for married life as they will showcase their skills to their in-laws and transfer this knowledge to their children.

Today, AmaNdebele women are entrepreneurs who use mathematical concepts and ideas in their art to sustain their livelihoods, create their own brands and improve their economic status (Chambers & Conway, 1991). The documentation and management of Ndebele indigenous knowledge is crucial for future utilization. One of the mandates on the National Indigenous Knowledge Systems Office (NIKSO) is to manage and protect indigenous knowledge from being extinct and illegally exploited. The conceptual framework of this study is graphically represented in Figure 3.3 below:

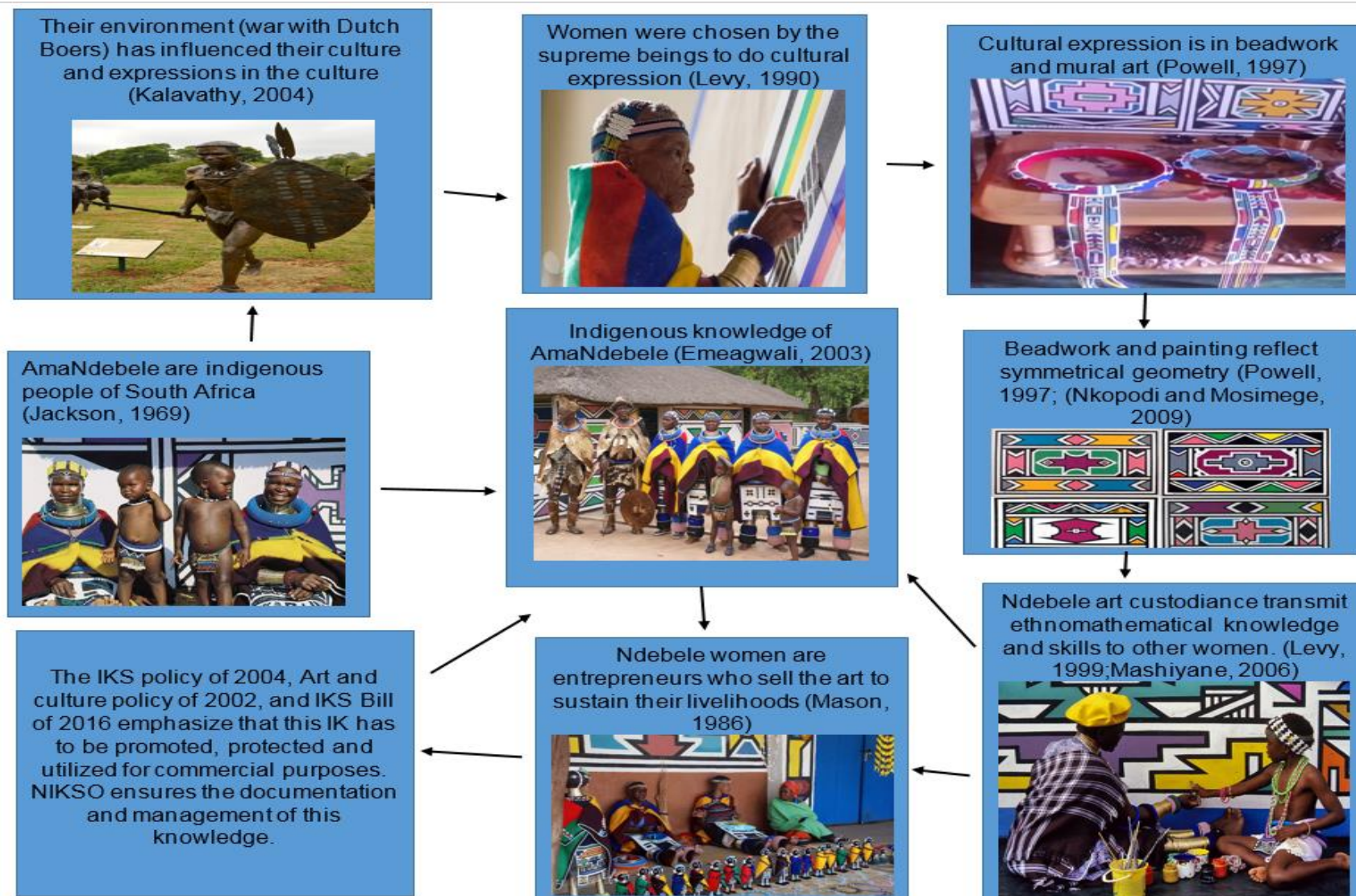


Figure 3.3: Graphical representation of the conceptual framework for the study.

3.4 Theoretical framework of the study

For this study, the researcher has used both eZiko Sipheka Sisophula theory by Goduka (2005) and Indigenous Cultural Creativity theory by Jacob, Lee, Wehrheim, Gökbel, Dumba, Lu and Yin (2013).

3.4.1 *eZiko Sipheka Sisophula Theory*

eZiko Sipheka Sisophula (eZiko) is a theoretical framework that was postulated by Goduka (2005). According to Goduka (2005), this theory is rooted in the African worldviews not forgetting languages and cultures that build on a relational/ecological assumption of the African cosmology that deepens our understanding of our interrelatedness. This resonates with Taleni, Nyoni, and Goduka's (2012) contention that eZiko is derived from the African design of a circle. Based on this design, African life moves in a cycle that is perceived from a circular perspective. eZiko can also be described as holistic, feminine, experiential and participatory. It is holistic as indicated by the circle around which spiritual, intellectual and psychological rituals, dialogues and intergenerational and intercultural teachings take place.

Furthermore, within curricula, pedagogies and research methodologies, eZiko seeks to de-colonize Western-based knowledge, worldviews and questions the relevance of Western and colonial positivist approaches for addressing sustainable development and indigenous knowledge within rural contexts. Therefore, eZiko Sipheka Sisophula as a theoretical framework aims to recover, restore, recognize, and recreate and 'research back' utilizing indigenous African epistemology, axiology, ideology and logic, and relational ontology, teleology and cosmology as methodological constructs (Shava & Manyike, 2018).

This theory was relevant for this study because the researcher focused on the role of ethnomathematics in the indigenous cultural life of AmaNdebele women by focusing critically on the spirituality involved in ethnomathematics, what ethnomathematics symbolises, and how ethnomathematics is used for communication. This theory enabled the researcher to understand the relationship the Ndebele people have with the supreme beings dwelling in the spiritual realm and how these beings have influenced their cultural expression in a form of ethnomathematics. Furthermore, the theory has assisted in understanding the link between the Ndebele ethnomathematics

and cosmic knowledge. This theory is derived from the African design of a circle and has therefore helped the researcher to understand the mechanisms of ethnomathematical knowledge transmission, the reasons ethnomathematical knowledge is transmitted and how ethnomathematical knowledge rotates from the spiritual world, to custodians, to younger generation, the next generation and back to the spiritual domain. Due to this theory being feminine, it is relevant for this study since it supports the contribution of women in culture expression, culture development and culture preservation (Talení, Nyoni & Goduka, 2012).

3.4.2 Indigenous Cultural Creativity Theory

Another theory that was used for this study is the Indigenous Cultural Creativity theory. According to Jacob *et al.*, (2013), this theory states that cultural and community environments may influence the development of creative tendencies. Westwood and Low (2003) and Richards (2011) agree with Jacob *et al* that culture and environment influence the ways in which creativity is defined, and also how it is conceptualized. This theory uses various forms of creativity within the indigenous cultural context that expresses ways of knowing such as spiritual (cosmic) ways of knowing that tap into the creative practices of indigenous cultures, both from the past and the present. Such practices include, indigenous art forms which are done on a primarily hand, and include various media, such as painting, craft production, beadwork, pottery, clothing production and other fine art (Semali & Kincheloe, 1999; Teasdale & Rhea, 2000; Mutua & Swadener, 2004; Reagan, 2005; Kovach, 2009; Dei, 2012; Chilisa, 2012; Smith, 2012).

Within the curricula, pedagogies and research methodologies, Indigenous Cultural Creativity theory welcomes a decolonizing perspective against Western worldviews on Africa, as well as knowledge and questions in Africa. It argues that a decolonizing theoretical perspective is necessary within indigenous research given the existing social inequities that indigenous peoples continue to experience. A decolonizing perspective is significant to indigenous research because it focuses on indigenous-settler relationships and seeks to interrogate the powerful social relationships that marginalize Indigenous peoples (Igusi & Igbinomwanhia, 2018). Interrogating the power relationships found within the indigenous-settler dynamic enables a form of praxis that seeks out Indigenous voice and representation with research that has

historically marginalized and silenced Indigenous peoples (Smith, 1999). This theoretical framework seeks to restore pillars of African indigenous methodological implications which are strengthened by African ontology (reality), and African epistemology (Know) African cosmology (view), African axiology (do), and African teleology (purpose) (Chabalala, 2018).

The researcher used this theory to investigate how culture and environment have influenced creativity amongst the Ndebele people after they lost the war to the Dutch-speaking Boers in the 19th century. Furthermore, this theory has guided the researcher to examine how the Ndebele spirituality affected ways of creativity in the Ndebele culture after losing the war to the Boers. Indigenous Cultural Creativity theory provided a platform for this study to assess the mathematical concepts and ideas embedded in Ndebele art which is used by Ndebele women for creativity in culture and other purposes.

3.5 An introduction to the study area

3.5.1 An overview of Mpumalanga Province

Mpumalanga Province is located in the north-eastern part of South Africa, bordering Swaziland and Mozambique to the east. Also, it borders Limpopo, Gauteng, Free State and KwaZulu-Natal within South Africa. It is the second smallest province in the country. It occupies an area of 76 495km² with a population of 4 335 964, making it the sixth most crowded in the nation. It is arranged, for the most part, on the high plateau fields of the Middleveld, which move eastwards for several kilometers. In the north-east, it ascends towards mountain tops and ends in an immense slope. In a few places, this ledge plunges several meters down to the low-lying region known as the Lowveld (Statistics South Africa, 2011).

Mbombela (previously known as Nelspruit) is the capital of the Mpumalanga Province and the administrative and business centre of the Lowveld. Other major cities and towns include eMalahleni (previously known as Witbank), Standerton, eMkhondo (previously known as Piet Retief), Malalane, Ermelo, Barberton and Sabie. The best-performing sectors in the province include mining, manufacturing and services. Potential growing sectors include Tourism and agro-processing. Mpumalanga is

divided into three district municipalities, which are further subdivided into 17 local municipalities as shown in the map below (ibid, 2011).

According to Statistic SA (2011), the languages mostly spoken in Mpumalanga include Swazi with 27.7% of population, Zulu with 24.1%, Tsonga with 10.4%, Southern Ndebele with 10.1%, Northern Sotho (Pedi) with 9.3%, Afrikaans with 7.2%, Southern Sotho (Shweshwe) with 3.5% and English with 3.1%. Nkangala District is dominated by Ndebele speaking people followed by Zulu and Afrikaans speaking people. Ehlanzeni District is mostly dominated by Swati speaking people, followed by the Zulu, Tsonga and Afrikaans speaking people. Gert Sibande municipality is dominated by Northern Sotho people, Southern Sotho people, and Tsonga people (ibid, 2011).

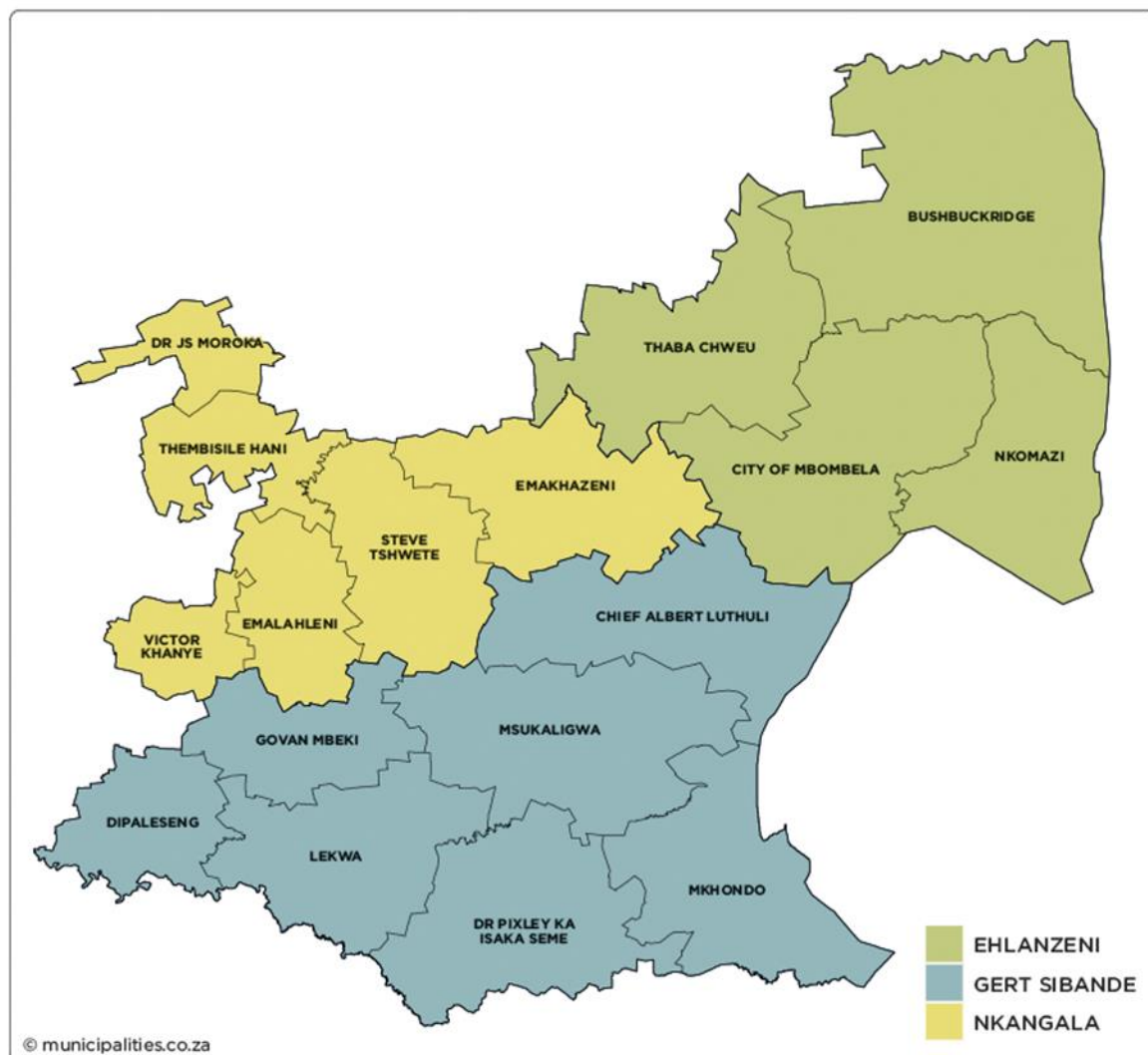


Figure 3.4: Districts and municipalities in the Mpumalanga Province, South Africa (Municipalities of South Africa, 2017).

The study was conducted at Ekosini village situated in the JS Moroka District Municipality, under the Nkangala District in Mpumalanga South Africa. Ekosini village which is shown on Figure 3.4 is cross proximity to Weltevrede and Ga-Mapogo.

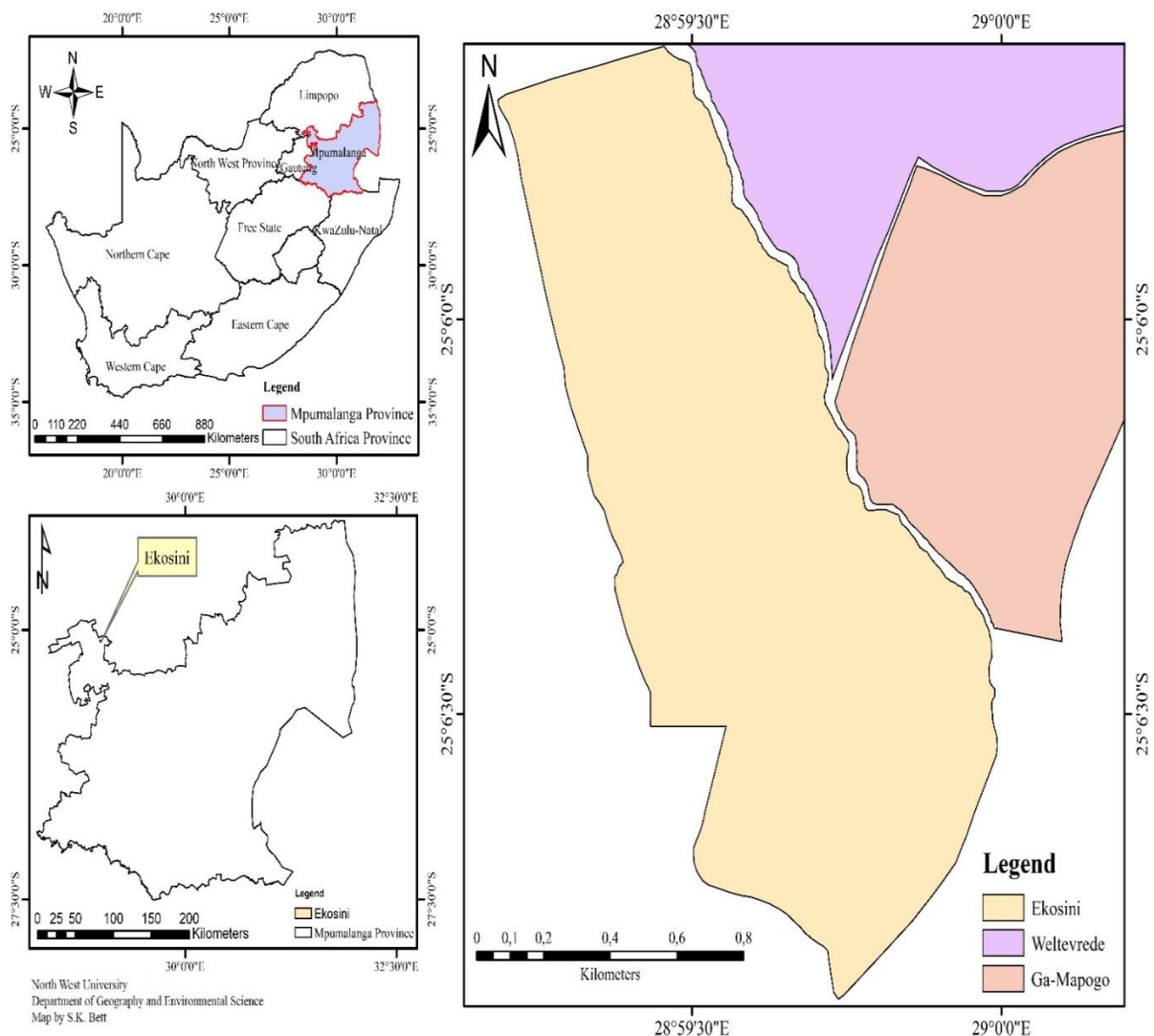


Figure 3.5 Map of the study area (Source: North West University, 2018).

According to Statistic SA (2011), the DR JS municipality has a total population of 249 705 individuals, 99, 4% of whom are Black African. Indians and other Asian groups make up 0,3% of the population, and the remaining 0, 3% is occupied by the other race groups. Ekosini village has a total population of approximately 2050 individuals with 18% youths, 46% elderly women (35+) and 36% elderly men (35+). Of those aged 20 years and older, 4, 7% have completed primary school, 31% have some secondary education, 25, 2% have completed Matric and 6, 6% have some form of higher education. 17, 5% of those aged 20 years and older have no form of schooling (Statistic SA, 2011).

Ekosini village is the selected study area of this research. It is within Nkangala district in the JS Moroka municipality. Ekosini is in the low-veld region of KwaNdebele, and it is one of the villages situated in Weltevrede area (Statistic SA, 2011). The majority of the residents that reside in Ekosini village are Ndebele people who still maintain their traditional cultural practices. Their current businesses include beadwork and mural art which have been established by local women in that area. The market of selling Ndebele articles stretches to other neighboring villages which are mostly Ndebele dominated. Ekosini village is approximately 120 km from Pretoria in Gauteng Province. Pretoria is a city where most Ndebele people travel to work daily, while others relocated to surrounding townships. The attractive tourist places in JS Moroka municipality include the Mapoch (Mabhoko) Ndebele cultural village, the Ndebele experience, the Ndebele foundation, Fransina Ndimande Ndebele art market, Sinivusile MaNdebele Art & Craft and Guest House established by Dr. Esther Mahlangu.

3.5.1.1 The Ndebele culture

For the purpose of this study, a clear understanding of culture is important in order to understand the culture of the Ndebele people in the Ekosini village. According to Kroeber and Kluckhohn (1952: 181), "culture consists of patterns, explicit and implicit, of and for behavior acquired and transmitted by symbols, constituting the distinctive achievements of human groups, including their embodiment in artifacts; the essential core of culture consists of customary ideas and especially their attached values; culture systems may, on the one hand, be considered as products of action, on the other, as conditional elements of future action". Culture is liquid in nature, it develops and changes constantly (Spencer-Oatey 2008).

The culture of the Ndebele people of Ekosini revolves around rituals such as rites of passage or initiation ceremonies and traditional weddings. *Ukuwela*, which is part of the Ndebele culture, for example, is a male initiation that marks the passage to adult status from childhood. Through the procedure of initiation, young men are enlisted into traditional lore and the profound secrets of the gathering (Van Vuuren, 2012). This knowledge is passed on from one generation of initiates to the next, guaranteeing that the transfer of knowledge is maintained. Another occasion in which culture is embodied is when Ndebele maidens are initiated through *ukuthomba* (girl's initiation). Another

ritual ceremony is called *idwendwe nobukhazi* which is a traditional wedding and marks the stage where young adults become either a husband or a wife. For all rituals, AmaNdebele women adorn themselves with colourful beaded sophisticated attires. These colourful beaded clothes also bear vivid testimony to the distinctiveness of Ndebele culture within the broader world of inter-ethnic politics (Mashiyane, 2006).

The Ndebele people have always managed to retain their cultural practices. Women at Ekosini who belong to the Ndzundza society are the custodians of *isikhethu* ('that which is ours'), which is basically a term that explains the Ndebele culture which consists of the relationships, beliefs and practices on which the very essence of Ndebele identity is centred. Alongside the care of ageing in-laws, and the socialisation of and inculcation of values in children, this role includes the manner in which women clothe their bodies in various ceremonial contexts (Magubane, 1998). The AmaNdebele women in Ekosini continue to preserve the culture of using symmetrical geometric designs in their artistic works which are a center of their identity. As of late, art designs have been categorized into two which are: *Isitjhefana* (Figure 3.6) and *isirayithoni* (Figure 3.7). *Isitjhefana* contains symmetrical geometric designs that have cultural significance (cf.3.3) though *isirayithoni* mirrors the impersonation of present day buildings, streets lights, road signs as so on. *Isirayithoni* has no cultural significance however, it is simply an innovation practiced by a few artists in the 21 century.



Figure 3.6: Ndebele designs known as *Isitjhefana*.



Figure 3.7: Modern Ndebele designs known as *isirayithoni*.

The food which is eaten by the people of Ekosini is made of maize and sorghum. Maize porridge known as *umratha* is normally accompanied with meat. People from Ekosini are surrounded by grasslands which provide them with fruits and vegetables (Smith, 2018). Varieties of vegetables include *irude*, *ihlathu*, *ibhambham*, *imbuya*, *idelele*, *ibhobola*, *amahlamvu endumba*, *umadoyi* and many more. The AmaNdebele of Ekosini also prefer wild fruits which include; *umdlawuzo*, *umkhemeswana*, *umvito* and many more. Males of Ekosini are cattle rears and they get their milk from the cows and make various foods such as porridge and milk known as *isathiyane* (Abid, 2018).

Concluding remarks

This chapter has justified the importance of underpinning this study on African philosophies. The views and arguments from different scholars on African philosophies were presented in this chapter in order to support the researcher's justifications. The first part of this study focuses at the feminine cultural expression of Ndebele ethnomathematics in the lives of AmaNdebele women. Its purpose is to examine the mathematical ideas and concepts embedded in the Ndebele art.

CHAPTER 4: THE FEMININE CULTURAL EXPRESSION OF ETHNOMATHEMATICS IN THE LIVES OF AMANDEBELE WOMEN

4.1 Introduction

African culture is expressed in its artworks, folklore and religion, attire, food, music and language, among other such socio-cultural expressions. Expressions of culture are abundant in Africa, with a lot of cultural diversity being found crosswise over various nations as well as within single nations (Schneider, 1985). According to Arinson (1991), creative artistic endeavors, similar to all production in Africa, are clearly divided according to gender. There are dependably special cases to the rule. However, generally women work with clay and make pottery, paint walls, do bead work with natural substances while on the other hand men work with wood and metals to make sculpture. Men and women both contribute to the creativity of geometric shapes.

For many years, AmaNdebele women, by tradition have been given authority (rights and responsibilities) by supreme beings to represent and express the Ndebele society through art forms which are beadwork and mural art while men have their own tasks to carry out (Mashiyane, 2006). Ndebele sensitivities to frame and colour, and preferences for using mathematical ideas and concepts such as geometric symmetry in their art (Schneider, 1985) have survived the starting phases of modernization, due to their annual rituals (ceremonies) such as traditional weddings and initiation processes/rites of passage. According to Levinsohn (1985), the Ndebele rituals provide the vehicle of passing traditional skills, practices and attitudes that make up a real AmaNdebele woman. For a very long time, the art of the Ndebele was centered on beaded attires and mural art until recently (approximately from 20th century to date), women started creating beaded articles and painted artefacts.

Though not the sole ethnic group, South African AmaNdebele women who are artists and ethnomathematicians exemplify the consistent minute adjustments in consciousness essential always to recognize oneself. Given the approach of outside cultural influences, with its myriad visual decisions and creative and financial purposes, the interpretations of these artistic women remain strikingly consistent to

the image of being Ndebele. To date, their ancestral visual memory appears intact, regardless of contact with Western free capitalism (Van Vuuren, 2010).

This chapter explores the feminine cultural expression of ethnomathematics in the cultural life of AmaNdebele women. To achieve the objective of this study which was to explore the feminine cultural expression of ethnomathematics in the cultural life of AmaNdebele women, this chapter focuses on the colour symbolism in Ndebele art, assesses the mathematical ideas and concepts used by AmaNdebele women in art and looks at the cultural significance of Ndebele art. This chapter is guided by the following question: In what way are mathematical ideas and concepts expressed in Ndebele art?

4.2 Methodology

4.2.1 Research design, approach and paradigm

First, an exploratory research design was used in this chapter. As it was explained in Chapter 1 (cf.1.6), the researcher has a background of Ndebele cultural expression because she is from KwaNdebele yet there were many aspects she did not know prior to carrying out the present study and which were not covered by previous scholars that required expert knowledge which motivated her to explore by conducting this study.

Second, an indigenous relational approach was used for this entire study in order for the research to reflect the context of the community. Thus, the researcher as a Ndebele carried out the responsibility of ensuring that the knowledge provided by the community was presented in this study as it was captured, ensuring that the knowledge and meaning given by the participants was not lost in translation. Therefore, the researcher took the responsibility to create a good rapport with the community to correct misconceptions about the lack of ethnomathematics in the Ndebele nation (Wilson, 2008). Third, an indigenous research paradigm was used in this entire study as a guide on how to accumulate and assess the knowledge of the AmaNdebele women without the researcher constructing her own knowledge. During the period the researcher spent collecting data, she came to understand how the AmaNdebele women view their reality and what has influenced their reality. Even though the researcher is from KwaNdebele and is familiar with cultural expression and

Ndebele art, she had to willingly learn from the participants, and at the same time, share her own experience and knowledge in a way that did not undermine or overlook the knowledge of the participants (Moloi, 2013). Becoming a 'learner' instead of a 'knower' has made the participants of this study to be free to share their knowledge without being criticized or judged by the researcher (Hart, 2010; Chilisa, 2012).

4.2.2 Target population

The target population for this chapter was ten Ndebele people, including Dr Esther Mahlangu and women at Ndebele Art School. This population was selected through purposive sampling because they are well-known custodians and knowledge holders of Ndebele ethnomathematics as compared to other women within the village. Further, the target population for this study has a cultural background of ethnomathematics and many years of experience in both practice and cultural expression (Vonk, 2016).

4.2.3 Sampling size and sampling procedure

A total of six participants were sampled using an expert purposive sampling procedure (Palys, 2008). Dr. Esther Mahlangu selected the participants based on their knowledge and experience in practising art, which were relevant for this study.

4.2.4 Data collection strategies

4.2.4.1 Tools

An in-depth interview guide was used as tool to collect data from Dr. Esther Mahlangu (see Appendix 1), whereas a focus group interview guide (Appendix 2) was used to collect data from women at Ndebele Art School.

4.2.4.2 Methods

The interview with Dr Esther Mahlangu was conducted outside in a place called *ebaleni* (which will be explained in Chapter 5). The researcher explained the study process to the participant before she proceeded with the interview. An in-depth interview guide was used with the participant in order to have a face-to-face encounter so that a rapport could be created. The researcher wanted to listen rather than talk. She was very observant of the body language used by the participant. The interview was more of a guided conversation (open ended questioning) rather than an answer session. Figure 4.1 shows the researcher interviewing Dr Esther Mahlangu.

For the focus group interviews with women at Ndeble Art School, the interviews were done outside the house in a round table setting. This researcher welcomed the participants, introduced the research process and gave them an opportunity to ask questions before the interview began. While asking questions, the researcher was observant of the body language of participants, facial expressions and how they responded to questions asked. The questions were open ended, allowing the researcher to probe further where necessary. A tape recorder, camera and note book were used to capture the data collected from both in-depth interview and focus group interviews. Figure 4.2 shows a focus group discussion within a round table setting.



Figure 4.1: The researcher interviewing Dr. Esther Mahlangu.



Figure 4.2: Focus group interview with participants.

4.2.5 Data analysis

The data that emerged from the in-depth interview and focus group interviews was manually analysed through a thematic analysis using the following protocols, as outlined by Braun & Clarke (2006): (1) This researcher read all the transcribed data from the in-depth interview and focus group interview thoroughly; (2) Once familiar with the data, she identified recurrent phrases and concepts that were considered important on which were highlighted and colour-coded in all the interviews; (3) concepts and phrases from the different data sets that were matched were then categorized into themes; (4) the researcher refined and defined the themes and potential subthemes within the data and similar themes emerged; and (5) the themes were reported as the results of the study.

4.2.6 Ethical considerations for the study

The research proposal for this study was first submitted to the Faculty Research Committee (FRC) of the Faculty of Agriculture, Science and Technology (FAST) for approval on 17th August 2017. The FRC changed its name to Higher Degrees Research Committee (HDRC) when the FAST changed to Faculty of Natural and Agricultural Sciences (FNAS). That approval was obtained on the 15th September 2017. The Indigenous Knowledge Systems (IKS) Center provided the researcher with an introductory letter on the 20th October 2017 (see Appendix 6) which gave her

permission to proceed with the research process while waiting for the NWU ethics certificate. The letter from the IKS Centre was emailed to *ikosi yamaNdebele kaNdzundza*, (King of the Ndzundza Ndebele) on the 25th October 2017. The King who by name is Sipho Etwell Mahlangu continuously communicated with the researcher on the phone to get a clear understanding of the study before handing her a permission letter to conduct the study at Ekosini on the 7th December 2018 (see Appendix 12).

After obtaining the letter, the researcher provided the letter to her supervisors before proceeding with data collection. The letter was also issued to the key participant (Dr Esther Mahlangu) and other participants of the study. Before each interview, a consent to conduct the study (see Appendix 8) and publish research findings was obtained and before observations were made. This was done through reading the consent form in Ndebele language and having participants to attach a signature or thumb print as a concern to participate. The researcher also requested that the representatives of the custodians be available when reading the consent form in other for them to read the document and validate the researcher's statements.

A participant non-disclosure agreement form (see Appendix 9) was explained to the participants in IsiNdebele in the presence of their representatives. The participants however stated verbally that they had no problem with their names used in the research study and advised the researcher to honour the rest of the agreement (see Appendix 8). Azizova, Azizova, Barnes, Cormier, Gohar, Irani, Kamp, Kiprop, Krahn, Kyoon-Achan and Linstroth (2016) observe that, indigenous people of oral culture believe that verbal agreements are as legally binding as written agreements. Therefore, a verbal consent was provided by the participants. As an established brand, Dr. Esther Mahlangu's name was used in this study to support arguments and discussions that were made in order for the reader to have a clear direction which the study has took. Participants were assured by the researcher that all information provided would be kept under lock and key for a maximum of five years. The participants were also given a benefit sharing agreement form (see Appendix 10) to sign which the researcher explained in full details. A material transfer agreement was also provided to the participants in any case the researcher wanted to take their artefacts for analyses (see Appendix 11).

In addition, the researcher understood the customary laws of the Ndebele people on how a woman should be dressed and how she should speak to elderly people. The researcher wore long skirts and dresses with shoulders and hair covered all the time she carried out research in Ekosini. Prior, the researcher consulted with her elders about the protocols that were to be followed which she was not aware of. The researcher provided participants with refreshments as a token of appreciation.

The NWU ethics certificate was obtained on 21st May 2018 (see Appendix 7). The researcher had to email a copy of the ethical approval certificate on the 25th May 2018 to the King in order to confirm that the study was approved by the FAST health science committee and to show that the scholar has followed ethical protocols.

4.2.7 Risks and risk management

Money as a token of appreciation was requested by the participants before sharing their indigenous knowledge. The researcher had to show the participants the permission letter which was provided by the King as proof that she was a student with passion of preserving Ndebele indigenous knowledge. The letter was provided to the representatives of the participants to read and explain. The researcher was then welcomed by the participants with a traditional song and allowed her to proceed with the research process.

4.3 Results

4.3.1 Introduction

This section presents the themes that were found during data analysis, which are as follows: mathematical concepts and ideas in Ndebele art; mathematical concepts and ideas used by Ndebele artists in their art techniques, styles used by Ndebele women in their art; the meaning of geometric shapes embedded in Ndebele beadwork and mural art; the process of colour mixing in mural art; colour symbolism in the Ndebele beadwork and mural art and the cultural significance of Ndebele art. A theme that emerged was as follows: significant role of Ndebele women in cultural expression.

4.4 Mathematical concepts and ideas in Ndebele art

A majority of participants agreed that they specialize in both beadwork and mural art. They stated that they had never been exposed to formal education but rather learnt through indigenous education. According to the participants, they learned through experiments, observations and participations. The Ndebele people have an ability to do basic counting which includes addition, subtraction and division, which they learn through indigenous education. According to participants, basic counting is also done in cattle and house hold stock. The mathematical concepts that they have learned through the years are counting, repetitive cycles, measurements and estimation of lines an angles and similarities in figures.

The results of this chapter show that the shapes found in the Ndebele art is symmetrical geometry (mirror of a shape). The shapes that this researcher found in the Ndebele art are triangles, squares and rectangles, circles, zig zags, diamonds, chevrons, horizontal shapes and perpendicular shapes. The Ndebele artists use the following calculations to construct their shapes:

4.4.1 *A triangle shape*

Ndebele artists prefer to use triangles in their work, and they come in different positions and sizes such as upright or inverted. What is important when creating this shape is the skill employed by the artist which involves the accurate centering of a triangle, size maintenance and shape.

According to participant 1, creating this shape requires years of experience in calculations. For example, when it comes to creating a triangular shape using beads, the artist needs to employ accurate calculations to the size of the triangle, its height, the number of triangles required, position of the triangles and decide on the colours of the triangles.

For mural art, Ndebele women create the basic geometric patterns, by firstly drawing the black outlines on a white wall surface, which is later filled in with colors. Areas contained within the same broader lines are typically filled with the same color. Usually, one pattern is filled in and completed before the process is repeated for the next pattern, resulting in a sequential process that slowly covers the desired area. Participants do not use any objects for measuring the shapes and space but rather

use their hands to calculate the space for the shape and then highlight the area with a tiny dot (preferably black) which will be replaced by the actual paint of the same colour. Participants carefully did the first coat of the shape, in black which is the highlighter then later filled in the shape with the desired colour. Black gives life to the painting thus the preferred choice as a highlighter by most artists.

According to participant 3, this process for mural art is done by artist for all shapes. However, unlike mural art and other painted artefacts, the process applied in beadwork is complex and requires advanced skills of mathematics. It takes years of experience, talent and professionalism for artists to come out with a masterpiece that is admired by other bead workers and potential buyers. It was observed by the researcher that there are certain calculations made by the bead workers to create a certain shape. For instance, if a bead worker chooses to create a triangle, she needs to decide the position of her shape. If the beadworker? chooses the center, what she does is to count the bead grains forming the beadwork and divide these by two to arrive at the centre. From that point she has to know to what extent the base of the triangle will be. She then counts the actual number of grains to the left, and again from the centre move the same number to the right, giving the beads desirable colour which will be the one to form and determine the border of the triangle. As she continues with her decorations of the next line, the beads forming the border decrease to one less on both sides. This step narrows the hands of the triangle towards each other up until the top is attained thus covering the inside of the triangle with a suitable colour. If the triangles are more than one, the above-mentioned process gets continuously repeated (see Figure 4.3).

If the artist chooses to create an inverted triangle, she does the above-mentioned process, reversed. After the centre of the article has been secured, the artist uses only one grain with a different colour to mark the top of the triangle. As she continues to the following row the beads on the inner side of the triangle will increase in a regular and even manner with one or two beads each time, it all depends with the bead-maker. The final product always ends with two styles; first, a triangle can end up being a right-angle triangle with each angle amongst the two having other two a forty-five degrees' magnitude. As far as the hypotenuse is concerned, the other two sides are always equilateral. The angles may also be vertically opposite to each other or face one

direction. Second, the triangle at the end can be an equilateral isosceles triangle. This is a triangle that has two equal sides with two equal angles opposite of those sides.

This expression has been confirmed by participant 1 who said the following:

“Abafazi abaphothelako babantu abanelwazi leminyaka ngomncamo. lindlela abaphothela ngayo, ikhipha iinqephu ezihlukahlukenekho ngeskhathi sinye. Umma ophothelako sekayazi bonyana nakangabala imincamo yakhe ngendlela ethize nakaphothelako, imiphumela yejamo lento bekayiphothela izokubanjani”. Women who specialize with beadwork are people with superior knowledge and experience with beads. The manner they work allows them to produce different shapes at the same time. A woman who is a bead maker knows that when beads are carefully calculated using a certain strategy, then she will be able to predict the outcome.

4.4.2 Squares and rectangles

Squares and rectangles are the most used shapes in the Ndebele beadwork and mural art. The researcher discovered that what makes these figures to be simple especially when bead makers make them is that there is no subtracting or adding of beads involved in their creation. Once it has been concluded on how many beads are needed to create either a horizontal or a perpendicular line, a similar number of beads is held up until the point when the figure is finished. The artist can then choose to make her craft sophisticated by adding other shapes inside the square or rectangle when completed.

Participant 3 told the researcher that creating rectangles that have shapes within is usually done by artists who specialize with mural art as shown in Figure 4.5 and when the bead worker decides to do the same, she depicts a house that is rectangular in shape. It is her decision to depict the rectangular shape found in windows or arch doors. In case such happens, a bead worker will do many calculations to achieve the perfect figures she desires. In addition, a matured and well-experienced bead worker who has passion for beauty can only attempt. Participant 5 mention that it is such a complicated figure. Creating such figures consumes time and requires patience with the art and experience in bead calculations. Common beaded rectangular artefacts can be seen in female aprons (see Figure 4.4).

Participant 5 further elaborated that “...*akusiwowoke umuntu okghonako ukuphothela ngalendlela ...*” (Pointing at a rectangular apron with complex geometric figure). In English, the participant meant that not everyone has an ability to do these sophisticated shapes.

From the responses the researcher gathered, women who create this complex beadwork have exceptional knowledge of bead making and it is highly unlikely for them to make any errors because they have years of experience in bead calculation and are able to predict the outcome of their work.

4.4.3 Circle shape

It was brought to the researcher’s attention by participant 1 that it was unusual for a Ndebele artist to make round figures in her art. For mural art and beadwork, round figures are found on a rare occasion when an artist decides to depict a car or a bus. According to this participant, a round figure is avoided because it is not easy to make a circle using beads. One could have to go through some intricate calculations in order to obtain a round figure. These types of calculations are not involved when other shapes are made.

In support of the above statement, participant 3 stated the following:

“Ngingatjho bonyana kubudisana ukwenza indingiliza ngomncamo. Kunokubala okunengi okwenziwako ngaphambi kokobana into efunekako yenzeke”. I can say that it is difficult to create a round figure using beads.

Complex calculations are employed in a process of getting a desired figure.

Ndebele artists prefer to have round/circular figures in beadwork in a form of hoops for hands, neck and legs because the calculations are less complex and not time consuming (see Figure 4.3). The process of making these crafts was explained by participant 1 who said that firstly, it includes collecting grass, measuring the amount of grass which will be needed for the hoop and depending which body part the hoop is for. Secondly, the grass is carefully bent to create a round figure while it is moist/wet then tied with a wool around. Thirdly, a bead maker uses a thread and needle in order to be certain that the grass does not break and creates a perfect shape. She later covers the round grass with a cloth and uses both a thread and needle to join the cloth to the grass. She then creates a joining point where she will start knitting her beads to

the cloth. A bead maker is not certain about the number of beads needed to complete the hoop. Therefore, she predicts how many beads she will need. She carefully places her beads inside a long thread before start knitting on the cloth. The hoop guides her to increase the number of beads in the thread until the hoop is finished. Ndebele artists prefer having one set of colours for hoops, which makes it less complicated to create the craft. Since the colours are almost uniform, the artists do not need complex mathematics to make the hoop but simply follows the lead of the hoop in terms of how many beads to knit around the craft. Participant 6 stated that another round ornament made by Ndebele women is brass/copper rings. However, this ornament was introduced to them through trading around the 20th century. It is bought while packaged before sorted by the artists. The artists measure the desired brass ring using their body features such as necks, legs and hands. They will then coil the brass according to the length and width of the body feature. Participant 1 argued that most women prefer creating their own brass rings of which they were until they die because they are not allowed to remove them for cultural purposes.

4.4.4 Zig-zag (fuzzy) patterns and shapes

This researcher discovered that zig-zags are easier to construct and are mostly favored by the artists (see Figure 4.3). Zig-zags are in essence baseless triangles linked together and just like chevrons, zig-zags are mostly used as borders on an article. It was observed that zig-zags are found in small sizes and the largest can be approximately six centimeters and the smallest about one centimeter. Zig-zags mostly are found in two shapes. The first one is wherein the two arms meet at a sixty-degree angle before turning into a different direction. The arms will continue to link and form a chain and the length will be decided by the artist. The second type is when one arm moves in a side inclination to a required height in order to meet the other arm which will result on forming a sharp angle of about forty-five degrees with the other arm remaining in perpendicular position. This combination continuously repeats and creates the required chain length. The construction of these figures requires complex calculations. For instance, in order for a zig-zag art to lean towards the right-hand side, the artist will then have to constantly increase the number of beads on the left-hand side, each line having one extra bead than its predecessor. Zig-zags are mostly used on headbands, chest coverings, belts, blanket borders and many other beadwork articles.

4.4.5 Diamond shape

The results for this chapter indicate that an artist needs to determine the exact spot where the diamond figure had to be placed then after creating the bottom-most point of the diamond shape. This is done by quickly changing the initial colour and have one grain of bead that contains different colour which is mostly a brighter one than all used this far. The mathematical technique used for this figure is increasing the beads in the next row in order to form the shape in the next row from one to two and three in the third and continuously doing so until the desired width has been achieved. The artist will then apply the same technique but use a reverse action whereby the beads are decreased rapidly until there is only one bead of that colour on the last row.

A diamond figure in beadwork is used by the artist mainly as a divider and no complex calculations are necessarily required in creating this figure, hence preferred by many bead makers. For this figure to be created, the artist applies her skills and knowledge of simple mathematics that are addition, subtraction and division which support the statements made earlier in literature review section of this study.

Moreover, it is the decision of the bead worker to decide how many diamonds are needed in the beadwork. The size of the diamond also plays a vital role in a sense that its size as compared to other figures should indicate that it is a decider or partition. There is a need for the diamond shape to have a relationship with other figures as the start indicates the position or role of the diamond figure in the article. Bead workers prefer bright colours for their diamond figures in order to allow the figure to stand out in the article and also use that as a strategy to attract customers as shown in Figure 4.3.

4.4.6 Chevrons (V) figures

Participant 2 mentioned that a V-shape is always present when creating a decoration consisting of chevrons. In most cases, the artists places the V- shape at the center of the beadwork article in order for it to divide the craft into two equal parts. The half on the left will have chevrons leaning to the left and the half on the right hand will have chevrons sloping to the right as shown in Figure 4.3. In case of the V-shape facing upside-down, the order of the chevrons uses a converse arrangement of the order discussed before.

The most important measurement in chevrons is the first pillar because all calculations rely on it. The chevrons commonly tilt at forty-five-degree angles in both left and right sides. In order for this tilting to be achieved, the artists will have to calculate the needed number of beads on the first row until to the position where she wants the first pillar of the chevron to be situated. She then changes colours to the desirable colour she wishes the chevron to have. This new colour will be kept up to cover the required width of the pillar. Normally, the colour of the pillar is a complexity of the foundation colour. Subtracting one bead far from the pillar guarantees that the pillar tilts to the left.

Turning around this activity makes the pillar tilt to the right side. Chevrons and v-shaped figures are a major and excellent fascination. They function admirably on little articles and utilized for the most part as borders stamping either the base or the best most piece of the bead-work. Once in a while, the artist may utilize chevrons and V-shaped figures to stamp the center of an article.

4.4.7 Horizontal shapes

The manner used by the artist in creating a horizontal object or artefact differs compared to the one used by other artists who use a pencil and brush. In bead-work, the method requires the artist to use a certain colour of beads as if a straight-line design is employed as shown in Figure 4.4. The artist has to imagine the size of the shape before creating one because there is no prior sketching of the figure made by the artist. Therefore, the shape and size of the product is in the mind of the bead worker expert. Supporting these findings, participant 3 mentioned that following:

“Thina njengabomma abagwalako sisebenzisa isthombengqhondo, sitjheje bonyana sifuna siguna ukuphothela umcamo ubemude kangangani. Asitloli phasi begodu asimedi kodwanan sibanesthombengqhondo”. As bead workers, we use our brains to predict the size of an object. We do not use any measuring tools but our imagination.

To portray a horizontal line well, the artist utilizes different colours. To start with, she utilizes the colour that she has picked as the base or foundation of her work. The white colour used to be extremely well known with the early bead workers. Depending on the size of the object, the artist would begin by utilizing her base colour to shape a belt of a specific thickness. The artist after deliberately thinking of her alternatives, will pick a spot where the horizontal line will begin. She makes this by suddenly changing colour

and picking one that will shape a solid difference to the original colour she was using. Provided upon how thick the line ought to be, she will keep up that same colour for a couple of more rows. To accomplish that, she may choose to move back to the original colour or utilize an alternate colour all to assemble. This strategy will be repeated for whatever length of time where there are horizontal lines required. From an exposed eye, this arrangement of beads resembles a watertight horizontal line. Lines like these are a trademark feature of most Ndebele beadwork.

4.4.8 Perpendicular shapes

What influences a perpendicular shape to be genuinely simple to develop is the way that the quantity of beads utilized are genuinely reliable in number when contrasted with an inclining figure. After the artist has set up what numbers of beads are vital before and after the figure, a similar number is repeated continuously. Care is constantly taken that the borders of the perpendicular shape are constantly parallel to the sides of the main article. The excellence of a perpendicular shape lies in the parallelism framed by its own borders with the borders of the main article. Perpendicular shapes are found in figures portraying high dividers of a building, figures like electric poles and in addition, tree stems. Windows in a house and all other box-molded figures also usually require perpendicular shapes. Artists who specialize in mural art mostly draw perpendicular lines when separating or creating a mirror of the same shape as shown in Figure 4.5 below.



Figure 4.3: Circles, Triangles, Zig-zags, Diamond, and Chevrons in Ndebele beadwork.

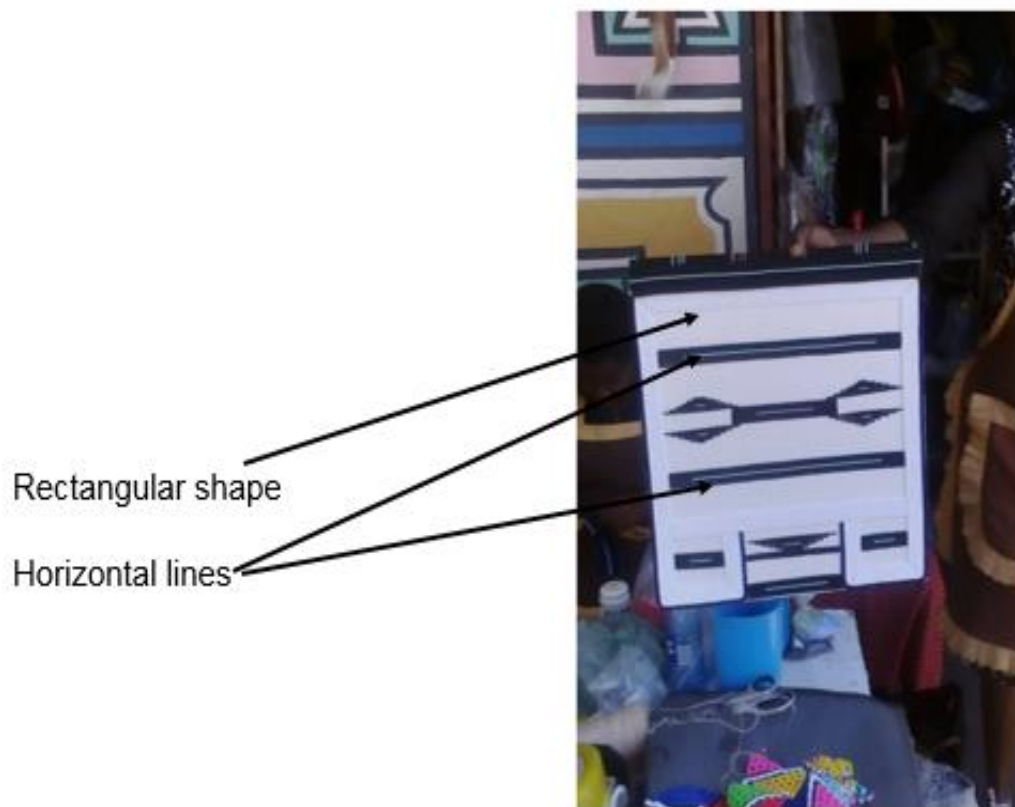


Figure 4.4: Rectangular shape and horizontal lines in female beaded apron.

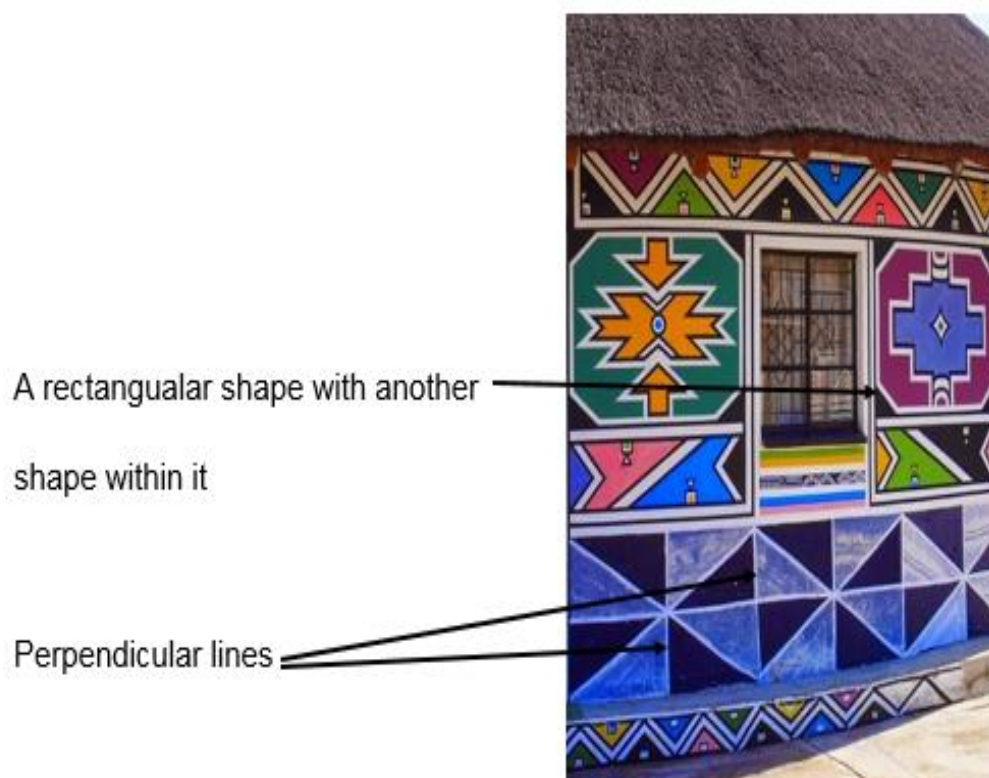


Figure 4.5: Rectangular shape and perpendicular lines in mural art.

4.5 Mathematical concepts and ideas used by Ndebele artists in their art techniques

The results of this study show that AmaNdebele women employ different techniques in both beadwork and mural art. The techniques which were identified are as follows:

4.5.1 Technique in beadwork planning

The Ndebele beadwork undergoes the preparation stage. This stage includes the sorting of beads according to their colour or size. Different colours are kept by artists in containers. This is done to make the job of an artist easier as shown in Figure 4.6 since she may need to use one coloured beads for a vast space on her work. She may choose to use other beads with different colours at a later stage. In the Ndebele language, the bigger beads are known as *iindalama* and are carefully kept in a separate container by the bead worker.

The Ndebele beadwork can be categorized into four. Firstly, there are necklace articles which are not complex to design. Secondly, there is beadwork used on grass hoops (*iinrholwani*) finishing. Thirdly, there is beadwork where beads are attached onto a hide backing or a cloth-like material. Lastly, there is a type of beadwork where beads are joined together, forming a belt shaped article.

Unlike other plannings that require measurements, a Ndebele bead worker does all the planning in the mind. It takes an artist with vivid imagination to come out with well-done articles. Before the artist commences her work, it is necessary that she imagines the complete article which includes the colours involved, length and width of the finished product (see for example, Figure 4.7). Normally, if the artist is making beaded attire for another female, she then measures using sight (eyes), string or wet long grass.

The bead worker needs to have all the material for the article ready. This includes having enough beads of desirable colours, enough tread and more than one strong needle. One of the challenges an artist can have is to experience shortage of beads which may force her to use other colours and change pattern of the article from the original one.

4.5.1.1 Drafts drawing

Drawing takes place in the form of planning. An artist is able to think of the shape she needs to use for her article and draw it on a piece of skin using an object of the same shape that has the same size. For instance, items like *iphephephethu* which is a front apron for maidens and the front apron which is worn by married women is known as *isphokgho* in IsiNdebele are firstly drawn on a skin then later cut carefully and tailored. It is not until the whole planning has been thoroughly planned and completed that the first bead is sewn onto the leather

The Ndebele artists have not mastered the stage where colours of beads required are shown on the drawing in advance. Also, the patterns they use for decorations are not recorded down in a written form. Therefore, the coloring in the art depends on the desires of the artist.

4.5.1.2 Technique used in mural art

The planning of a Ndebele artist takes place in her mind. She imagines the pattern she wants to paint. According to participants, they observe the size of the wall piece they want to paint in order to decide on its pattern. Ndebele artists use a free hand drawing for their art and no measuring instrument is utilized as seen in Figure 4.8. The process of making a painted artefact or mural art is discussed on 4.4.1.

Beads sorted according to size



Figure 4.6: Artists showing the researcher how beads are sorted.



Figure 4.7: Artists instructing the researcher on how to measure the beaded artifact desired, mentally.



Figure 4.8: Dr Esther Mahlangu teaching the researcher how to paint using free hand drawing

4.6 Styles used by Ndebele women in their art

When participants were being interviewed during the focus group discussion, they kept mentioning to the researcher that they have their own preferred styles which distinguish them from other female artists in the continent. Those styles were shown to the researcher in Figure 4.9. During the focus group interviews, participants for this chapter agreed on doing two types of styles which are adjacent structures and rhythm and rhyme structured. The following are the results:

Adjacent structures: The Ndebele artists will prefer having a beaded structure with the same size and shape facing one direction. According to artists, it is very unlikely to find Ndebele beaded item with different figures standing next to each other. An artist also constructs beaded items that are always in pairs. The researcher observed that an artist would create a beaded item with a figure at the beginning and with its mate created at the end of the item. However, the two shapes face opposite direction. This is known as coupling figures. Furthermore, the researcher observed that artists employ back to back figures in their beaded pieces. The beaded item will have to have the same figures with equal measurements facing direct opposite to each other with a different figure in the middle separating them. The Ndebele artists also prefer doing beaded items with two of the same figures vertically opposite to each other.

Rhythm and rhyme: A bead worker places her shapes in strategic manner to evoke communication with her audience, and this is done in mural art. Rhythm and rhyming in mural art are like “sisters” that go together to communicate with the outside world and express the feelings of an artist without her altering any sound.

Subsequently, participant 8 alluded the following:

“Umgwalo ufana nomvumo. Indlela umvumo wenzwengayo kufanele kubenehlelo lakhona, begodu nnensimbizakhona zikhambelanne. Yeke, ngendlela kuhlelwa ngakhona kufanele kube nendlela yokukhambiselana begodu kubenomlayezo othulwako nendlela ukukhuluma nabanye abantu”.

Mural art and beadwork are like music. The manner in which music is designed has to be a rhythm and everything has to rhyme. Therefore, the manner the patterns are constructed have to have both rhythm and rhyme

and a message is established and communication is conveyed to an audience.



Figure 4.9: Ndebele artists showing the researcher styles they prefer to use in art

4.7 The meaning of geometric shapes embedded in Ndebele beadwork and mural art

Participants were asked a question on the meaning of geometric shapes found in Ndebele art. Similar responses were provided by the participants who showed that they did not know the meaning of each geometric shape. Participant 1 said she believes and was told by her elders that Ndebele shapes are related to the cosmos, but she does not know what each shape means. She noted that some of the knowledge about Ndebele art got lost along the way. In her own words she elaborated by saying the following:

“nakungimi angazi, kodwana ilwazi elinengi ngemvelaphi yethu lalahleka. Mhlambe ukhethiwe bonyana ulirhubhulule, ngekhe wazi”. As for me I do

not know, but most knowledge about the history of the Ndebele got lost on the way. Maybe you were chosen to do research about it, you may never know.

She further stated that people who can provide the researcher with answers are diviners because they are the people who have the powers to interpret such knowledge. She also made the researcher aware that Ndebele people have knowledge of the universe and an ability to interpret stars.

Participant 4, on the other hand, said she can associate the circle with the sun which is the source of life. She further noted that knowledge is from God and the gods, then it is sent to us so that we can be able to transfer it to the next generation. Knowledge can be associated with a circle; its infinity meaning that it never ends. In her own words, participant 4 had this to say:

“Ilwazi libuya ebezimini kunye na kuZimu, lize kithi ebantwini nasiqeda la silidlulisele phambili kunzukulwana zethu. Ilwazi lingafaniswa njengendingiliza, alipheli. Furthermore, regarding the circle, participant 6 stated that:

“Abandrwana nasibaqoqela iinganekwane ebsuku sibahlalise phasi bazombezeze umlilo. Ngaleso skhathi vane inyezi iphumile begodu neenkwekwezi zikhanyisile esbhakabhakeni. Sibafundisa neengomma ezimumethe ilwazi lethu”. When we tell stories to the children at night, we sit them down in a circular setting. By then, the skies will be open, the moon and stars will be shining bright. We even teach children songs which have our indigenous knowledge.

4.8 The process of colour mixing in mural art

Colours are sourced from nature in order to apply in Mural art. According to participant 3, colours for mural art are sourced from the following: red colour sourced from red ochre; white colour from white clay; black colour from charcoal and cow dung; yellow colour from yellow ochre; green colour from leaves and other colours are produced from mixing different colours.

First, colours obtained from natural sources mentioned above are squashed on a flat rock using a round rock until they turn into powder. Secondly, impurities are removed from the powder using a traditional man-made separator tool. Thirdly, the powder is

measured using small calabashes, then poured to big calabashes (or empty tins). Fourth, required water is poured into the small calabashes for measurements before poured into big calabashes. Colours are mixed with water by way of stirring using wooden spoons. They are then applied on a wall or object.

4.9 Colour symbolism in the Ndebele beadwork and mural art

Participant one stated that the usage and interpretation of colours differ according to cultures. AmaNdebele women have chosen to use variety of colours according to occasions. The usage of colour by the Ndebele. However, because Ndebele people are scattered all over South Africa, the interpretation of colour and usage may differ according to area and geographical location. For this study, the research found out that women at Ekosini interpret colours in the following manner:

White colour

A white colour “*umbala omhlophe*” in isiNdebele is associated with purity, light, hope and good fortunes. Participant 1 stated that in the olden days, a Ndebele bride would be dressed in a white traditional attire with a beaded veil known as *isiyaya* covering her entire face. The reasons for the bride to dress in white were to symbolize her purity and celebrating her own virgin. The concept of purity is highly regarded amongst the Ndebele and it is because of such reasons that Ndebele art for a long time had a dominant white colour. Even the Ndebele diviners sacrifice a white chicken or goat when performing rituals for the gods.

Participant 1 expressed herself as follows:

“...*mbala umhlophe esiwusebenzisa khulu nasigwalako. Mbala uhlathulula ukuthula nokuhlambuluka*”. ...white colour is mostly utilized by women in mural art because the colour symbolizes peace and purity.

Green and yellow colours

The green “*umbala ohlaza*” and yellow “*umbala otjheli*” colours have a very close relationship and can be interpreted almost the same. The Ndebele artists agree that yellow is the result of mixing white with green. While some colours are associated with positivism, others are interpreted as negative, symbolising sadness and evil.

The AmaNdebele women do not often use green for their art. Green and yellow colours are never used as a background colours as compared to white colours. In most cases, the green colour is used for the maiden's hoops and hardly used by grown up women. Toddlers and young girls' beadwork attire does also include green but mostly absent in adult women and yellow colour in art has been unheard of. The green and yellow colours are associated with growth in spring, abundance in summer, and the harvests in autumn.

Participant 6 highlighted that for any Ndebele, spring is always welcome because it drives away the adversely cold winter conditions. It ushers in green looking sights of green tracts of grazing land and plantations. Therefore, the green colour in the hoops of maidens symbolise a new female that has entered womanhood and has left childhood behind, which also explains the interlink of the green colour and spring season which is when the girls are initiated and prepared for womanhood. Because green is seen as a colour of growth, Ndebele maidens wear beaded attire with this colour during their initiation ceremonies to show that they have received blessings from the elders to marry, start their own families, and have plenty of children.

Sky blue colour

A sky blue which is known as *umbala wesibhakabhaka* in IsiNdebele is one of the most dominant colours in the Ndebele art. For instance, Participants 6, 3, and 2 gave an example of the multi-coloured blanket worn by Ndebele people on special occasion known as *unokhethwako*, where a blue colour is always dominant. Blue is a powerful colour because it is associated with the sky and the sea. Therefore, a Ndebele female wearing a blue beaded attire or having a painted house walls with blue colour symbolises a position of power. The blue in the art communicates that the power of that individual is associated with nature such as tempestuous storms in the sea or hurricanes and is as high as the sky.

Opaque red colour

An opaque red colour "*umbala obomvu kwegazi*" can never be missed in Ndebele art. It is the colour that symbolises pain, stress and uneasiness. At the same time, it symbolises love and romance. However, the participants of this study associated this colour with pain, anger and death. In support of this argument, participant 1 noted the following:

“... asingakhohlwa bonyana amaNdebele walwa namabhunu. Umbala lo utjho ubuhlungu boke esahlangabezana nabo namaphilo esawalobako thina njengetjhaba sikaNdzundza...” (...It shouldn't be forgotten that the Ndebele people has a war with the Boers. This colour symbolises the pain and deaths we faced the Ndzundza Ndebele...)

Black colour

Amongst the Ndebele people, black colour has always been associated with bad luck, wizardry, witchcraft, and bad spirits. In IsiNdebele, a black colour is known as *umbala onzima*. It was discovered by the researcher that for a very long time, Ndebele people did not want to associate themselves with the black colour and artists have tried to avoid it in their art. This was affirmed by participant 1 who stated that black colour is avoided by the Ndebele because they were in a dark stage for a very long time oppressed and killed by the Boers in the Mapoch (*mabhogo*) caves during the Mapoch war. The Ndebele were forced to hide in the dark caves and only sneak out in the darkness to get food and water. There is an expression amongst the Ndebele known as *ifu elinzima* which means dark cloud. This expression is mostly said when a person is facing difficulties in his life or is experiencing bad luck, and misfortune, which all symbolise a dark period. However, because culture is dynamic, liquid and changing, the Ndebele art of today is seen to involve black colour in a large quantity. Participant 1 made it known to the researcher that the black colour still speaks volumes to the Ndebele history and in this modern period, it has been utilized as a way of communication. According to participant 3, black colour amongst the Ndebele is now associated with dignity, strength and bravery. The decision of using this colour has shifted the paradigm in the Ndebele belief system and people are slowly accepting its utilization.

Pink colour

Pink colour known as *umbala obomvu kokukhanya* in IsiNdebele is found in female hoopoes. The colour is associated with growth, prosperity and good fortunes and can never be missed in female beaded attire. In an elderly and newly wedded women attire, each body hoop has a pink colour. An example was given by participant 6 that

the neck thin hoop known as *ubukhobe* is pink, one hand hoop is pink, one waist hoop reflects a pick colour and one leg hoop must have a pink colour.

4.10 The cultural significance of Ndebele art

The Ndebele art reflects Mathematics and has cultural significance. Ndebele art (with colours included) symbolizes the struggles experienced by the Ndzundza Ndebele. According to participant 1, Ndebele people started communicating using this art after they had lost the war to the Dutch speaking Boers in the 19th century. This art was firstly reflected in mural art before it was adopted in beadwork. This was a way of communication that the colonizers did not understand so it was permitted because it was not seen as harmful or threatening. According to participant 1, women are responsible for this cultural expression. In her own words, participant 1 further elaborated that:

“umgwalo lo usikhumbuzo kithi AmaNdebele begodu uysisindu sethu. Yeke, siragela phambili nomgwalo lo ngombana uqakathekile esindwini sethu”.

This art is a reminder of what we have gone through and it also part of our culture. Therefore, we continue embossing this art because it has cultural significance.

Participant 3 added that the Ndebele art also symbolizes the status and age of individual. How a house is painted/decorated reflects the wealth of the family/husband. Also, the sophistication and presentation of beaded attire worn by a female reflects her status (wealth, power and marital status) within the community and age group. Culturally, these attires were worn in everyday life but currently are utilized for different ritual ceremonies such as traditional wedding and rite of passage ceremonies.

4.10.1 The cultural significance of AmaNdebele women dress codes which display Mathematical ideas and concepts

A participant argued that one of the most important lessons taught to Ndebele girls is to learn the laws surrounding the attires worn by women at different stages. From a tender age, young girls are taught about the different life stages of AmaNdebele women, attires they wear and what they mean to the society. In the Ndebele culture, there are highly strict laws associated with female dress codes. Dress codes are believed to serve as communication, have symbolic meaning and associated with

spirituality. The following are dress codes associated with female at different ages that hold different status.

4.10.1.1 Ndebele toddlers

Toddlers are introduced to an outfit known as *irhabi* (Figure 4.10), which is a tiny front rectangular apron for girls whose sizes differ according to their age, body size and height. This is one single item which is so important to any Ndebele girl's wardrobe to the extent that dressed up in anything else with the *irhabi* absent makes her feel half-naked. Girl toddlers usually wear *irhabi* and waists circular hoops known as *iinrholwani* (singular *isirholwani*) *zedidini* with nothing covering the back symbolizing that they are still infants. It is not offensive to the Ndebele people for a girl to be dressed in this manner. The toddlers' attire sometimes includes leg hoops, which is something that does not happen likely. Toddlers also wear what a beaded neck accessory called *irasu*, which is circular in shape. Toddlers, young girls, teenagers and maidens wear this necklace.

In support of the above, participant 4 stated the following:

"Irhabi limbathwa bendwana babendrazana abasanuka ibisi khulu begodu akukho abakumbathako okuvale ngemva. Ngokuya ngesikhethu, lokho akusingilo ihlazo". Female toddlers wear the tiny rectangular apron without covering their back. Such is not a disgrace but allowed within the Ndebele culture.

Irhabi consists of tassels known as *ubhagede* in IsiNdebele, suspended on stiff leather and are worked to be knitted tightly together. These tassels have a white bead finishing at the end and are always hang downwards. Younger girls depend on their mother to create the outfit for them and properly dress them. For young girls, the embroidering is less sophisticated. The beadwork, colour and designs in the beaded attire are the choice of her mother who is responsible of making this attire. See figure 4.10 below which shows:

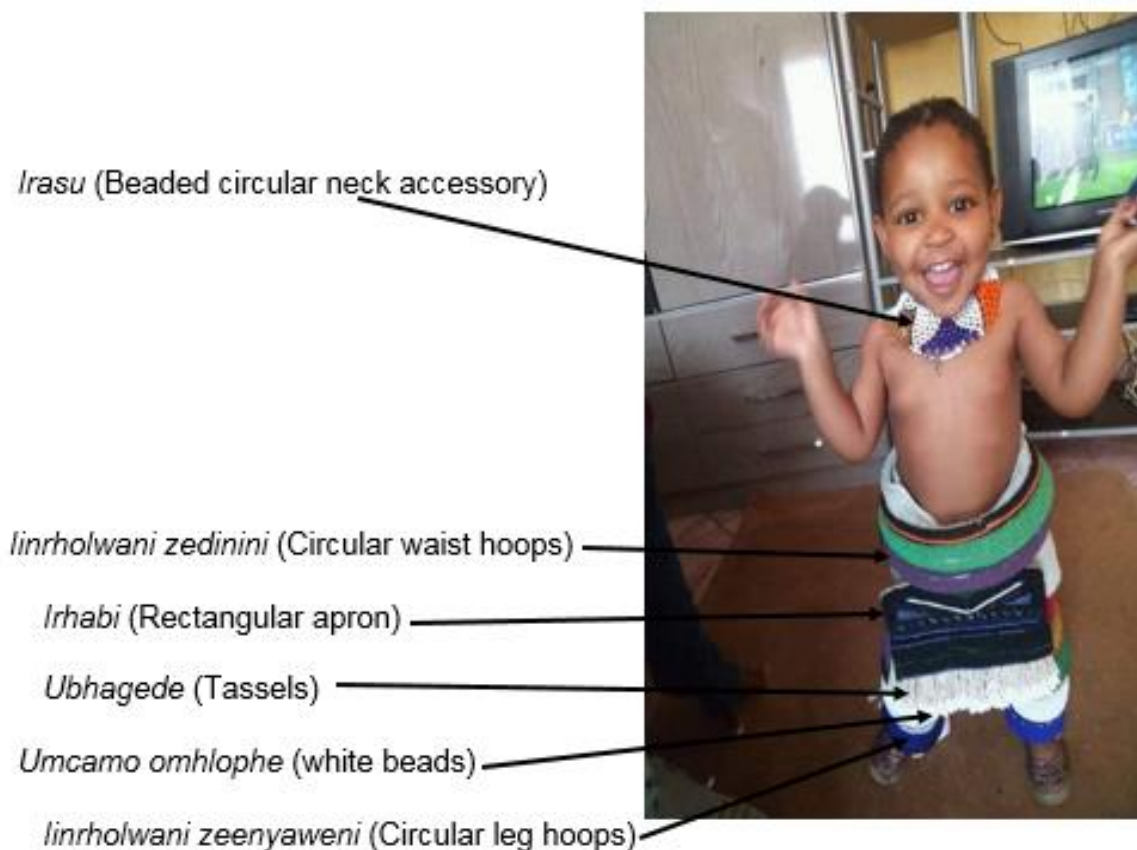


Figure 4.10: A Ndebele toddler wearing beaded attire. The attire illustrates many mathematical concepts.

4.10.1.2 Girls at puberty

When a girl reaches puberty, she gets to be exposed more to the Ndebele attire that has mathematical concepts and ideas. The girl begins to wear an *irhabi* which is bigger in size, with a sophisticated embroidering of her choice and more respectable than the one worn by toddlers. Older girls who have been exposed enough to the Ndebele art and have been selected as old enough to be involved in cultural creativity, wear very sophisticated artistic pieces of embroidered attire which is the product of their own hands. Such can be seen in the *irhabi* (beaded rectangular apron) and *iinrholwani* (circular beaded hoops). This has been supported by participant 4 that:

“Umndrazana okulesisigaba ukghona ukubonaumehluko begodu uyazikhethela bonyana irhabilakhe lirhabiswe bunjani. Uyakghona ukuzenzela irhabi kodwana ngerhelebho likanina”. The paragraph above, translated into English, means the following: A young girl at this

stage is able to choose how her apron is supposed to be decorated. She is capable of making her own apron with assistance from her mother.

A young girl at this age can have two or more *amarhabi* which is a plural word for *irhabi*. The young girl can wear one of *amarhabi* for everyday life and another for a special occasion just as seen in Figure 4.11 below. Unlike younger girls, a girl at this age is advised by her mother or any female senior to always wear a small skirt at her back which is known as *ibhayana* and has recently been substituted by a towel or a small blanket that a suitable size for the young girl. A young girl at this age wears wider circular waist hoops and she is introduced to leg hoops known as *iinrholwani zeenyaweni* for the first time.



Figure 4.11: A Ndebele girl at puberty stage wearing beaded attire. The attire illustrates many mathematical concepts.

4.10.1.3 Ndebele teenagers

The next remarkable stage is when a Ndebele girl becomes a teenager. The point of demarcation is when the young lady observes her menstrual period for the first time. As a sign that the young lady is becoming matured, her parents organize a ritual ceremony for her which is known as *iqude*. This event lasts for approximately one to two weeks. If it lasts for two weeks, it is extended by a week-long preparatory event known as *Ipugu* but that depends on the surname of the family and protocols surrounding it. *Ipugu* is attended by both men and women. The second week, only women are permitted to participate and men are not allowed to even come closer to the house where the ritual is taking place. All the members of the community are invited in the last day of the event which is mostly on the weekend. On the last day, there is a feast for the entire community to enjoy. The slaughtering of a cow, bread and jam form the most important visuals during such an occasion.

After *iqude* ritual ceremony, the young woman joins the next level of womanhood with a different dress code. At this stage, the Ndebele maiden wears an outfit that displays her status and shows that she is now a matured lady. At this level, *iphephethu* and *isithimba* are introduced. *Iphephethu* is a rectangular beaded apron for matured Ndebele women (Figure 4.12). At this stage, the maiden can wear both *iphephethu* and *irhabi*, making the *irhabi* act as an underwear. According to participant 1, on an ordinary day, young women wear *irhabi* alone as a casual outfit then save the *iphephethu* to be worn on a special occasion. *Isithimba* is a piece of a cowhide that is carefully cut by an expert, used to cover the lower back of a maiden.

It is at the same time that a Ndebele young maiden is introduced to the *ukunghadela* practice which is a term used by women in an occasion when a female is dressed with a new set of beaded hoops made from grass. A Ndebele maiden receives her set of circular grass hoops which are known as *iinrholwani* and this is customary practice. However, it should be noted that it is not bound for her to wear these hoops but most of her peers put them on, therefore it would be very strange for her not to have a set of hoops and wear them. Participant 2 stated that the scale as found at this stage/level of hoops in this age increases.

Participant 5 argued that there are two types of grass used to make hoops. Firstly, there is grass known as *utjani bomthanyelo* (grass for making brooms) found in

forests, secondly *umthala* grass found in wet areas and dams. Both these types of grass are preferred because they can easily bend without breaking especially when dry. To prevent the grass from breaking, it is soaked for overnight and worked on whilst damp. A beautiful round hoop is created carefully with a length that can allow movement. It is later tightened with a thin strap cut from a goatskin but recently Ndebele women use strong cotton.

There are four different types on Ndebele circular hoops: the arm hoops, waist hoops, leg hoops and neck hoops. The waist, leg and arm hoops are never meant to stay permanently on the body. For this reason, they are made to have bigger holes in case of removal. Arm hoops are smeared with fat then pushed to the upper arm. The fat is applied in order for them to glide easily without any or little discomfort. The arm hoops are only used only as a formal attire for special occasions and not in ordinary days. Neck hoops appear in two types, the permanent ones and the non-permanent ones. Permanent neck hoops follow more or less the same pattern of making hoops. In support of the above finding, Participants 8 elaborated by stating that:

“Thina njengabomma abaphothelako siyakghona ukumumeda ngamehlo bonyana uzokulingwana ziinrholwani ezingangani nokuthi zingakghona ukwembhathwa ngaphandle kokuthagisa”. (As artists, we are able to measure the size of the grass hoops for an individual using sights and able to predict if they can be easily worn by that individual without having any struggles).



Figure 4.12: A Ndebele maiden in beaded attire. The attire illustrates many mathematical concepts.

The researcher found out that Ndebele maidens usually put on a set of circular bangles in both arms for any special occasions. These bangles start at a very young age. The difference is that at this age, most of the young lady's bangles have been beautifully decorated with beads. During an ordinary day of the week, the Ndebele young women walk around with two or three plain bangles. They only wear the sophisticated bangles on special occasions which are about eight and four on each side. Each bangle may have its own colour or be decorated in geometric shapes. Participant 10 stated that it is at this age that a Ndebele maiden gives in to the persuasive courting of a persistent young man who will not take "no" for an answer. Traditionally, Ndebele maidens are not allowed to tell young man persuading them face to face that they accept their

proposals. Instead, they give the boys called *amasokana* in Ndebele one of their favourite bangles as a sign of accepting the young man's proposal.

After receiving the bangle, the young man will hold on to it as a symbol of promise. He will later wear it as a sign of pride and also as a symbol that he is currently in a relationship. In the Ndebele culture, a relationship of this kind is seen as something that will lead to marriage. Due to this, the young man is not required to kneel down and propose to marry the lady as it is done in western communities. Special beadwork accessories prepared by the woman later follow the promissory bangle. These accessories are sent from time to time as a symbol of love from the young maiden to the young man. The young man is allowed to wear these accessories in any special occasion in the area. The young man can continue to receive bangles if he has multiple girlfriends and this practice is called *ukubhayela* and was done by males who were interested in polygamy. However, this practice is no longer popular amongst most of the Ndebele.

In support of the above, participant 3 highlighted the following:

“Thina indaba yokubawa umkhamanzi uguqe phasi asiyazi simaNdebele. Ngokuya ngeskhethu, umndrazana wembatha iingrholwani ezincazana ezihle azenzelwe isokana elitjengise itjisakalo kuye. Isokaneli ngilo elikhetha ukwembatha isrholwaneso emnyanyeni ehluhlukeneko njengephawu bonyana uvunyiwe”. The quoted response of the participant means that it is not a tradition of the Ndebele for men to propose women kneeling down. Instead, girls wear small bangles to attract boys and give one to a boy interested in her. The boy can wear the bangle in different ritual ceremonies as a symbol that he has found a suitable young lady for himself.

4.10.1.4 Newly wedded women

In the Ndebele culture, the traditional wedding day is called *idendwe* which officially marks the last day of wearing *iphephethu* and the beginning of wearing two rectangular aprons worn by married women known as *iintjorholo* and *isphokgho*. *Itjorholo* (singular) is Ndebele wedding gown which is worn by a lady on her wedding day. There are two types of *iintjorholo* (plural) which are: plain *itjorholo* (singular) with no beads worn by a Ndebele bride and a beaded *itjorholo* worn at ritual ceremonies by married

women of any ages (Figure 4.13). *Itjorholo* is a form rectangular shaped apron which is cut from a cow skin by a professional. Depending on the body size of the woman, it normally has a width of between 32cm and 35cm and in some cases even more. The top part around the waist has a seam about idem folding downwards. The seam has the strong straps on either side top corner whereby the *itjorholo* is securely strapped around the waist. From the waist it drops down till a little below the knees and the bottom part ends in five rounded flaps.

The *itjorholo* is later decorated with threaded beads by a professional. Just like *iphephethu*, *itjorholo* has a beaded border about 2-3 cm wide right around the apron. Any colour may be used in creating the boarder which symbolises, peace, love and unity. Some individuals may prefer to have their *itjorholo* doubly bordered with different colours. The middle part is carefully decorated with geometric shapes or designs which are attractive. When an individual looks at it from far, they can think that it is easy to make only to realise that there are complicated complex calculations involved. It is not just anyone who can be able make *itjorholo* but an experienced bead worker. The bead worker uses her vivid imagination to design the *itjorholo* in her mind then design the geometric patterns carefully that will be used to decorate the apron. The bead worker when constructing the shapes carefully does calculations such as addition of beads, subtraction and division. Newly wedded women are also introduced to two circular neck hoops known as *ijuba* and *ubukhobe*. *Ijuba* is a thick blue neck hoops and *ubukhobe* is a pink thin neck hoop (cf. 4.10).



Figure 4.13: A newley wedded woman wearing beaded attire with many mathematical concepts.

The young bridegroom, known in IsiNdebele as *umlobokazi* wears *isiyaya* in order to avoid eye contact with the people and the in-laws. In the Ndebele culture, avoiding eye contact is a sign of respect. The custom of *ukuhlonipha* does not allow the bride to have a direct eye contact with elderly people, especially the in-laws.

An *isiyaya* is a traditional Ndebele veil made out of beads. It comprises of a headband around 2cm in width. Correct estimations are taken with the goal that the headband fits her head well. From the forehead, strings of white beads hang downwards to cover the entire face. Only pure white beads are used in the making of *isiyaya*. The white colour is a symbol of the good wishes coming from everybody, peace and luck.

The *isphokgho* (Figure 4.14) is a beaded rectangular apron specifically worn by adult married women. The wearing of *isphokgho* symbolises that a woman has been married for a long period of time. The outfit is similar to *itjorholo* in terms of shape and appearance. The only difference in these outfits is found at the bottom finishing. The

isphokgho outfit has only two panels, one on each bottom side of the apron resembling the five flaps of the *itjorholo* in shape.

Isphokgho is similar to *amaphotho* which is a plain apron (not beaded) worn by women as a morning gown. There is a row of beaded fringes in between the panels which give *amaphotho* and *isphokgho* an attractive finishing. Now and then, these fringes might be spun from pure leather to have a rope-moulded finishing.

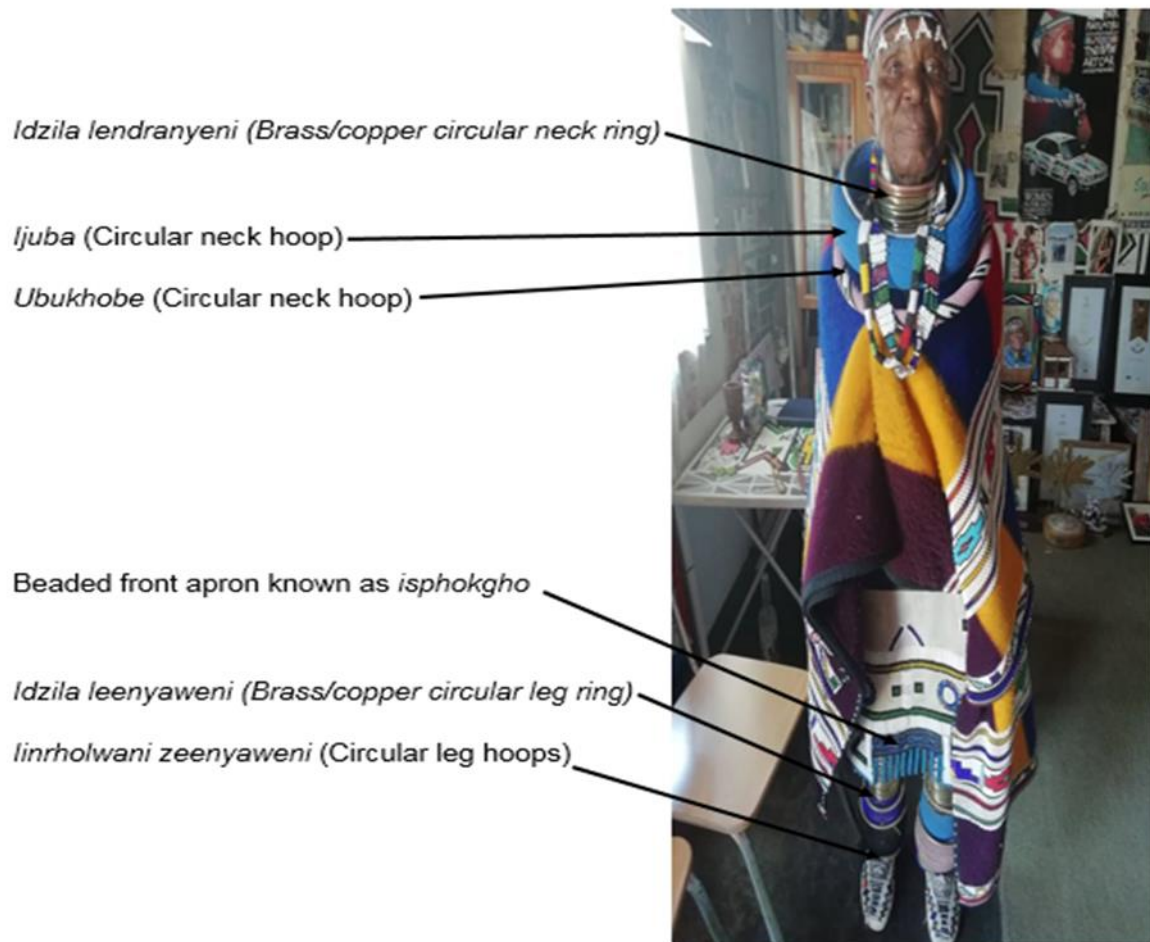


Figure 4.14: Dr Esther Mahlangu wearing a beaded attire for elderly married women. The attire illustrates many mathematical concepts.

In this class of women, *isithimba* is also worn. *isithimba* is also a part of the entire outfit worn by elderly women. There is slight difference between the *isithimba* worn by young maidens and the one worn by grown up women. The one belonging to grown up women is much more dignified and slightly longer compared to the one worn by maidens.

Isithimba is decorated with small copper rings known in IsiNdebele as *iinkozo*. The bottom of the belt is always formed by *inkonzo*. These rings are acquired from a person who works with copper. They are made to be round with a roughly 2 cm diameter. They are strung in a row just below the hard belt of *isithimba* to run from one end to another. Some women cannot afford copper rings therefore; they can only afford two rows of *Inkonzo*. Women who are married to wealthy men can afford as many as approximately 6 rows. In the Ndebele culture, it is believed that the more the rows, in *isithimba*, the wealthier the husband. During ceremonies, women dance by slightly lifting what is called *unokhethwako*, showing off the glittering copper rings, as well as competing with her opponent. Today, Ndebele women also decorate *isphokgho* and *itjorholo* with copper rings. This is to show the development of cultural creativity and also symbolize the wealth of their husbands.

Ndebele women also wear the brass/copper circular rings called *idzila* on their neck, hands and legs. Women whose husbands have built houses for, only wear these rings. Husbands provide the rings for their wives and the more the rings, the wealthier the husband.

4.11The significant role of Ndebele women in cultural expression

An emerging theme was identified in this study where participants agreed that the AmaNdebele women hold the sole monopoly of Ndebele ethnomathematics and that cannot be disputed, they are cultural custodians of Ndebele ethnomathematics. According to the participants, women amongst the Ndebele nation have always been seen as creative and critical thinkers, which is the reason why they were chosen by the higher beings to be custodians of Ndebele art. Since the Ndebele women are responsible for cultural expression, it is their duty to understand the spirituality and symbolism in their craft, not forgetting to express the communication hidden in these artefacts.

There are Ndebele taboos that restrict men from involving themselves in cultural expression (cf.5.6). It is believed that men who involve themselves in this art will experience the wrath of the gods. Ndebele males are only found to be the users of beadwork and they are traditionally responsible for the construction of architecture and

taking care of livestock. According to one participant, little boys are taught at an early age about their expected duties and the same applies to girls. Children grow up mastering their own respective tasks. This means that tasks are divided according to gender. Participant 1 who was asked questions about gender issues supported this. The following was her statement:

“Umgwalo nokuphothela kwesikhethu sakhula ukuyinto yabomma namtjhana khengithi abantu bengubo. Msebenzi wabantu bengubo ukurhabisa begodu yinto thina esakhula ngayo”. (We grew up knowing that the Ndebele beadwork and mural art are the responsibility of women. It is the duty of women to be creative using in the Ndebele culture and it is something we grew up knowing. Males only do difficult tasks like building houses).

The researcher will not give full details on the role of men in the Ndebele art because this study limits itself only to women.

According to participant 3, Ndebele women are believed to carry spiritual powers which enable them to speak to their creators. AmaNdebele women represent purity, givers of life and peace makers. AmaNdebele women carry messages from the higher being using art. After losing the war to the Boers, the art that evoked within women was a tool used by the higher beings to guide the Ndebele people about the way forward regarding their lives. Most rituals involved in the Ndebele culture are female dominant and are carried out by women. It was found by the researcher that AmaNdebele women have authority from the supreme beings to wear their symbolic beaded attire and also perform rituals in some of rituals involving men such as *igwabo* which is a ritual ceremony before young men return from an initiation school. Regarding this statement, participant 4 stated that:

“Iminyanya eminengi emaNdebeleni yenziwa bomma bonyana iphemelele bodu ngibo abayiraga ngaphambili. Abomma banesphiwo sokuletha ipilo emnyanyeni ehlukahlukene begodu ngibo abanamandla wokwenza iminyanya ikhambe ngehlelo. Abomma abambathi ngendlela abazizwa ngayo kodwana imbatho labo nendlela abaziphatha ngayo iya ngomnyanya abawurholako ngaleso sikhathi”. (Majority of Ndebele ceremonies are done and led by women. Women have abilities and capabilities of bringing life to

all ritual ceremonies. They have powers that to prevent evil from disturbing the ceremonies. Their attire is always associated with a ceremony or ritual at hand).

Furthermore, A Ndebele item such as *idzila* is believed to carry spiritual powers, which binds the wife to her husband. The *idzila*, which is a brass ring, is designed for married women to wear until death. The removal of *idzila* will not only show her betrayal to the husband but also means that she will be surrounded by bad luck and miss fortune all the days of her life for she would have broken a spiritual bond. In case her husband passes away, she has to undergo several rituals held by the family and the in-laws in order to spiritually release her from the bond she made with her deceased husband. After the rituals, she can freely re-marry a brother or relative of the late spouse as it is a customary law of the Ndebele culture.

4.8 Discussion

4.8.1 Introduction

This study has explored the feminine cultural expression of Ndebele ethnomathematics in the lives of AmaNdebele women. Mathematical ideas and concepts in the Ndebele art were also discussed in this chapter. This discussion emerged from the findings for this chapter.

4.8.1.1 Ndebele art is constructed using mathematical concepts and ideas

Ndebele art is constructed using mathematical ideas and concepts. These mathematical ideas and concepts are also reflected in their beaded attire and mural art in a form of symmetrical geometry (Dabula, 2000; Mosimege, 2017). According to a study by Zaslavsky (1999: 318), "the applications of mathematics in the lives of African people, and, conversely, the influence that African institutions had upon the evolution of mathematics". Mathematical ideas and concepts in African art can be traced in architecture, beadwork, murals, baskets, varved items, rock art, hairstyles, divination and so forth.

According to Gerdes (1995) who had previously insinuated the work that women do in artefacts such as coiled baskets, string figures, traditional mats, beaded ornaments, grass brooms, mural decorations, body painting and tattooing, women play a vital role in preserving indigenous knowledge. The work of Gerdes (1995) links to the definition

of IKS by Greiner (1990), where he recognises and emphasizes the role played by women in promoting IKS. It likewise specifies examples in which indigenous mathematical knowledge is displayed and widely utilized. In her book entitled *Africa Counts*, Zaslavsky (1999) contends that Africans have made critical contributions to the development of counting and numbers and deserve place in studies managing the subject. She at that point, keeps on expounding on the construction of the numerations system as experienced and practiced in different nations in the African continent.

Patel (2001) who conducted a study on geometry in Swazi mats stated that the Msithini group display what is known as “hidden moments of geometrical thinking” referred to by Gerdes (1995). The theoretical and empirical claims of Gerdes (1995) and Patel (2001) are supported by a fellow ethnomathematician, Ascher (2018) who believes that in order for mathematical aspects to be recognised, there has to be more understanding behind the artefacts as are culturally embedded.

Prominent ethnomathematicians, Washburn and Crowe (1988), conducted a comprehensive study of symmetry in cultural objects. Utilizing artefacts from Africa, such as Zulu beadwork, Zairean carvings, Nigerian weaving and Egyptian wall decorations, they offered a perceptual procedure of pattern acknowledgment and theoretical style analysis in material culture.

In further setting up the interrelationship between art and mathematics, Hardy (1940:30) contrasted a mathematician with a painter and a creator of patterns made with thoughts. He composed:

The mathematician's patterns, like the painter or poet's, must be beautiful. The ideas, like the colours or the words, must fit together in a harmonious way. Beauty is the first test: there is no permanent place in the world for ugly mathematics.

Recent research in Africa has uncovered the presence of mathematical connections. For instance, Zaslavsky (1999), in her work “Africa Counts”, pays tribute to the contribution of Africa in science and mathematics. From a mathematical perspective, the most fascinating find is a carved bone found at the fishing site of Ishango on Lake Edward, in Zaire (Democratic Republic of Congo) which dates back to between 23 000 and 18 000 BC. Prime numbers between 1 and 19 are represented in the marking of

the bone. The discovery of this bone proves that mathematical thoughts have existed in Africa since time immemorial.

It is reiterated that mathematics is an African cultural product- a symbol of technology, developed through engaging in various environmental activities. According to Bishop (1990: 59-60) the six activities may be identified which are:

Counting the use of systematic way to compare and order discrete objects. Locating exploring one's spatial environment and conceptualising and symbolising, with maps, drawing and other devices. This is an aspect of geometry where orientation, navigation, astronomy and geography play a vital role.

Measuring: Quantifying qualities like length and weight for the purpose of comparing and ordering objects.

Designing: Creating a shape or a design for an object or for any part of one's spatial environment. It may involve making an object as copyable 'template', or drawing it in some environmentalised way. The object can be designed for technological or spiritual uses and 'shape' is a fundamental geometrical concept.

Playing: Devising and engaging in, games and pastimes with more or less formalised rules that all players must abide by. Games frequently model a significant aspect of social reality, and often involve hypothetical reasoning.

Explaining: Finding ways to represent a relationship between phenomena. In particular, exploring the 'patterns' of number, location, measure and design which create an 'inner world' of mathematical relationships which model, and thereby explain the outer world of reality.

Colours that are found in Ndebele art obtained from natural resources and mixed carefully using measurements. Each colour utilized by the Ndebele people has its own cultural meaning and also serves as symbolism within the culture. Studies on colour meaning were also undertaken by Maphumulo (1993) amongst the Zulu youths, where he focused on the interpretation of colour in beadwork during courtship. He has found out that the usage of color was deployed to pass love messages. Zulu maidens create this beadwork for males as a way of passing romantic messages. The beadwork of the Zulu maiden to her lover can be associated with the modern love

letter. He also found out that using certain colours for beadwork required careful planning. In his explanation, Maphumulo (1993: 20) wrote:

Different colours and types of beads have symbolic function in traditional courtship. The mixing of certain colours of beads conveys the message to another person... It therefore becomes logical to transmit love messages in a most confidential manner, that is, through beads...

The findings of Maphumulo (1993) differ from those of this study. Usage of colours amongst the Zulu is different from the way Ndebele people utilise them. The Ndebele colours in art convey messages in different ways whereas amongst the Zulu, it is mainly associated with courtship.

Discoveries of this study show that shapes that are found in Ndebele art have symbolic meaning but the knowledge has been lost over the years. The symbolic meaning of the Ndebele shapes in art is believed to be associated with the cosmos. In support of these claims, the eZiko Sipheka Sisophula theory by Goduka (2005), urges the hermeneutical unpacking of African worldviews not forgetting languages, cultures and builds on a relational/ecological assumption of the African cosmology that deepens our (African people) understanding of our interrelatedness.

Furthermore, studies conducted by Van Beek (2004) on cosmology and astronomy reveal that African cultures have a close relationship with the cosmos. He makes an example of the Dogon people of Mali who have a rich astronomical knowledge and wisdom which dates back to 3200 B.C. Incredibly, the Dogon knew about Sirius, the most splendid star in the sky, and its three-star system (Sirius A, Sirius B, and Sirius C) well before researchers started examining the star's presence. They knew that Sirius B was undetectable to the naked eye and that it has a 50-year orbital period. They likewise have art and occasions dedicated to the cosmos.

In support of Van Beek (2004) and the findings of this study, Zulu (2014) in his book *'the sacred knowledge of the desert'* writes that the Basotho, like other Africans, trace their genesis to the cosmos. They originate from the Galactic core. One of their most valued stars is *Tosamasiu* (Sirius) which is regarded as a ternary star system. They refer to the orbiting star of *Tosamasiu* known as *Peo a Makgakga* (the seed of Makgakga). *Makgakga* is not visible to the naked eye. How could they have known about the orbiting stars of *Tosamasiu* without being assisted by some instruments? This is another confirmation that they are from the cosmos. They do not need

telescopes to trace their origin to the cosmos. This astronomical knowledge was passed on them by their forbears across many generations, and long before the advent of the Europeans in South Africa. Thus, all cultural expressions are interlinked with the cosmos.

Therefore, according to Indigenous Cultural Creativity theory, which guided this study, ways of knowing (including cosmos) in different indigenous communities, have influenced their cultural practices and expressions. With the knowledge provided by Zulu (2014) and Moyo (2018), using an indigenous lense, there is a need for indigenous sholars to futher investigate how cosmic knowledge has influenced the mathematical ideas and concepts in African cultures. Such a research contributes to African renaissance which recaptures what Ntuli (2002:60) called “the spaces we need to reinvent ourselves as African indigenous scholars, and to fashion our selves with knowledge systems and strategies to lead us into the next mallinium as independent people” (Ibid).

Amongst all the previous studies the researcher has reviewed, none of them critically looks at the cosmic knowledge of the Ndebele and the possibilities of the cosmos influencing the shapes used in beadwork and mural art. This research has made attempts to find out the link which the Ndebele geometric pattern has with the cosmos. Making it one of the few if not the first one to have a little breakthrough in this topic which requires further research as stated above.

According to Bell (2005), indigenous researchers have the “ability to ask meaningful questions and read non-verbal cues,” as well as the ability to “project a more truthful, authentic understanding of the culture under study” (Merriam, Johnson-Bailey, Lee, Kee, Ntseane, & Muhamad, 2001: 411). Furthermore, they are able to “understand the cognitive, emotional, and/or psychological precepts of participants as well as possess a more profound knowledge of the historical and practical happenings of the field” (Chavez, 2008: 481).

AmaNdebele women are believed to have spiritual powers which allow them to carry the culture of expressing the Ndebele identity using art. The permission to carry this art was given to them after the lost the war to the Dutch speaking Boers. The art seeing today in the Ndebele culture is the result of the war that took place in 19th century. In support of these discoveries, the indigenous cultural creativity theory states that

creativity in cultures is influenced by the environment. It also states that creativity within indigenous context expresses ways of knowing which influences the creative practices within indigenous communities. Therefore, to achieve the findings realised in this study, the use of an indigenous lense was necessary.

Concluding remarks

AmaNdebele women are ethnomathematicians who bear the knowledge of mathematics, and uses in constructing their art and which also reflects in their art. This art has cultural significance that is still valid to date. Ndebele women posses spiritual powers which allow them to pass messages from the higher beings using art that has mathematical concepts and ideas. Literature that was reviewed shows that African nations use mathematical ideas for different purposes their cultures. Mathematical ideas in African cultures are interconnected with arts, rituals, cosmos, agriculture and other knowledge systems. Thus, African indigenous knowledge is viewed as holistic. The transmission of this knowledge from one generation to another will be discussed on the next chapter.

CHAPTER 5: MECHANISMS OF ETHNOMATHEMATICAL KNOWLEDGE TRANSMISSION AMONGST AMANDEBELE WOMEN

5.1 Introduction

Indigenous peoples have their own methods for classifying and transmitting knowledge, just as they have indigenous ways of deriving a livelihood from their environment. Information, insight, and techniques are passed down from one generation to another and they are constantly improved. Knowledge holders observe ecosystems and gather eyewitness reports from others so that they can continually test and improve their own systematic, predictive models of ecological dynamics (Battiste, 2005).

For centuries, AmaNdebele women have been passing their knowledge of cultural expression to younger generation, specifically from mother to daughter. However, this knowledge can be transmitted to women of different age groups. This is done through oral transmission, participation, experiments and observation. History reveals that within the large Bantu group where the Ndebele people originated, it is the responsibility of the older women to pass down the knowledge of cultural expression (Zungu, 2000; Xulu, 2002; Costello, 1999; Mashiyane, 2006). Knowledge transmission is a process of social dissemination in which standards of conduct, cosmological beliefs, the way of life's innovative knowledge, and so forth are conveyed and acquired (Berkes; Colding & Folke, 2000). Warren (1991) brought to light that this way of transmission is not basic, and it relies upon numerous factors such as, age, gender and other socio-cultural factors. Knowledge transmission happens between people of various ages yet within genealogy, just like the case from parent to child, it might likewise happen between people of a similar age, regardless of their relationship. The objective of the work reported in this chapter was to investigate the mechanisms used by Ndebele women in transmitting ethnomathematical knowledge. The following question was asked: how is Ndebele indigenous knowledge transmitted amongst women?

5.2. Methodology

5.2.1 Research design

An ethnographic research design was used by the researcher to guide this chapter. The period that was spent collecting data has enabled the researcher to establish a strong relationship with the participants because the quality of the research findings depended on such relationships (Minkler, 2004).

5.2.2 Target population

The target population of this chapter was obtained through the snowball sampling procedure. The name of the first participant was provided by Dr Esther Mahlangu (after her first interview). In brief, after each interview, participants were requested to refer the researcher to the next participants of the study and the person was then approached and recruited to participate. The snowballing proceeded until no new Ndebele knowledge holders could be identified (Atkinson, 2001). Ten (10) elderly women at Ekosini village were identified who also had years of experience practicing Ndebele art and with rich cultural background of this art (Vonk, 2016).

5.2.3 Sampling size and sampling procedure

A sample size consisted of five (5) participants from Ekosini village who were available for the focus group interview. This enabled the researcher to use the convenient sampling procedure.

5.2.4 Data collection strategies

5.2.4.1 Tools

A focus group interview guide was used as a tool to collect data from participants. An observation guide was also used as a tool to capture information and conduct research on the activities that were observed.

5.2.4.2 Methods

The interviews were conducted in a round table sitting (Figure 5.1). The interviews were conducted in IsiNdebele which is also the language used by the researcher. The duration of each interview took 3 hours. Activities and information were captured during the observation schedule. Information provided by participants during the focus group interviews was captured on a voice recorder. Pictures were also taken using a

camera with the consent of participants. Notes taken during interviews were recorded on a diary.



Figure 5.1: The researcher with participants in a round table sitting during a focus group discussion

5.2.5 Data analysis

A thematic analysis was used to analyse data obtained from focus group interviews. Data collected during the interviews was first transcribed from the voice recorders and translated from IsiNdebele into English. The analysis was manually done on the data. To check the accuracy of the data, the researcher read across data files and themes were identified (Braun & Clarke, 2006). Triangulation was done with field notes and observations. The themes were reported as results for this chapter.

5.3 Results

5.3.1 Introduction

For this chapter, themes that were identified during data analysis will be presented as follows: Mechanisms of knowledge transmission amongst AmaNdebele women;

Reasons women embrace Ndebele art; The importance of preserving and transmitting the knowledge of Ndebele art and culture; as well as taboos in knowledge transmission. Results from an observation schedule are also presented in this chapter.

5.3.2 Mechanisms of ethnomathematical knowledge transmission amongst Ndebele women

Generally, this knowledge is transmitted from mother to daughter. However, women with knowledge can also teach or share this knowledge with other women of different age groups. The results of knowledge transmission are presented below as follows:

5.3.2.1 Setting for ethnomathematical knowledge transmission

Women can be taught in groups or individually. Women taught in groups or pairs are placed according to their age groups. Knowledge transmission takes place at *ebaleni* or *erhodlweni* for all women of different age groups. A normal sitting for a group is circular, allowing the teacher to move around and observe students without having challenges. *Erhodlweni* is an open space in front of the main house. The floor/ground of the space is normally smeared with cow dung for decoration and to represent dust. This process is known as *ukurhuphula*. *Erhodlweni* can also be decorated with a small wall fencing that is painted as seen on Figure 5.2. *Ebaleni* is an open space anywhere in the yard either than the front of the main house. A suitable space is identified as a collection by women to carry their artistic endeavours. *Ebaleni* can also be decorated or a structure can be built where women can practice their art and share their knowledge with their children or other women as shown in Figure 5.3. Sharing the same sentiments, participant 1 stated that:

Thina sibomma abagwalako sihlala ngerhodlweni namhtjhana ebaleni senze umsebenzi wethu. Nabantu bengubo abanetjisakalo yokufunda bafundiselwa la. Nangabe beza ngenchema, sibahlukanisa ngokuya ngeminyaka". (As women who do this art, we sit at *erhodlweni* or *ebaleni* and do our work. Other women who have passion to learn this art are also taught in these settings).



Figure 5.2: An Erhodlweni setting where ethnomathematical knowledge is transmitted.



Figure 5.3: A circular structure built at ebaleni setting where women practice and transmit ethnomathematical knowledge.

5.3.2.2 Methods of knowledge transmission

Beginners observe the process used by artists in constructing art. Observation can last for as long as the artist feels that the student is not ready to present their own art.

Once the artist is assured that a student is ready, an apprenticeship begins. The artist gives the student her own material to do the art with supervision to test her skills (Figure 5.4). At this stage, the learner through trial and error tries to implement what she has observed from the artist in her own art. The artist will then orally give her instructions on what to do and what is not supposed to be done. This supervision will go on for days sometimes months until a learner constructs a perfect art for her level. Training continues whereby a learner can independently do their art (Figure 5.5) and later show their teacher how they have improved their skills. According to participant 3, it is up to the artist to decide whether a student is ready to practice her art without supervision. Teachings are continuous. They become complex and sophisticated according to the experience and practice of a learner. For students to arrive at this stage takes time, passion and a lot of dedication. She further stated that:

“Itjisakalo yomundru bonyana afunde ukugwala namtjhana ukuphothela ibonakala ngandlela enzangayo nemibuzo ayibuza emndrini omfundisako. Umrhabiso wesikhethu ufuna abantu abazimiseleko”. (The passion a person has for art is seen in her determination to learn and the questions she asks her teacher).



Figure 5.4: A learner being supervised by an artist.



Figure 5.5: Learners independently doing their art after being taught.

5.3.2.3 Purpose for knowledge transmission

Young girls who are not married are taught this art in order to showcase their skills to their in-laws after they get married. A newly wedded woman is expected to decorate her first house called *iqathana* after she gets married. Her skills will be observed by her inlaws in order to confirm that their son chose a woman from a rich cultural background. In support of this statement, participant 5 stated that:

“Indluyakho yokuthoma ebizwa bonyana yi qathana, mude uyozigwalela wena ngokwakho nyama nepelesanakho nasele wendile ufika ekhakhakho. Nawuthoma ukugwala lapha umndeni uyabizana uzabezwa bethi ‘mrharibo uthoma ugugwala ngeqathaneni’ nakuthi kuyabhala, bathi ‘bababelo! Zankhe wafunda!’ Yinto eyangitjhisako bonyana ngigwale into ererhe. Nawugwala iqathana lakho kuhle bathi ‘maye uMadzela (referring to the husband) uthethe umntazana ofundisiweko yeses umrharibo loya qala wenze kuhle’. Bekuyinto etjhisisa umntazana ngaskhathi leso ngombana bebahlekwa. Yinto eyangenza bonyana ngibambelele emgwalweni kuze kube kunamhlanje. Ngibambelele ngaze ngenda

nafundisa naberndrwana bami ngelwazeli ukuze baligqhine bafundise nabentwana babo”.

The paragraph above, translated into English, means the following:

A newly married woman will have to paint her first house called “*iqathana*” as a symbol that she was taught how these designs are done from home. The family will come together at that time to witness the entire process. If she fails to do proper sophisticated designs, she will be considered as a shame and embarrass her family and the husband. If the designs are beautiful, they will give praises to the newly wedded wife and her husband, and say ‘Madzela (referring to the husband) has indeed chosen a skilled wife. This was what girls looked forward to at a young age and trained themselves for. I have held on to this knowledge and have passed it on to my children so that they can preserve it and pass it to their children. A new bride is also expected to create beaded attires for her husband and children if they are already present. Another purpose the Ndebele custodians transmit this knowledge to other women is for them to pass it down to the next generation; employing the methods they were taught. This knowledge lies in the ‘heads’ of Ndebele custodians and documented in artefacts in a form of beadwork and paintings.

In support of the above quotation, the process of knowledge transmission is confirmed in table 5.1

Table 5.1: Feminine ethnomathematical knowledge transmission observation overview.

The table presents what was observed and recorded on a field when ethnomathematical knowledge transmission was taking place.

Levels	Knowledge transmission Setting	Knowledge type (common knowledge or secret knowledge)	Purposes

Toddlers	<i>Erhodlweni/ebaleni</i>	Knowledge transmitted is common. Teachings become complex according to the level of practice.	1. To prepare women for married life 2. To preserve knowledge so that it can be passed down to the next generation
Teenagers	<i>Erhodlweni/ebaleni</i>	Knowledge transmitted is common. Teachings become complex according to the level of practice	1. To prepare women for married life 2. To preserve knowledge so that it can be passed down to the next generation
Maidens	<i>Erhodlweni/ebaleni</i>	Knowledge transmitted is common. Teachings become complex according to the level of practice.	1. To prepare women for married life 2. To preserve knowledge so that it can be passed down to the next generation
Newly wedded women	<i>Erhodlweni/ebaleni</i>	Knowledge transmitted is common. Teachings become complex according to the level of practice.	1. To showcase skills to the new in-laws 2. To preserve knowledge so that it can be passed down to the next generation
Ndebele elderly women	<i>Erhodlweni/ebaleni</i>	Knowledge transmitted is common. Teachings become complex according to the level of practice.	1. To preserve knowledge so that it can be passed down to the next generation

The results presented in this table interlinked with data which is presented in this chapter. The results of this table show that women are educated from a tender age about the importance of knowledge transmission. They understand that the skills of doing Ndebele art vary according to gender and they do not go against customary law by attempting to do art done by women at higher level/age group. Instead, they work in perfecting their own art until they are ready to proceed to the next level.

5.4 Reasons why women embrace Ndebele art

Ndebele art is embraced by AmaNdebele women for different reasons. The researcher has identified four main reasons, which are: (1) to preserve cultural identity; (2) to motivate young people to continue preserving this art; (3) to develop this art for fashion industry; and (4) to continue embracing and promoting this art in order for the department of basic education to consider implementing Ndebele indigenous knowledge in the curriculum and integrating it in classrooms.

Participant 5 who had an emotional moment before responding, said that this knowledge of their ancestors is what they do not want to see fading away. She further noted that she vowed to be a story teller and custodian of Ndebele knowledge so that they can share it with the younger generation. This was supported by participant 10 who stated the following:

“Ilwazi esilitjhiyelwe ngabaphasi kfanele libulungwe ngombana lihlathulula ubuthina. Ngaphandle kwelwazeli AmaNdebele alahlekile.” (This knowledge was passed down to us by our ancestors therefore it needs to be protected. Without this knowledge, the Ndebele people are lost).

Participant 2 indicated that her goal is to recruit young Ndebele girls, teach them this art and develop strategies on how this art can be developed and be disseminated for the whole world to know. She further mentioned that it is important for the world to know that the Ndebele people exist; that they have their own culture which has a unique art that has been preserved throughout generations using a special mechanism of preservation. She further stated that she wants to see this art developed and used in the fashion industry which will be an honour and acknowledgement to the Ndebele people.

Participant 4 added that she wants their Ndebele art to develop her economic status and working with young people to make this art fashionable will give her exposure which will bring her opportunities in both the art and fashion industries. She further stated that developing and embracing Ndebele art can also attract the government officials who are responsible for policy development to include this art in the curriculum so that Ndebele children are able to relate what they are taught in the classroom to their cultural background. The teaching of the Ndebele art in the classroom will mean that the culture of the Ndebele is protected and preserved.

5.5 The importance of preserving and transmitting the knowledge of Ndebele art and culture

The participants of this study were very concerned with people slowly losing interest in preserving the Ndebele culture. Most of the Ndebele people situated in other provinces have quickly adopted other cultures in South Africa. Participants stated IsiNdebele is not only a dying language but a fading culture as a whole. Participants were worried also about how English is quickly replacing the Ndebele language and how the rate of modernization is influencing the Ndebele people. Participant 1 stated that the Ndebele culture, language and heritage reflect and shape beliefs, value sand aspirations and the identity of AmaNdebele. The participant continued to say that that it is imperative to preserve such a legacy and pass it from one generation to another. It is also the duty of the Ndebele nation to take an initiative to protect, disseminate and restore their culture. If the Ndebele people fail to preserve their own culture, the next coming generation will find it difficult to access the indigenous knowledge and utilize it for the development of South Africa and Africa.

A majority of the participants said that they were willing to work with the local authority and government in developing strategies that can preserve this culture. They stated that majors were taken before by the local authority at some of townships situated in Gauteng Province but failed dismally as people did not show any initiative in learning the Ndebele culture. Ndebele young people are showing interest in making the contemporary styles of Ndebele art but only a few are interested in the cultural significance of the main original Ndebele art where the identity of the people lies. The participants stated that if urgent initiatives to present this knowledge are not established, then the knowledge will disappear with them when they die. They stated

that even though culture develops, it is important to understand the significance of the original culture and the stages of its development. In support of this statement, participant 3 pointed out the following:

“Iskhethu siyatjhabalala begodu itjisakalo yokusiphulusa ngiyibona ingekho. Angekhe sibeke umlandu kurhulumende kodwana simandebela asitjengisi itjisakalo yokusiphulusa. AmaNdebele abona IsiNdebele njengesiko elibarhorhela emuva begodu engenaskhala emhlabani banamhlanjesi. Barhabele amanye amasiko begodu batjhugulula into abangiyo. AmaNdebele akasifuni isikhethu bayasala begodu babhalele namakhosi.” (The Ndebele culture is fading away and there is no passion of preserving it. The blame cannot be shifted to the government for not having enough strategies on preserving it. The Ndebele people do not show interest of protecting the culture and according to so some Ndebele people, this culture is backward and has no space in the modern world. The Ndebele people are adopting other traditions and changing who they were born to be. They do not want this culture and have rejected it even when the local Kings asked them to promote and protect it.

In support of participant 3, participant 1 mentioned that there is an urgent need to preserve the Ndebele culture because it is one of the least practiced cultures in South Africa. In her own words, she stated the following: *“...kurhabekile bonyana isiko nelwazi lamaNdebele libulungwe...”*

5.6 Role of Taboos in knowledge transmission among AmaNdebele women

Regarding the feminine knowledge transmission, there are taboos and customary laws involved which have survived for many years in the Ndebele nation. Among other things, these rules succeed in keeping outsiders, including men, from learning the knowledge and secrets of the female profession. Ndebele artists, who act on all available forces to ensure protection in their profession, restrict men from participating in beadwork and mural art. They fear men will disturb the tasks that given to them by supreme beings which is to preserve and express the Ndebele culture through arts.

According to participant 1, it has always been a Ndebele belief system that men who associate themselves with art will face the rage of the ancestors such as bad luck or even death. When teaching girls, mothers would dismiss young boys who are spectators during periods when young girls are taught both beadwork and mural art. Girls are separated and taught the ways of cultural expression where boys were taught hard labor and other male duties. This does not mean that what girls were taught by their mothers is sacred. However, boys were not allowed to carry same tasks as girls.

Feminine knowledge transmission takes place at *erhodlweni* and *ebaleni* which was discussed before in this chapter. It is a taboo for women to teach young girl beadwork and mural art in *ebandla*. *Ebandla* or *ibandla* is strictly a dwelling place inside the yard reserved for men to sit or hold meetings. Participant 5 told the researcher that women who invade that dwelling face shame and fines such as compensating the tribal authority with cattle and they are also labeled as a disgrace in the community. Knowledge transmission requires all participants involved sitting down with their legs stretched on the traditional mat but sitting on a chair is also permitted. It is believed that women who stand while doing beadwork will instantly receive their menstrual cycle on the spot. However, amongst the Ndebele, participant 2 said there is an ongoing argument amongst the Ndebele regarding such claims. Participant 3 noted that knowledge transmission take place before sunset, whereby girls need to wake up in the early hours of the morning, perform their household chores, and prepare the material custodians they will need for the teaching.

5.7 Discussion

5.7.1 Introduction

This study has achieved to investigate the mechanisms of knowledge transmission amongst Ndebele women. It further looked at the reasons women embrace Ndebele art, the importance of preserving the Ndebele culture and transmitting the knowledge of Ndebele art and taboos in knowledge transmission. This discussion is based on feminine knowledge transmission.

5.7.1.1 Feminine knowledge transmission

The research has revealed that Ndebele women are knowledge holders who have a duty of transmitting this knowledge to their daughters and other women using different

mechanisms. According to Warren (1991), women, as essential teachers in indigenous communities, have sustained their structures and associated knowledge systems for centuries, even while experiencing significant social changes because of transformative powers beyond their ability to control. If indigenous knowledge is not preserved, recognized and protected, it will not be passed on (Warren, 1991). Flannery, (1995) argued that in traditional African societies, indigenous knowledge is acquired by children through their steady interaction with both the adult world and the physical environment around them. This knowledge includes the understanding of the biological system around them, the obtaining of skills in the utilization of the different devices and tools in their every day activities, their acquaintance with the traditions and practices of the relevant society, the understanding of the societal values and beliefs, and the development of a world view that reflects the experiences of the society in which they live. Thus, through the consistent communication with the adult individuals from society and the physical milieu or nature, the youngsters dynamically master not only the structural aspects of their language, but also the rich vocabulary which reflect the society's knowledge of its physical world, cultural experiences and practices and its conceptualization of the universe. In this way, indigenous knowledge is constantly accumulated and continually transmitted from one generation to the next (Preston, 1975).

Ruddle (1993) examined the transmission of traditional ecological for sites in Venezuela and Polynesia. He found that two-to five-year-old children already knew the names and characteristics of the more common biota. By the age of 14, children were competent in household tasks, cultivation (plant distinguishing, identification and harvesting) see selection, weeding, animal husbandry, fishing and hunting. Overall, he discovered that the training was age specific, structured and systematic. Specific times are allocated to training during the daily work schedule.

Clarifying how culture is passed on as a generational legacy, Fafunwa (1974: 48) composes that:

The child just grows into and within the cultural heritage of his people. He imbibes it. Culture, in traditional society, is not taught; it is caught. The child observes, imbibes and mimics the action of his elders and siblings. He watches the naming ceremonies, religious services, marriage rituals,

funeral obsequies. He witnesses the coronation of a king or chief, the annual yam festival, the annual dance and acrobatic displays of guilds and age groups or his relations in the activities. The child in a traditional society cannot escape his cultural and physical environments.

Similar studies to the current research were also conducted by Ohmagaril and Berkes (1997) on the transmission of Indigenous Knowledge and Bush Skills among the Western James Bay Cree Women of Subarctic Canada. It was discovered that bush skills are not taught in formal education. Female students from indigenous communities 'learn by doing' (Preston, 1975, 1986) through apprenticeship. The apprenticeship starts when a child figured out how to walk; she is relied upon to help with and share in the work of a bush camp (Long, 1978). The child is not generally given verbal guidelines but rather encouraged to learn skills by playing and by imitating adults through participation in subsistence generation activities (Flannery, 1995). At the same time, the child gains the Cree values of self-reliance, independence, and competence, and furthermore of sharing and cooperation (Sindell, 1997).

Skills which children learned are skills from parents, grandparents, older siblings, and members of the extended family with whom they camped with. Parents had the main responsibility for their children's education. However, members of extended families were readily available to take over teaching responsibilities whenever needed (Preston, 1986). After an extended period of learning by watching and helping, the child is urged to attempt and repeat the observed skills. Depending on the complexity of the skill, the apprentice starts to perform one part of the skill complex and eventually learns the entire skill complex. Mastery of the skill complex is a gradual process and only achieved by trial and error (Preston, 1975, 1986). In this process of trial-and-error, teachers are patient and supportive even if the apprentice fails countless times, as long as she is determined. The apprentices are told to keep trying until they get it right (ibid, 1986).

Furthermore, the apprentice is expected to follow the prescribed recommended approaches to master the skill. When she does it legitimately, the teacher praises her saying *ekute* (that is the way!). In traditional Cree culture, parents teach their youngsters adequate survival skills that enable them to live in the bush by the time they reach their mid to late adolescents (Flannery, 1995; Rogers & Rogers, 1963;

Blythe, Brizinski, & Preston ,1985). The age range, 13-15 years, as the key time period for the mastery of most of the bush skills.

Studies that were reviewed in this chapter confirm that different societies have mechanisms of transmitting knowledge as a tool of preserving. The study by Ohmagaril and Berkes (1997) is acknowledged by the researcher as it gives in detail how knowledge is transmitted. The findings of this study by Ohmagaril and Berkes (1997) are aligned with the ones for this research.

The study also reveals that knowledge is transmitted to other women (such as young women) in order to prepare them for married life, so that as married women as time passes can share it with their children or children in the area they live in as a way to preserve it for future generations. Women are able to capture the knowledge orally, through observations, experiments and participations. This type of knowledge transmission is aligned with the theory guiding this study which is eZiko Sipheka Sisopula by Goduka (2005), which states that indigenous knowledge is transmitted using indigenous methods such as practical learning and experiments. The theory further supports the holisticity of indigenous knowledge transmission settings where intellectual and psychological rituals, dialogues and intergenerational and intercultural teachings take place.

Knowledge transmission amongs the Ndebele is bound by taboos. According to Osei (2006), in Africa cultures, taboos are sources of moral guidance and motivation for the purpose of maintaining social order. Taboos speak to the primary sources of guiding principles and controlling and coordinating the conduct of individuals and the individuals towards the Supreme Being and particularly the gods and the ancestors in African societies. The study conducted by Osei (2006), validate the findings of this research which are that taboos regulate and govern morals/ behavior in the Ndebele society.

It was discovered in this study that AmaNdebele women have different reasons why they want to preserve ethnomathematical knowledge. One of the reasons was for ethnomathematical knowledge to included in the curriculum and taught within the classroom. According to Emeagwali (2003), the integration of African culture's mathematical ideas and concepts in the mathematics curriculum for instance will motivate learners to recognize mathematics as part of their culture and enhance

students' ability to make meaningful mathematical connections by deepening their understanding of all forms of mathematics (Furo, 2018) .

There is a need of preserving the Ndebele culture and strategies have to be put in place on how this knowledge can be protected. The arts and culture policy of 2002 that was used to guide this study emphasizes the protection, preservation and promotion of South African Arts, Culture and Heritage to prevent them from being eroded or replaced by other knowledge systems. "When a knowledgeable person dies, a whole library disappears" is an African proverb. This proverb was quoted based on the concerns that were revealed in this study which stated that with IsiNdebele is a fading culture. According to Grenier (1998), because IK is transmitted orally, it is vulnerable to rapid change especially when people are displaced or when young people acquire values and lifestyles different from those of their ancestors. It was also discovered that the concern stretched to the Ndebele language. The Ndebele language according to Statistics South Africa (2011) is one of the least spoken languages and faces extinction. Therefore, there is a need for urgent strategies to be put in place by the government and Ndebele leadership to save the culture (including language) of the Ndebele people. This statement is supported by the National language policy of 2003 which states that language and embracing culture one of the most important manners in which a person can confirm his/her human dignity.

Major studies on the Ndebele people were carried out towards the end of the 20th century by anthropologists, non-African indigenous scholars and historians who focused mostly on Ndebele history with an interest of recording history of personal adornment, rituals and how the Ndebele Kingdom got scattered using a Western worldview. In most historic records such as of Weiss (1963) focus on beadwork and which Ndebele group it belongs to rather than its significance and how this knowledge has been kept alive for generations. Before the 21st century there were no attempts in deep studies on Ndebele feminine knowledge transmission until recently. It is consequent that, while the recording of Ndebele history manufactured on, the study of feminine knowledge transmission was overlooked and, in this manner, lagged behind. It is for this reason the researcher recommends that indigenous scholars should conduct studies on their own cultural background in order to reveal what for a very long time has been overlooked. This can only be achieved when indigenous scholars utilize an indigenous lens in the research with indigenous communities.

According to Gegeo and Watson-Gegeo (2001), when outside researchers such as anthropologists do ethnographic studies of other people's knowledge(s), or when they construct theories of other peoples' ways of living and doing, they definitely constitute an epistemological community. However, the knowledge which they are theorizing is not created by the epistemological community. In other words, anthropological theories of other people's cultures were not constructed by those cultures. "Anthropological accounts of other people's cultures are not indigenous accounts of those cultures even though they may be based on interviews with and observations of indigenous communities, individuals, and societies" (Gegeo & Watson-Gegeo, 2001: 58). They imagine all of the foregoing activities, conceptualize, and carry them out within the theoretical and methodological frameworks of Anglo-European forms of research, reasoning, and interpreting while they draw on indigenous cultural knowledge.

Concluding remarks

AmaNdebele women pass ethnomathematical knowledge using different mechanisms. These were also found consistent with other cultures across the world. There are taboos surrounding ethnomathematical knowledge transmission within the Ndebele culture. In order to preserve this knowledge, women participants recommended that the IK of the Ndebele people should be integrated within the curriculum. With everything being said, the issue is that, does this knowledge benefit livelihoods? This is a question investigated in the next chapter.

CHAPTER 6: THE ROLE OF ART IN SUSTAINING THE LIVELIHOODS OF AMANDEBELE WOMEN

6.1 Introduction

AmaNdebele women have been seen in the course of recent years to increase tremendous market experience. According to Levy (1993), these women have now come to understand the adjustments in the aim behind their ritual endeavor of art making. Initially, their artwork was exclusively the practice of making beaded and painted walls and other structures to preserve the Ndebele culture. However, today their specialty lies in making has some economic driving force, not just customary motivations (Van Vuuren, 2012).

Schneider (1986) argued that Ndebele art, which has mathematical ideas and concepts, now serve as an aesthetic commodity. This art is now seen as an economic bridge to the current 21st century for women and their entire families'. The Ndebele ethnomathematics is currently seen as fashionable and the products are being sold to tourists and South African citizens. According to Steiner (1994), women are now able to become breadwinners for their families. This has been seen by women as a strategy to eliminate poverty and become more independent and self-reliant. Van Vuuren (2012) mentioned that today, AmaNdebele women like Dr. Esther Mahlangu are able to show case their talents and skills internationally and most women are selling their artistic work in their homes, at local central business districts and art galleries across South Africa. The objective that informed this chapter was to explore how art sustains the livelihoods of AmaNdebele women. The work was guided by the question: How does Ndebele art with mathematical concepts and ideas help in sustaining the livelihoods of AmaNdebele women?

6.2 Methodology

6.2.1 Research design

This chapter adopted an exploratory research design. The researcher wanted to explore how Ndebele entrepreneurs are able to sustain their livelihoods using their art.

6.2.2 Target population

The target population for this chapter were fifteen women at Ndebele art school. This population was selected because they are entrepreneurs who are making a living using their art. For years, they have been able to improve their economic status and livelihoods using their artistic works (Vonk, 2016).

6.2.3 Sampling size and sampling procedure

Sample size consisted of twelve entrepreneurs from Ndebele art school who availed themselves. Thus, a convenient sampling procedure was used (Creswell & Clark-Plano, 2017).

6.2.4 Data collection strategies

6.2.4.1 Tools

A semi structured face-to-face interview guide was used as a tool to collect data from participants (see Appendix 4). It was divided into two parts, which are: (1) Section A which had closed ended questions where the researcher focused on the demographics of the participants, and (2) Section B, which focused on open-ended questions.

6.2.4.2 Methods

The semi structured face to face interviews were conducted with entrepreneurs (Figure 6.1) which included Dr Esther Mahlangu (Figure 6.2) at the Ndebele art school which was initially for children but currently accommodates all women of different age groups (Figure 6.3) in IsiNdebele with no assistance of a translator since the researcher knew and understood the language. For each interview, the researcher explained to each participant about the research process. The participants had an opportunity to ask questions before the interviews commenced or withdraw from taking part. The semi structured interviews had close ended questions and open-ended question, which guided the researcher to present data in two analyses. Each interview with a participant took approximately an hour. A digital recorder, diary and photo camera were utilized as instruments to capture data.



Figure 6.1 Some of the participants of this study



Figure 6.2: The researcher with Dr. Esther Mahlangu



Figure 6.3: A board in front of the Ndebele art school

6.2.5 Data analysis

For this chapter, two data analysis processes were utilized. Firstly, the data was analyzed using the descriptive analysis process. The process consisted of calculating data using the IBM-Statistical Package for Social Science (SPSS - version 24.0) data sheet. Defined data was analysed to generate descriptive statistics (Oja, 1983). Descriptive analysis included percentages and currency. The results were used to construct different charts and graphs for this chapter.

Second, a thematic analysis was used to analyse data from open-ended questions. Data collected during the semi structured face-to-face interviews was first transcribed from the voice recordings and translated from IsiNdebele to English. The analysis was manually done on the data and themes were identified (Braun & Clarke, 2006). To check the accuracy, the researcher read across data files. Where gaps were identified, the researcher had to member check the study area to seek clarity for trustworthiness (Lincoln and Guba, 1986).

6.2.6 Strategies of enhancing the validity and trustworthiness of this study

This tool was tested for validity by piloting it in the Gauteng Province, Pretoria CBD (Marabastad) which is an area where most elderly AmaNdebele women sell their

artefacts. The content validity of the semi-structured interview questions and observation schedule were determined through feedback obtained from the pilot participants. The researcher translated the semi-structured interview questions in IsiNdebele when piloting the tool with participants. The same method (changing the language) was used on the observation schedule. The researcher wanted to validate the language used for the interview, the length of the interview and the sequence of the questions. Based on this, the researcher reduced the length of questions, used the local terms that women understand and know, and aligned the questions in a proper sequence. The manner in which the questions were structured allowed the researcher to make follow up questions where they were required. Multiple data collection instruments such as tape recorder, camera and a diary were used to support the data collection tool in order to provide reliable data (Carter, Bryant-Lukosius, D. DiCenso, Blythe, & Neville, 2014).

6.3 Results

6.3.1 Introduction

The results of this chapter are presented in two sections. Firstly, the results received from SPSS; second, the themes that were generated from the thematic analysis.

6.3.2 Demographic characteristics of participants

Figure 6.4 shows that 52% of the participants were widows with no means of income other than bead making. That contributed on how most women decided to become breadwinners and develop strategies of eliminating poverty, using their art. Most women argued that, having no means of income made them responsible of taking care of their households financially and paying for the tuition fees of their children. One of the most difficult decisions AmaNdebele women who are widows are expected to make is to wed the male sibling of her late husband in order to have financial security. The family of the late husband neglects those who choose to ignore this cultural custom financially and they are expected to provide for the family in any means possible. 35 % of participants were married whereas 9% were single and never married. 4% of women were divorced. According to them, they divorced their husbands traditionally and had to gain financial independence because they had previously depended on their husbands for financial assistance.

Figure 6.5 shows that the majority of AmaNdebele women who are artists and entrepreneurs at Ndebele cultural school are 40 years old and above. About 40 % of the participants of this study were elderly women who were 62 years and older. The results of this chapter show that the number of young people who are entrepreneurs is less. This means that the majority of people who make a living and use this art are elderly women. Figure 6.6 indicates the level of formal education participants have received. About 88% of participants never went to any formal school. Most of these participants do not know how to read and some of them only know how to read their names because that is what they are able to write. The 8% shows that there are participants who were able to attend the foundation phase level of education (Grade 1-3). About 2% who were young adults, under the age of 40 years were able to attend between grades 4-6 while the other 2% of young adults attended between 4-6 grades.

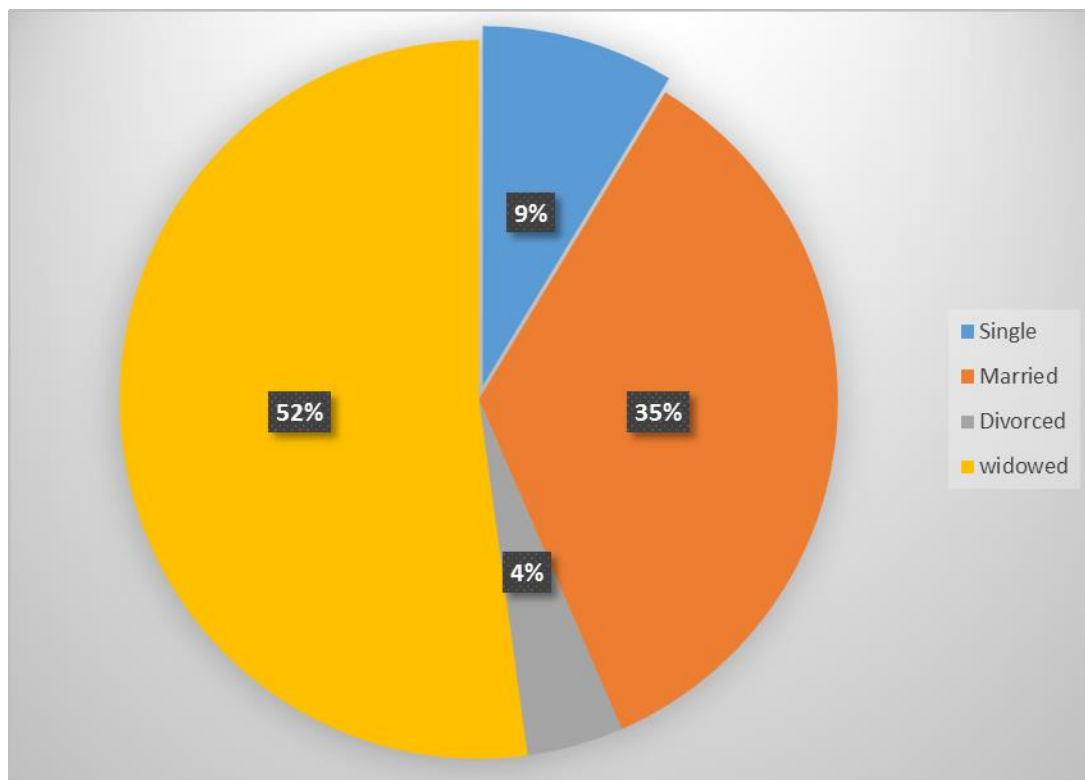


Figure 6.4: The marital status of participants.

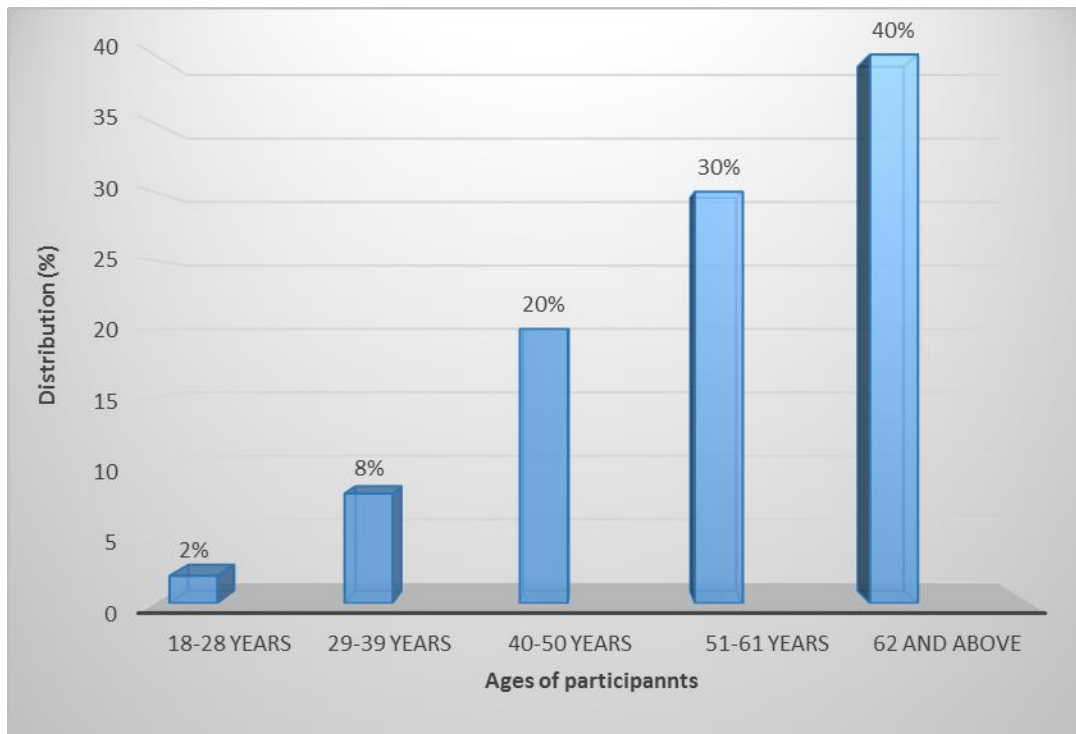


Figure 6.5: Age groups of participants.

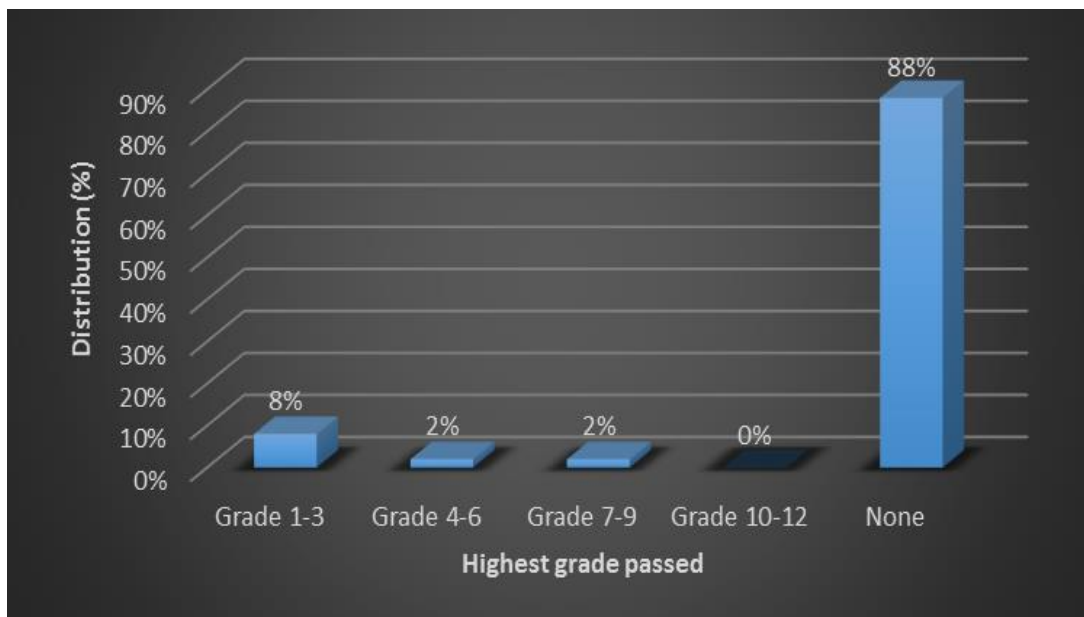


Figure 6.6: The level of formal education participants have received.

Figure 6.7 indicates the speciality of art by Ndebele entrepreneurs. The responses showed that about 55% of the participants in this study specialize in both beadwork and mural art (painting). Participant 10 justified her response by stating that it is very unlikely to find an AmaNdebele women specializing in one type of art. She further argued that that once a woman masters one art, she can easily learn another.

According to Participant 1, being a master of beadwork and painted art sustains a business because customers are able to purchase all sorts of beaded and painted art from one entrepreneur. About 30% of the participants specialize in beadwork whereas 15% are experts in painted art. Justifying her response, participant 11 argued that she prefers mastering beadwork because it is her passion. Participant 7 justified her specialization by stating that she was taught only mural art from a young age by her mother who mastered it and has never thought of doing beadwork before. However, she stated that a gap for painting in commercial market has been identified and she is currently painting other artefacts and cloths utilizing designs that were initially used in mural art.

Figure 6.8 shows the percentages of responses by the participants on their years of practicing this art. 45% of participants indicated that they have 41 years of experience and above, 35% indicated that they have an experience of 31- 40 years in Ndebele art practice. About 20% of participants indicated that they have been practicing for over 20 years. Participant 1 who has been practicing for over 41 years indicated that she stated doing this art at a very tender age. She further stated that the sophistication and neatness of her art shows that she is not an amateur but an expert with years of experience. This was supported by participant 3 who said that a woman's skills and years of practice can be seen by the sophistication and details of her art. On the other hand, participant 12 who has been practicing for 30 years indicated that she developed the passion for this art when she was a teenager because her peers used to compete with each other.

Figure 6.9 shows that 50% of the participants have been selling their art for more than 20 years. They argued that they have been selling to locals for a very long period and they grew up exposed to this business from their homes. In support of this statement, participant 12 stated that they have learnt how to manage this business from an early age, trained by their mothers. One participant stated that when she got married, she continued with her business and taught her own daughters at a later stage. 38% of participant indicated that they have been entrepreneurs of Ndebele art for not more than 20 years. Participant 8 indicated that she only started selling her art after a neighbor advised her to do so. The participant further indicated that she used to borrow people beaded attire until she was advised to make a business out of it. It is then that she started to sell her beaded art and hire other art to customers for a certain period.

The 12% indicated that they only develop interest to sell their art after their husbands died and which they had to take care of their families. Participant 11 argued that they had children to provide for and they were stranded because they depended on their husbands to provide for the families. Currently, the participant has grandchildren to provide for and which is one of the reasons why she is still selling this art.

Figure 6.10 shows the money participants make per month. Participants are fully employed by Dr Esther Mahlangu but are not restricted to make extra income separately. Participants are paid R3000.00 monthly by Dr Esther Mahlangu. In an arranged order, participant 6 provided three cases to the researcher as follows: The first case was that, the artists are also employed by for Dr. Esther Mahlangu and she pays them salaries that are equal at the end of the month. Secondly, the Ndebele entrepreneurs are not restricted from selling their own art in the comfort of their own homes or on local markets. Thirdly, in case Dr. Esther Mahlangu is invited to exhibit in a gallery, she gives artists who work with her an opportunity to exhibit their individual art to potential buyers in order to earn extra income. In support of this arrangement, participant 9 indicated that their basic salary is R3000 received from their employer but they can make an extra income by freelancing such as having stalls in town or selling at home. Figure 6.10 indicates that there is only one participant who was Dr. Esther Mahlangu, which earns a higher salary/income compared to artists. She elaborated that there are different streams that she utilizes which generate monthly income. She made an example of the of the Belvedere Vodka bottle she painted in 2017 for the popular musician John Legend from the Unites States of America from which she still receives royalties.

Figure 6.11 shows that about 58 % participants indicated that this money helps them for household expenses such buying groceries, electricity, renovating their houses (when necessary), buying furniture and paying other expenses. About 40% of the participants highlighted that the capital made from selling articles has assisted them with taking their children to schools and pay for their tuition fees. Participant 12 indicated that her children are currently higher institution graduates and working proper jobs. She further indicated that the money she makes selling this art assisted taking her children to higher institutions so that they can get good jobs. Moreover, she stated that she still uses some of her money to pay for her grandchildren's education. The 2% of participants argued that they use their money for non-important purposes,

which are not urgent needs to their lives. The results from this figure reveal that AmaNdebele women depend highly on the work they do to survive and take care of their loved ones.

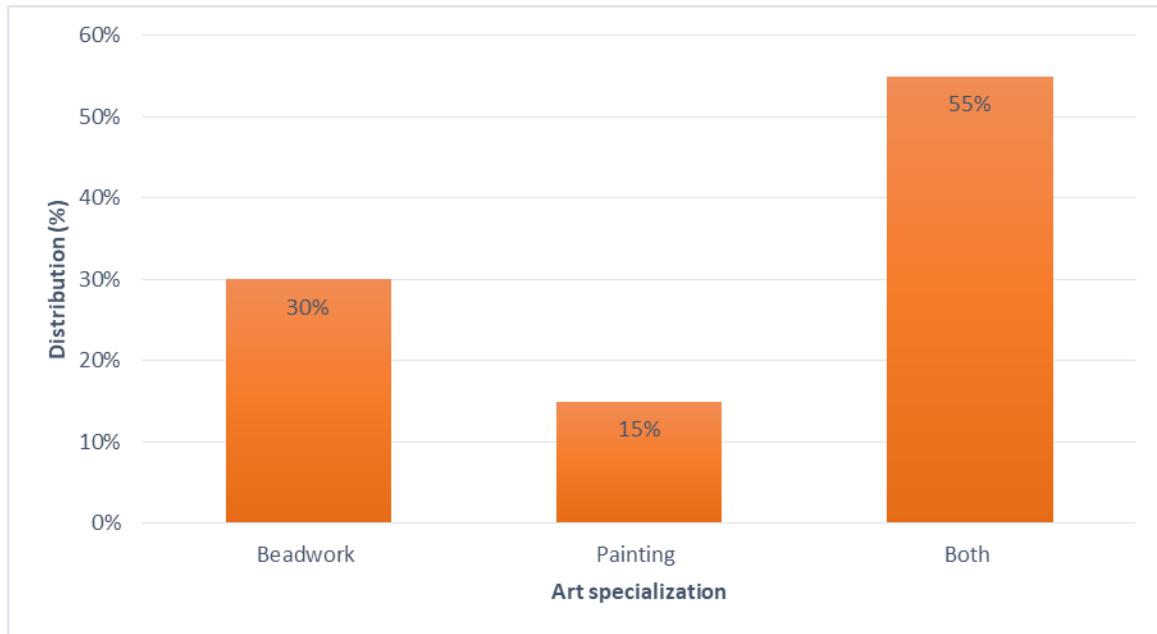


Figure 6.7: Types of art specialization.

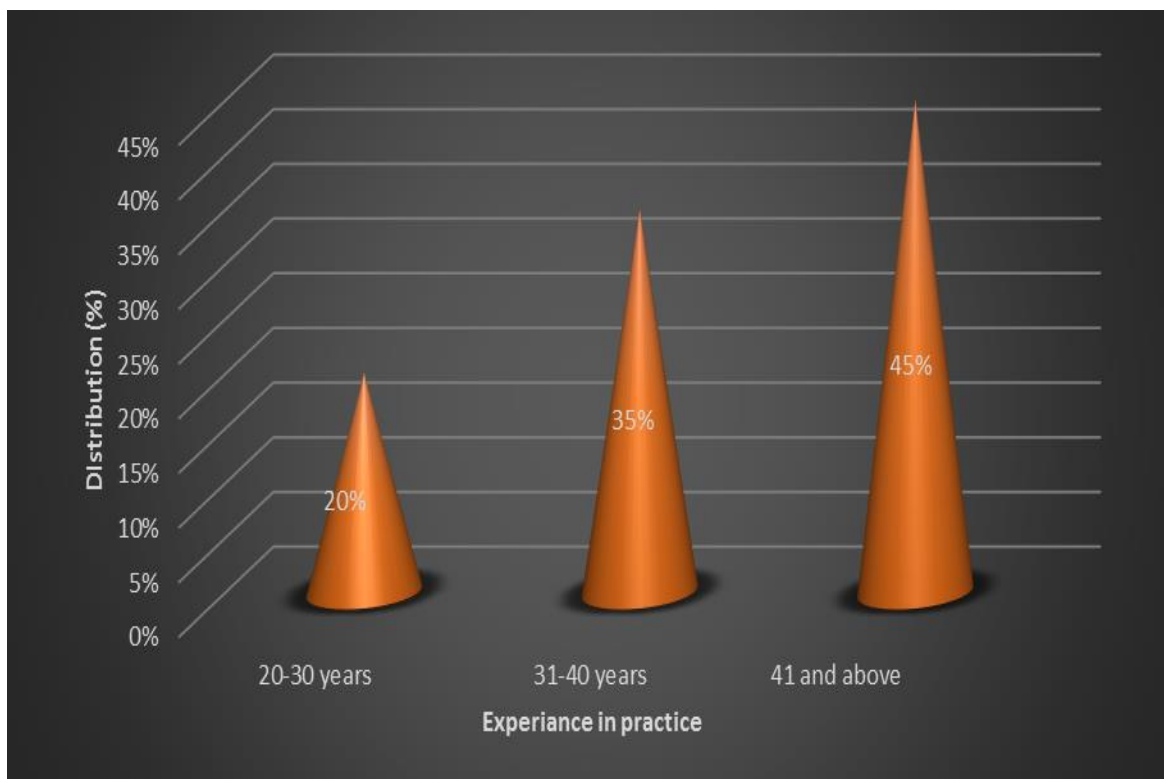


Figure 6.8: Experiance in practice.

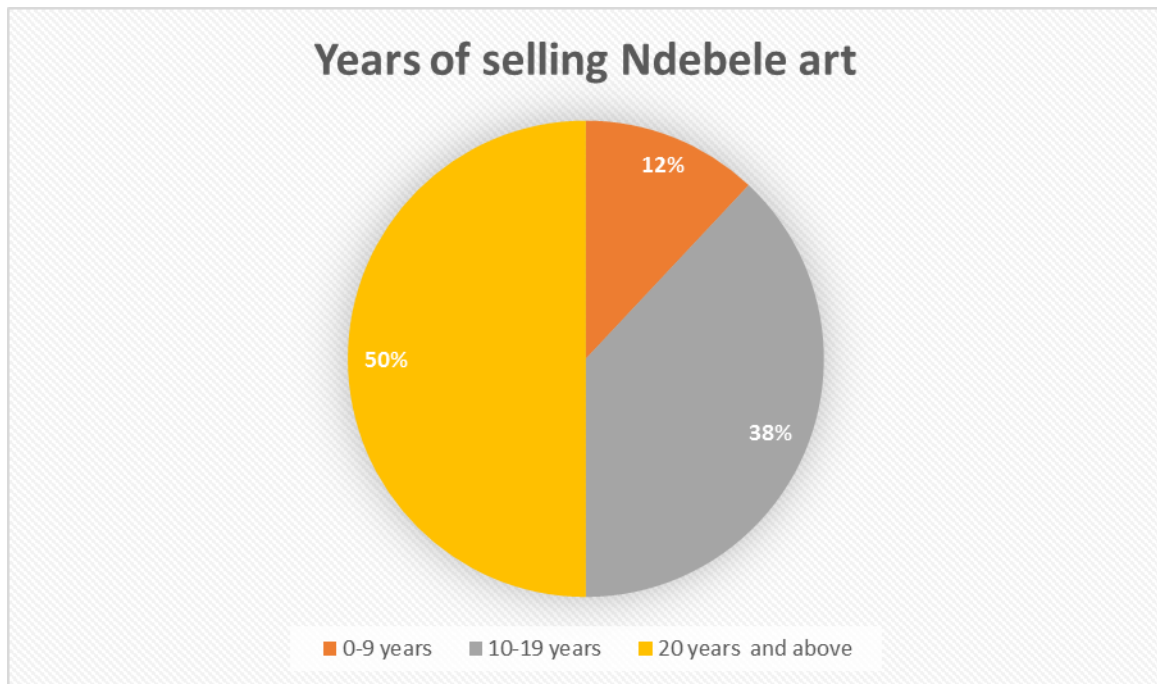


Figure 6.9: Years of selling artefacts among study participants.

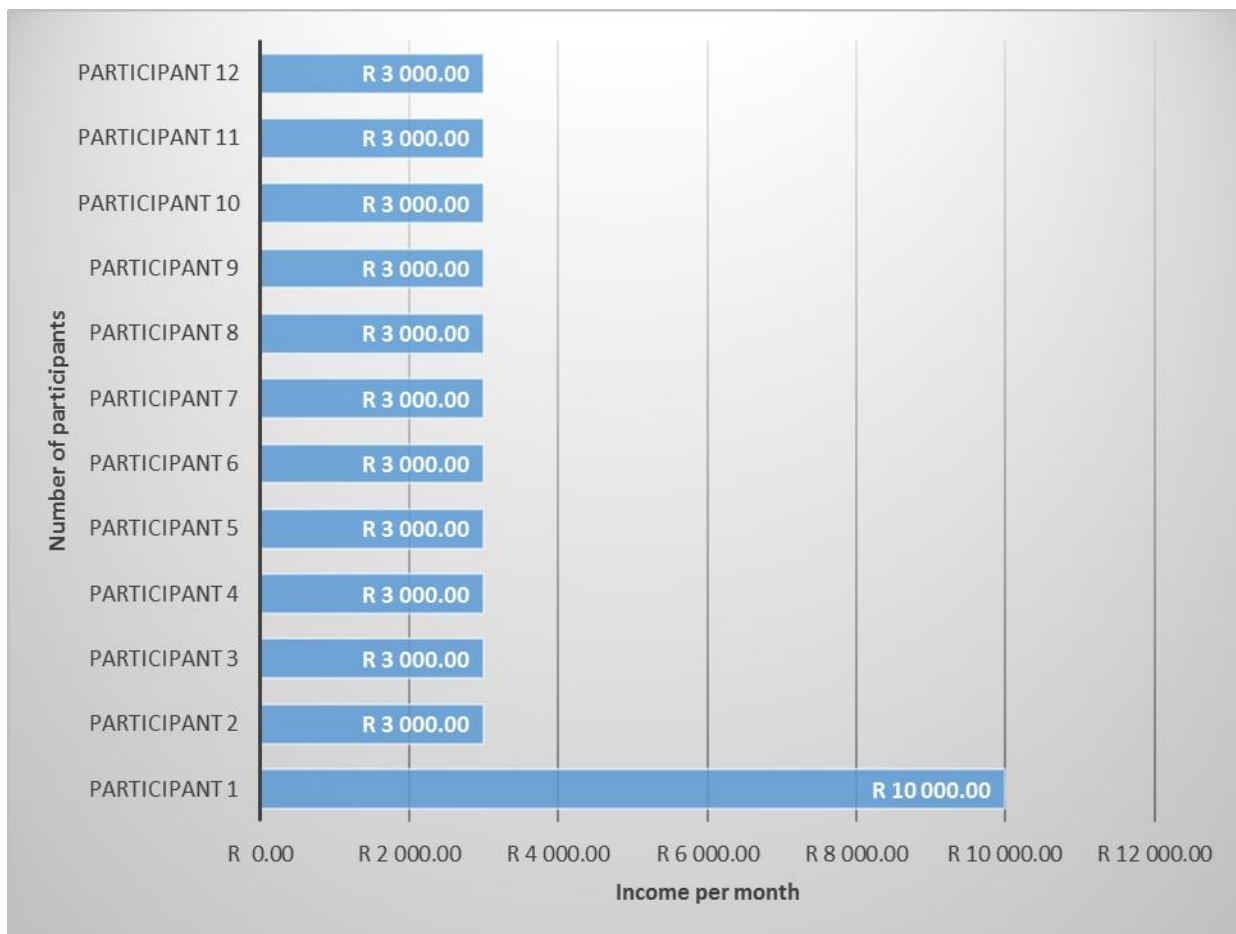


Figure 6.10: Monthly income from selling artefacts among participants.

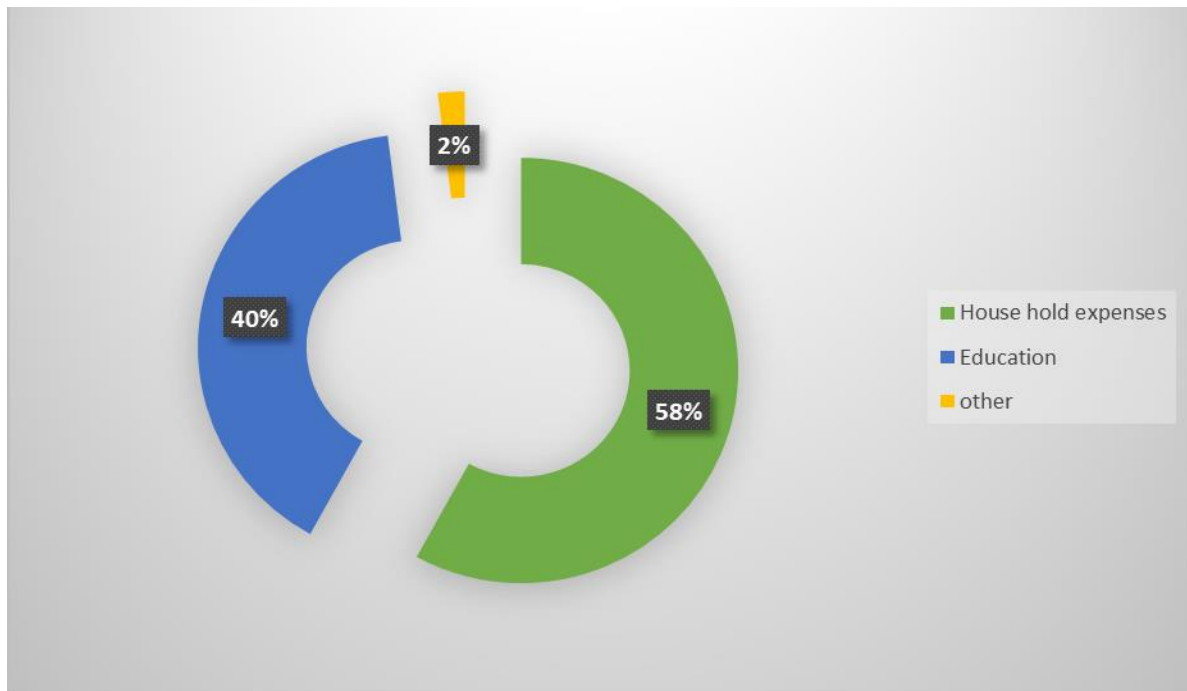


Figure 6.11: Uses of income by women entrepreneurs in the study.

6.3.3 Themes identified

The themes that were identified were as follows: (1) the commercialization of Ndebele art; (2) the target market for the Ndebele art; (3) the use of Ndebele art for branding of commercialized products; and (4) the recognition of individuals due to Ndebele art.

6.3.3.1 The commercialization of Ndebele art

Ndebele artists sell artefacts such as beaded dolls (Figure 6.12) and other ornaments such as decorated fashionable neck hoops (Figure 6.13). Ndebele women sell through different platforms such as galleries and art festivals. Ndebele women continue to be innovative in order to 'keep up' with current fashion trends so that they can target not only elderly people but also young people who love fashion. The commercialization of this art has opened many job opportunities for AmaNdebele women who have no means of income and who have the major responsibility of taking care of their loved ones. Regarding the commercialization of Ndebele art, participant 12 expressed her self by saying that:

“Ukuthengisa ngomrhabiso lo weskhethu kungirhelebhe khulu. Mina ngabhujelwa yindoda ngasala ngingena litho kodwana ngaphuluswa kuthengisa. Abandru abanengi bayazi bonyana ngyathegisa bedodu

ngisebenzela ugogo ngize ngibe nerhwebolami ngeqadi". Selling the Ndebele art has improved my life. My husband passed away a long time ago and I had no means of income until I started selling my art. People know that I am an entrepreneur who works with gogo (referring to Dr. Esther Mahlangu) and selling alone on the side.



Figure 6.12: Ndebele beaded dolls.



Figure 6.13: Fashionable Ndebele beaded neck hoops.

6.3.3.2 The target market for the Ndebele art

The target market is for both local people and international tourists who visit Dr Esther Mahlangu's indigenous cultural art gallery (Figure 6.14) and the Ndebele art school (Figure 6.15). According to the participants, people from all over the world travel to see this art. In support of these findings, Participant 2 said the following:

“ugogo waziwa iphasi loke, aloke nguye odosa abandru”. (Dr. Esther Mahlangu is a brand and a world known artist. Therefore, in most cases, she is the one attracting potential buyers).

Participant 10 highlighted that every month new international tourists arrive to see the home of Dr Esther Mahlangu, which has a school and a gallery that are separated by a small distance. Due to such exposure, Dr. Esther Mahlangu had to hire brand name officials and managers. As a result, brand name officials and a manager conclude deals on her behalf. The job of these people is to ensure that the product is received and perceived positively by outside markets. Brand officials have the ability of protecting the product from being misused in any possible way. Furthermore, they run the maintenance to ensure that their adversaries in the industry do not meddle with their brand name or promote perversely and unfairly against them. Brand names also insure that 'middle' men do not get opportunity to rob Ndebele women who are trying to make a living off their art.

Regarding employing brand name officials, Dr. Esther Mahlangu (who was participant 1) contended that:

“Ukuthola kwami ithuba lokukhamba iphasi mazombe kwangenza bonyana ngithole abandru abazongirhelebha engibathembako. Abandwaba bakhandela bonyana abalingitjhudu abangihlukumezi begodu baletha amaphepha ngaphambi atjengisa bonyana ngizokuzoza kunjani”. (Receiving an opportunity to travel all over the world made me hire brand name officials and a manager I trust. Brand officials ensure that the “middlemen” do not exploit me in case they want to work with me, they must provide documents of benefit sharing).

A



B



Figure 6.14: Dr. Esther Mahlang's indigenous cultural art gallery

A



B



Figure 6.15: Ndebele art school in Ekosini village

6.3.3.3: The use of Ndebele art for branding of commercialized products

In the 1991, Doctor Mahlangu painted the BMW 525i (Figure 6.16), which made her popular and made her known all over the world. Since then, she has been travelling and branding products for companies. According to this participant, one of her breakthroughs is when she worked with the famous musician, John Legend (Figure 6.17) and designed the Belvedere Vodka bottles (Figure 6.18) which was shown to the researcher (Figure 19). In 2018, Dr Esther Mahlangu worked with Tiger Brands and decorated the cover of Tastic Rice (Figure 6.20) and Albany Bread (Figure 6.21). She also worked with Freshpak Company and decorated the container of the Freshpak rooibos tea (Figure 6.22). This was done during Heritage month (September). During interviews, Dr Esther Mahlangu did mention to the researcher about the projects she was going to be involved in. Therefore, the researcher had to make a follow up on those projects in October 2018.



Figure 6.16: BMW 525i decorated by Dr. Esther Mahlangu in 1991. (Sourced from: www.wheels24.co.za).



Figure 6.17: Dr. Esther Mahlangu with musician, John Legend showing the Belvedere vodka bottle. (Sourced from: (Previdar, 2016)).



Figure 6.18: Dr. Esther Mahlangu decorating a Belvedere vodka bottle. (Sourced from: (Previdar, 2016)).



Figure 6.19: Dr. Esther Mahlangu with the researcher, showing the Belvedere vodka bottle.



Figure 6.20: The researcher holding the Tastic rice from one of the supermarkets in the Republic of South Africa (RSA), which was decorated by Dr. Esther Mahlangu.

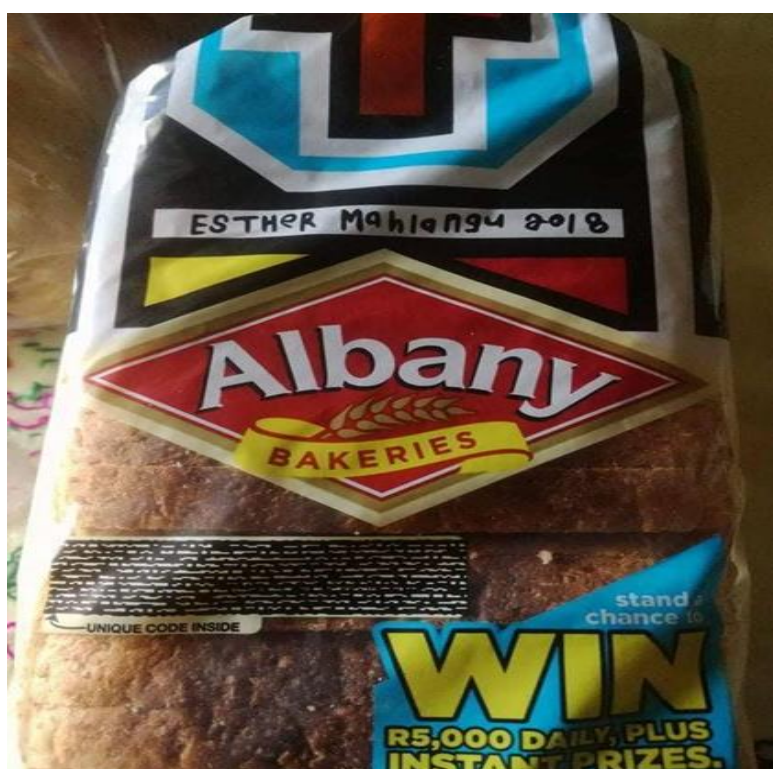


Figure 6.21: The Albany bread plastic decorated by Dr. Esther Mahlangu.



Figure 6.22: A Freshpak rooibos tea container decorated by Dr. Esther Mahlangu.

6.3.3.4: The recognition of individuals due to Ndebele art

In September 2017, Dr Esther Mahlangu was honored with a Ndebele street mural named *Xola* which means peace in English (Figure 6.23), situated in New York, in the United States of America (USA). Some of her work is currently exhibited in an African gallery in the Virginia Museum of Fine Arts in Richmond, USA (Figure 6.24). Dr Mahlangu received an honorary doctoral degree in March 2018 from University of Johannesburg (UJ) as shown in Figure 6.25. She later received another honorary degree in September 2018 from Durban University of Technology (DUT) as provided in Figure 6.26. In her own words, Dr Esther Mahlangu said the following:

“Umrhabiso weskhethu wangivulela indlela ngakhamba iphasi loka bogudu nomsebenziwami wabona iphasi zombebele. Ngithokoza abezimubami ngekghonoleli”. (The Ndebele art has given me exposure and I have travelled all over the world. Today, people all over the world know my work. I thank the gods for this gift).



Figure 6.23: Ndebele street mural dedicated to Dr. Esther Mahlangu in New York City, United States of America. (Sourced from: (Stephens, 2017)).



Figure 6.24: Dr. Esther Mahlangu's paintings at the African gallery of the Virginia Museum of Fine Arts in Richmond, USA. (Sourced from: (Privateedition, 2017)).



Figure 6.25: Dr. Dr Esther Mahlangu receiving an honorary degree at the University of Johannesburg (UJ). (Sourced from: (Khoza, 2018)).



Figure 6.26: Dr. Esther Mahlangu receiving honorary doctorate from Durban University of Technology (DUT). (Sourced from: (Bhengu, 2018)).

6.4 Discussion

6.4.1 Introduction

The objective on exploring how the Ndebele art sustains the livelihoods of AmaNdebele women was achieved in this study. The Ndebele entrepreneurs have provided the researcher with information which shows how they are able to sustain the livelihoods through art. The findings of this study are discussed below.

6.4.1.1 The role of Ndebele art in sustaining the livelihoods of AmaNdebele women.

This chapter has revealed that AmaNdebele women sell their art in order to make a living. The commercialization of art has improved the livelihoods of Ndebele women in different ways. An example was made of Dr. Esther Mahlangu. Her art has made her a renowned artist who has been honoured in different ways over the years. The commercialization and wealth creation using IK has been supported by the IKS policy of 2004, which has guided this study.

Regarding commercialization of indigenous knowledge (Agan, 2013:29) wrote that:

Commercialisation can improve the general economic status of indigenous communities, resulting in better health, sanitation, education, standard of living, lowering of infant immortality, better food security and nutrition, which can all result in longer lifespan. Such communities need to be able to afford good education in order for them to understand their ecosystem well. Scientists, conservationists, doctors, economists, business experts and botanists should emanate from these communities.

Similar studies were also conducted by Levy (1990) who stated that the Ndebele art over the years has shown an expansion that has been influenced by the commercial market. The growth of this market has enabled women who are custodians to continue being gate-keepers of this knowledge while using it as a tool to survive. The popular Ndebele articles that are sold by custodians are beaded crafts such as the female attires and dolls. They also marketed for painted crafts, but this is not growing fast enough like the beaded articles. Levy (1990) has also noticed such an activity in the market of Ndebele articles. The scholar alluded that:

Today, Ndebele dolls have become prolific and popular items in the commercial market, and it is unlikely that too many dolls are made for

personal use in association with fertility. The commercial market has also determined the presence of an increasingly wide range and variety of styles in the making of the dolls (Levy, 1990:65).

According to Mashiyane (2006), South African women who are artists are able to provide for their families and use some of the money generated from this work for other purposes. Even though many do not possess sophisticated skills of trading, over a few years, there has been a paradigm shift achieved by the appealing costs offered by purchasers of beadwork-items and in addition tourists who purchase these articles as souvenirs. Carey in an article distributed and altered by Sciama and Eicher (1998: 91) composes that:

Beadwork enables a woman to become a wage-earner, by making and wearing massive quantities of personal beadwork and posing for photographs (for a fee). Well known are Ndebele of southern Africa or the Maasai of Kenya...

The above citation shows obviously how a characteristic ability and social habit can be pivoted and be utilized as intended to put bread on the table. According to Whooper (1988), in recent years beadwork has also been made for sale in the urban areas or to visiting dealers, and in this way women in very poor economic conditions have gained a small independent income.

According to Mashiyane (2006), there is a need for indigenous people especially elders to hire brand name officials who are part of the communities to prevent them being exploited by 'outsiders' and capitalists. Brand name officials can be young people with a formal education background and interested in protecting the intellectual property of indigenous people. Levy (1990) stated that brand officials must be able to understand and have knowledge on what intellectual property is, so that they can protect the indigenous knowledge of people. Majority of old people selling products from their indigenous knowledge have never received any formal education, it is unlikely for them to know their rights when it comes to intellectual property and benefit sharing (Becker, 1979). The lack of information in such an aspect therefore makes the vulnerable indigenous people to get exploited easily specially by "middle men".

According to Whooper (1988), Levy (1990), and Mashiyane (2006) middlemen are the general population who have the necessary capital and grab the chance to create thriving businesses. They present as a connection between the artists and the

prospective purchasers of art. The middlemen are capable of convincing indigenous entrepreneurs such as Ndebele women to buy articles in bulk from them, on a huge discount then later inflate their mark-up margin, ending up with a massive profit. According to Levy (1990), that is nevertheless exploitation and the producers ought to be ensured by legislation about this sort of industry. Powell (1995) likewise saw that this sort of action was occurring among the Ndebele. As indicated by him this begun by:

... a nationwide self-help scheme which, during the early 1980s, identified the potential of Ndebele beadworking as a way of generating some kind of economy within the depressed areas occupied by the people. ...its representatives made beads available to the women, placed orders for saleable items, and then returned on the next round trip to collect the finished products for sale via the organization's local and international outlets (Powell, 1995: 120).

To avoid exploitation, the middlemen must follow protocols of benefit sharing agreements before buying and accessing any indigenous products. The benefit sharing agreement will ensure that the entrepreneurs are not taken advantage of, and that they get rewarded handsomely for their intellectual property (Mashiyane, 2006). Alternatively, Pandor (2015) a former minister of Department of Science and Technology (DST) in South Africa agrees that a benefit-sharing agreement between the community and the third party must be concluded in case of gaining access to indigenous knowledge systems for the purpose of commercial or industrial application (cf.3.2.3) and this is according to the IKS Bill of 2016.

Presently, most of entrepreneurs have managed to organize themselves better, managed to expand their businesses and the fruits of their hard labour. In her study on the economic value of beads among the Zulu people, Xulu, (2002: 18) observed that:

Some modern bead projects found, especially, in KwaZulu Natal are commercial in nature and rake in huge revenue for both the bead makers and mostly the "middle-man".

Vermeulen (2007), Wynberg, Schroeder and Chennells (2009) conducted research on the exploitation of indigenous people. Making an example of the San people, the scholars found out that the San have utilized the hoodia plant as a hunger suppressant for a long time, particularly during hunting expeditions where little food was accessible

for a long time. In 1963, CSIR became aware of the plant's traditional use, from a 1937 paper by a Dutch ethnobiologist, and from San trackers who had worked for the South African military. During the 1980s, the CSIR resuscitated its enthusiasm for the plant and isolated its dynamic ingredient, a compound called P57, which at that point was patented in 1995. In 1997, the CSIR licenced P57 to a small British biotech organization, Phytopharm, which conducted double blind clinical preliminaries of the synthetic, affirming its hunger stifling qualities. In describing this case, Tellez (2008:3) wrote that:

A central problem in seeking an agreement with the CSIR to ensure fair and equitable sharing of benefits derived from the P57 patented Hoodia products was the deficiencies in South African legal framework for the protection on biodiversity and traditional knowledge. In the Hoodia case it was difficult to assert the claims of the San people regarding the P57 patent and the future commercialisation of Hoodia products because of the lack of a clear regulatory framework establishing their rights. The hardships suffered by the San people, that have in time have become dispersed and impoverished, also made it difficult for the community to assert their legitimate claims. Only recently, have the San been acquiring new land rights and efforts are being made to recover their heritage and reunite the San population. These difficulties are exemplified by the fact that during the early stage of the negotiations for a benefit sharing agreement the CSIR had argued that the San people no longer existed and hence they had not been consulted prior to the patent application for P57 nor had they tried to approach the San to negotiate any benefit sharing agreement once the patent was granted.

Similar studies on exploitation of indigenous people were also conducted by Fernando (2003) at Sri Lanka, an island country in South Asia who stated that indigenous people/villagers had a fear of foreign corporations taking control of their resources. These sentiments were politicized by both “radical” political parties—the Sinhala Urumaya (Sinhalese Heritage Party) and the Marxist-Leninist Janatha Vimukthi Peramuna (the People’s Liberation Front). They provided the villagers and the researcher with detailed information on the intrusion of multinational corporations into the area that took control of plants and species that hitherto were not marketable as well as how local populations lost control over their own environments and cultures. They also pointed out that large sums of money as aid and the promises of better income fooled the people. With the interventions of NGOs, local elites, and the

corporations, these foreign agents had consolidated their hold over the locals' livelihoods based on traditional systems of knowledge.

This study recognizes the commitment of researchers referenced in this section who have contributed with information on the commercialization of IK. Since an indigenous researcher completed this research, she has managed to gain indepth knowledge about how AmaNdebele women are able to sustain their livelihoods using their art. According to Bell (2005), indigenous researchers approach indigenous communities in an acceptable traditional manner, they are familiar with the cultural group and social setting, indigenous people are usually happy to participate, freely share indepth knowledge with people who understand (indigenous researchers) without fear of being judged, exploited and criticized (Bell, 2005).

Concluding remarks

In this chapter, the researcher argues that Ndebele women are entrepreneurs who sell their art to sustain their livelihoods. They have been able to eliminate poverty and grow their businesses over the years. Ndebele women are represented by brand name officials and managers who ensure that they are not exploited by capitalists. Previous studies conducted on this topic were reviewed to support the arguments made by the researcher. This study became the first academic research paper to review the works done by Dr. Esther Mahlangu, which has included the recognition that she received in previous year (2018). The next chapter focuses on the general discussion, recommendations and conclusions.

CHAPTER 7: GENERAL DISCUSSIONS, CONCLUSIONS AND RECOMMENDATIONS

7.1 Introduction

African women for a very long time have been gatekeepers of indigenous knowledge. Women have worked hard to preserve and protect this knowledge in order to be used by the next generation. The primary aim of this study was to answer the main question: how does the cultural life of AmaNdebele women reveal mathematical concepts and ideas? This question was answered in the research, and has, contributed immensely to the body of knowledge in this area of study. This chapter provides practical implications of the findings and discusses the limitations of this study. It further highlights some lessons that were learnt and the contribution of this study to the body of knowledge, as well as provide recommendations for stakeholders and researchers.

7.2 The role of ethnomathematics in the cultural life of AmaNdebele women at Ekosini village in Mpumalanga Province

The findings of this study have shown that AmaNdebele women are knowledge holders and gatekeepers of Ndebele art (beadwork and murals). Ndebele art is constructed using mathematical ideas and concepts. This means that AmaNdebele women are ethnomathematicians whose majority never attended any form of formal schooling (see Chapter 6). The AmaNdebele women transmit their knowledge to younger women and other women at *erhodlweni* and *ebaleni* where teachings take place. This is aligned with the tenets of the theory that was used for this study, eZiko Sipheka Sisophula by Goduka (2005) (cf. 3.5.1). According to Grenier (1998), there are specific conditions around which such Indigenous Knowledge Systems are developed. She defines it as ‘the unique, traditional, local knowledge existing within and developed around specific conditions of women and men indigenous to a particular geographic area’. Therefore, Grenier acknowledges women and the role they play in IKS.

Cultural creativity is another strategy women use to communicate with the outside world about what the Ndebele culture is. Women express their ways of knowing

(epistemology) and what they perceive as reality (ontology) through cultural creativity. This is aligned with the Indigenous Cultural Creativity theory by Jacob *et al* (2013) which looks at forms of creativity within the indigenous cultural context that expresses ways of knowing such as the spiritual (cosmic) that tap into the creative practices of indigenous cultures, both from the past and the present. Furthermore, the findings of the study show that the Ndebele art has been influenced by the cosmos. However, indepth knowledge on cosmic influence in the Ndebele art seems to be lost and unknown to majority of people.

The findings of this study pointed out the participants were also concerned with the fading out of this indigenous knowledge due to a lack of interest by other Ndebele people living in areas such as the Gauteng Province. The participants noted that they are willing to work with the government and local traditional authority in order to reach out to other Ndebele people and preserve this culture because according to them, not only is the Ndebele language is under threat but also the entire culture. Amongst other ideas, participants also raised a suggestion that this knowledge should be integrated in the CAPS curriculum so that it can be taught in schools. Teaching of this knowledge in schools will ensure its preservation and protection.

Findings of this study has also shown that AmaNdebele women are breadwinners of their households and they generate their income from selling their art to both local and international buyers. This shows that AmaNdebele women contribute to the development and growth of South African economy. This is in line with the South African IKS Policy of 2004 in which the prominence of the role of Indigenous women in economic development is stressed. Furthermore, Grenier's definition of indigenous knowledge systems which has been stated in 3.2.4 is an acknowledgement that through their indigenous knowledge, women are able contribute to the economic growth and development of the country.

It was discovered that previous scholars who conducted studies on Ndebele culture were anthropologists, historians and scholars from other disciplines rather than the discipline of Indigenous Knowledge Systems, which used their own worldviews to interpret the knowledge of the Ndebele people. Thus, this study recommends that African indigenous scholars should be responsible for researching, managing and documenting the indigenous knowledge of their people using academia as a tool.

Scholars who have done research and discussions on indigenous methodologies share the same sentiments with the researcher (see Chapter 3). The IKS Bill of 2016 and the Arts and Culture Policy of 2002 also argue that there is a need of documenting this knowledge and protecting it for future use and prevent Indigenous knowledge systems from being replaced by Western dogma and this can be done through NIKSO (cf.3.2.3).

7.3 Limitations of the study and reflections

When conducting this study, the researcher had challenges with the participants withholding some information that would have benefited the study. This resulted in data collected from Chapters 4 and 5 having gaps that needed the researcher to go back to the field to ask probing questions. The analysis of the follow up questions took longer than the researcher expected which shifted the date of submitting the study. Other challenges that were faced by the researcher are as follows:

7.3.1 Length of questions for focus group interviews (for both chapter 4 and chapter 5)

Before collecting data, the researcher tried to reduce the length of her questions for the tools she used. However, some of the participants got tired of answering questions and all they had to say is “I agree with her” the researcher had to politely ask them to further elaborate which some were able to. By saying, “I agree with her”, they withheld information that could have benefited the study. The researcher tried to be flexible and make everyone feel comfortable. More so, the researcher was able to read the body language of participants and their facial expressions. She tried to be on their level and created a common ground that made them more comfortable towards her.

7.3.2 Challenges of findings participants during snowball sampling

The participants that were referred to the researcher were far and required the researcher to walk distances. Some of the potential participants were unavailable and the researcher had to continue trying her luck. Some identified participants did not want to be interviewed away from the comfort of their homes and the researcher had to negotiate with them to meet in one place and conduct the study. At the last minute, some participants would cancel on the researcher and the researcher had to apologise on behalf of other participants. It was a very difficult task for the researcher to get the

participants in one venue. The postponing and unavailability of participants delayed the research project and the estimated time the researcher had in collecting data.

7.3.3 Challenges of booking Dr Esther Mahlangu

There are a few challenges the researcher had encountered before she had a scheduled appointment with Dr. Esther Mahlangu. The researcher had to call Dr. Mahlangu at least two months prior to conducting the study because she is always booked and forever travelling the world. The researcher received the permission after Dr. Esther Mahlangu's manager was told about the letter from the King which the researcher brought during data collection. Data collection took shorter than the researcher expected because she had other engagements to attend to. However, the researcher managed to get more data from this participant as she explained how she grew up and her journey as an artist. Dr. Mahlangu's responses were lengthy and had all the information the researcher needed.

7.3.4 Challenges of receiving a permission letter to conduct a study at Ekosini village from the Ndebele Ndzundza King.

It took me approximately a month to get a letter from the Ndebele King to conduct a study at Ekosini village. At first, it was a struggle for the researcher to communicate with the Ndebele King because of all his travels. The researcher had to wait for the king to come back from travelling before she got an opportunity to speak with him. After the researcher spoke to the king, it took at least two weeks for her to receive the permission letter. This delayed the initial plans of collecting data in November, which shifted to December.

7.3.5 Monetary compensations

Some participants of this study requested compensation in the form of money before proceeding with the research project. The researcher had to explain the entire process to them in the presence of their representative (cf.4.2.6) and that she was a student who was trying to document their knowledge (cf.4.2.7). They started cooperating after receiving confirmation from representatives and when the researcher explained that she will buy them meal after the interviews were conducted, of which did happen (see Figure 7.1).



Figure 7.1: Participants eating food after interviews.

7.4 Lessons learned from the study

The researcher brought to this study her personal orientation as described in chapter 1, and countlessly drew from those experiences to guide her relationship with the participants in this study. The literature on African philosophical underpinnings resonated with the researcher's background. This researcher knew and understood the importance of being part of the community and developing good rapport. She also understood her position among the participants which was that she was a child who came to learn from her elders with an aim of preserving this knowledge.

This researcher has learnt that communities like Ekosini value ethical protocols. The researcher's position was firstly explained by participants. They had their own guidelines on what constitutes ethical relationships. Participants did not shy away from asking the researcher about what they will benefit from the study. They were also thrilled to be informed that the researcher had a letter from the local King of which the participants belonged to (Ndzundza).

The researcher had to accept and adapt to circumstances that disturbed the research process. For instance, other participants from the first focus group were late in two different days. This caused confusion, frustration and doubt among other participants, which the researcher had to work on a plan to calm them down. The issue was quickly

addressed on the second day of data collection and the researcher worked on a plan to avoid such circumstances with other participants. Another obstacle that was faced by the researcher as discussed in 7.3.3 taught the researcher about the importance of acknowledging time and appointments. Dr. Esther Mahlangu is always a fully booked woman who was difficult to book initially. The researcher had to work according to her schedule. The researcher had to be professional, punctual and available on the days she booked the participant for an in-depth interview.

The entire data collection process felt like a ritual ceremony in the sense that the participants willingly shared information with the researcher that she never knew. The researcher was also allowed by participant artists to participate in activities such as beadwork and painting. This affirms the arguments of Wilson (2008) who stated that indigenous research is a ceremony. Throughout the data collection period, the researcher became a learner who was taught wisdom by knowledge holders. After data was collected, the researcher had to go to all her participants and acknowledge them individually for their contribution towards the research process. By showing acknowledgement and respect, one of the participants gave the researcher a beaded key holder as a token of appreciation. The gesture that was shown by this participant certifies that the researcher had indeed established a long-term relationship with the Ekosini community, which is a requirement when doing a study with indigenous communities. The researcher has provided a photograph of the key holder from the participant on Figure 7.2. This shows that when indigenous communities are approached in a correct manner, they acknowledge researcher by giving them gifts or singing them songs to show them that they have been welcomed and they are valued.



Figure 7.2: Key holder from a participant to the researcher.

7.5 Areas for further studies in the future

For further studies, the researcher suggests that more research can be done in the following areas:

1. The role of globalization in promoting the Ndebele beadwork and mural art;
2. The impact of Westernization in Ndebele culture and heritage;
3. Mathematical ideas and concepts in indigenous cultures;
4. The importance of transmitting indigenous knowledge;
5. Indigenous knowledge as a tool to create wealth and job opportunities for indigenous peoples;
6. The intellectual property rights of indigenous people;
7. Role of women in culture expression.

7.6 Conclusions of the study

Using an indigenous lens, the researcher has achieved to conduct a study on the role of ethnomathematics in the cultural life of AmaNdebele women at Ekosini village in Mpumalanga Province. Women on many occasions were proven knowledge holders of Ndebele art and that they were chosen by higher being to do this cultural. Ndebele women were also proven ethnomathematicians who use mathematical ideas and concepts to construct their art. The mathematical ideas and concepts are also visible in their beaded attire that has cultural significance. The meaning of the shapes found

in Ndebele art got lost previously. This study has also covered the purpose Ndebele women preserve the culture of using mathematical ideas and concepts in their art. Ndebele women have different mechanisms of sharing the ethnomathematical knowledge of art to other women. It was discussed in this study that Ndebele women use their indigenous knowledge to sustain their livelihoods. Using Dr. Esther Mahlangu as an example, this study has achieved to show that indigenous knowledge can be a source of improving livelihoods and social status of indigenous people. The study could encourage more academics from indigenous backgrounds to conduct studies related to this one from their own cultural groups using an indigenous research lens so that they can contribute to the “movement” of decolonizing African research and education as a whole.

7.7 Recommendations

Based on the findings of this study, the following is recommended:

1. The local traditional authority should work with Ndebele women and develop preservation strategies that could assist communities on how they can preserve this knowledge to be utilized and developed by the next generation.
2. Government needs to develop activities to promote awareness on how the Ndebele young people can make a living by doing this art.
3. Ndebele artist should attend annual *imbizo*'s (gatherings) to be taught by experts in entrepreneurship how to grow their business, and protect themselves from people who will try to exploit them.
4. Government working with traditional authority and Ndebele artists should work on a plan to develop an art school around KwaNdebele for young girls and other women interested in doing this art, as a strategy of preserving culture.
5. The Ndebele ethnomathematics should be integrated into the curriculum development of mathematics and art and culture.
6. There is a room to consider the amendment of the IKS policy of 2004 in order to accommodate and protect the current innovations and developments in IK made by indigenous peoples.
7. The government needs to higher professionals whose duty will be to educate indigenous people about intellectual property in order to avoid exploitation by capitalists.

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Statutory Sources

The Arts and Culture Policy of 2002

The National Language Policy of 2003

The Indigenous Knowledge Systems Policy of 2004

The Indigenous Knowledge Systems Bill of 2016

LIST OF APPENDICES

Appendix 1: In-depth interviews questions (for Dr Esther Mahlangu)

For objective one: To explore the feminine cultural expression of ethnomathematics in the cultural life of AmaNdebele women.

Section A: Questions

1. How long have you been practicing Ndebele crafts?
2. What does Ndebele art mean to you?
3. What made you embrace Ndebele crafts, or what has fascinated you about Ndebele crafts to make it such a crucial part of your life?
4. What shapes do you create in your art?
5. What is the meaning of geometric shapes in your art?
6. What is the meaning of the colours you use?
7. Where do you acquire the colours you use and how do u mix the colours you use?
8. What type of calculations are involved in your art which is used for cultural expression?
9. What styles do u use in your art?
10. What techniques do you use in your art?
11. How did you learn to make Ndebele art?
12. Where did you acquire the knowledge of using mathematical ideas and concepts in your art?
13. Is it true that only women get taught about Ndebele art? Why is it so?
14. Is there anything that you will like to add?

Appendix 2: Focus group interviews (for knowledge holders at Ndebele art School)

For objective one: To explore the feminine cultural expression of ethnomathematics in the cultural life of AmaNdebele women.

Demographical data

1. Marital status of the participant

Single ☐

Married ☐

Widowed ☐

Divorced ☐

2. Age of the participant

18-28 years ☐

51-61 years ☐

29-39 years ☐

62 and above ☐

40-50 years ☐

3. Experience in with practicing Ndebele crafts

0-10 years ☐

31-40 years ☐

11-20 years ☐

41 and above ☐

21-30 years ☐

Section B: Discussions

Researchers welcome and introduction to participants: Welcome and I would like to thank you for volunteering to participate. This focus group discussion is designed in order to assess your knowledge about Ndebele crafts. The focus group discussion will take no more than two hours of your time. Despite being recorded, I would like to assure you that this discussion will be kept anonymous and this researcher will follow all protocol stated by the consent form. May I please record the discussion to facilitate its recollection?

Rules for the participants

- a. I would appreciate if one person speaks at a time.
- b. There are no right or wrong answers in this discussion.
- c. You are not bound to speak in a particular order.
- d. When you do have something to say, please do so but only if someone has finished talking and you do not have to agree with the views of other people in the group.

Self-introduction by participants

- Firstly, before we begin I would like everyone to briefly introduce themselves.

Questions

Questions

1. How long have you been practicing Ndebele crafts?
2. What does Ndebele art mean to you?
3. What made you embrace Ndebele crafts, or what has fascinated you about Ndebele crafts to make it such a crucial part of your life?
4. What shapes do you create in your art?
5. What is the meaning of geometric shapes in your art?
6. What is the meaning of the colours you use?
7. Where do you acquire the colours you use and how do you mix the colours you use?
8. What type of calculations are involved in your art which is used for cultural expression?
9. What styles do you use in your art?
10. What techniques do you use in your art?
11. How did you learn to make Ndebele art?
12. Where did you acquire the knowledge of using mathematical ideas and concepts in your art?
13. Is it true that only women get taught about Ndebele art? Why is it so?
14. Is there anything that you will like to add?

Concluding remarks: Thank you for participating and your opinions are valuable.

Appendix 3: Focus group interviews (for knowledge custodians at Ekosini village)

For objective two: To investigate the mechanisms used by Ndebele women in transmitting ethnomathematical knowledge.

Demographical data

4. Marital status of the participant

Single ☐

Married ☐

Widowed ☐

Divorced ☐

5. Age of the participant

18-28 years ☐

51-61 years ☐

29-39 years ☐

62 and above ☐

40-50 years ☐

6. Experience in with practicing Ndebele crafts

0-10 years ☐

31-40 years ☐

11-20 years ☐

41 and above ☐

21-30 years ☐

Section B: Discussions

Researchers welcome and introduction to participants: Welcome and I would like to thank you for volunteering to participate. This focus group discussion is designed in order to assess your knowledge about Ndebele crafts. The focus group discussion will take no more than two hours of your time. Despite being recorded, I would like to assure you that this discussion will be kept anonymous and this researcher will follow all protocol stated by the consent form. May I please record the discussion to facilitate its recollection?

Rules for the participants

- a. I would appreciate if one person speaks at a time.
- b. There are no right or wrong answers in this discussion.
- c. You are not bound to speak in a particular order.
- d. When you do have something to say, please do so but only if someone has finished talking and you do not have to agree with the views of other people in the group.

Self-introduction by participants

- Firstly, before we begin I would like everyone to briefly introduce themselves.

Questions

1. How long have you been practicing Ndebele crafts?
2. What does Ndebele art mean to you?
3. What made you embrace Ndebele crafts, or what has fascinated you about Ndebele
4. How did you learn to make Ndebele art?
5. Where did you acquire the knowledge of using mathematical ideas and concepts in your art?
6. How does the knowledge transmission take place for women at different age levels?
7. What mechanisms do you use in transmitting ethnomathematical knowledge?
8. What are the levels or categories of learners do you teach Ndebele crafts and why are they taught the crafts?
9. Why is it important for knowledge of Ndebele art to be preserved and transmitted?
10. How do you protect and preserve this knowledge?
11. What is your role in art and cultural expression?
12. Is it true that only women get taught about Ndebele art? Why is it so?
13. What are the taboos involved in culture expression?
14. Is there anything that you want to add?

Appendix 4: Participant observation schedule (for the knowledge custodians at Ekosini village)

For objective two: To investigate the mechanisms used by Ndebele women in transmitting ethnomathematical knowledge.

Section A: Ethnomathematical Knowledge transmission observation overview.

Levels	Knowledge transmission Setting	Knowledge type(shared knowledge, common knowledge or secret knowledge)	Purposes
Toddlers			
Teenagers			
Maidens			
Newly wedded women			

Appendix 5: Semi structured interviews (for women who are entrepreneurs at Ndebele art school)

Section A: Demographic characteristics

For objective three: To explore how the Ndebele art sustains the livelihoods of Ndebele women.

Marital status of the participant

Single

☐

Married

☐

Widowed

☐

Divorced

☐

1. Age of the participant

18-28 years

☐

51-61 years

☐

29-39 years

☐

62 and above

☐

40-50 years

☐

2. Experience in practicing with Ndebele crafts

0-10 years

☐

31-40 years

☐

11-20 years

☐

41 and above

☐

21-30 years

☐

3. Level of education received

Grade 1 to 3

☐

Grade 10-12

☐

Grade 4-6

☐

None

☐

Grade 7-9

☐

4. Type of specialization

Beadwork

☐

Mural art

☐

5. Years of practicing

20-30 years ☐

31-40 years ☐

41 and above ☐

6. Years of selling

0-9 years ☐

10-19 years ☐

20 years and above ☐

7. Income made per month

R2000-R4000 ☐

R4100-R6000 ☐

R6100-R8000 ☐

R8100 and above ☐

8. Uses of income

House hold expenses ☐

Education ☐

Other ☐

Section B: Questions

1. Which Ndebele art do you specialize in?
2. How many years have you been practicing this art?
3. Why do you specialize with that art?
4. What inspired you to do this art?
5. How did you end up in this industry?
6. How are able to sustain yourself and family using this art that has mathematical ideas and concepts?
7. How have the proceeds from your business improved your lifestyle?
8. Who is your target market?
9. How have you benefited from this art?
10. Is there anything else that you would like to add?

Appendix 6: Introductory letter from the IKS centre



Faculty of Agriculture, Science and
Technology

Indigenous Knowledge Systems

Private Bag X2046 Mmabatho 2745

Tel: (018) 389 2453

Fax: (108) 389 5775

Website: www.nwu.ac.za

20 October 2017

TO WHOM IT MAY CONCERN

This is to confirm that Ms Monicca Thulisile Bhuda, is a registered student at the North-West University, Mafikeng campus (student no: 24464937). She is working towards a Masters degree on Indigenous Knowledge Systems in the Faculty of Agriculture, Science and Technology. Ms Bhuda is conducting a research entitled: The role of ethnomathematics within the indigenous cultural life of AmaNdebele women at Ekosini village in Mpumalanga province. The research requires her to conduct interviews with participants in order to collect data for research. The IKS centre has given Ms Bhuda permission to conduct the study at Ekosini village in the JS Moroka municipality under the Nkangala district, Mpumalanga province while waiting for ethical clearance. The IKS centre will greatly appreciate if you allow her to continue with the research process in Ekosini village.

Yours sincerely

A handwritten signature in black ink, appearing to read 'T. Saurombe', is enclosed within a rectangular box.

Dr T. Saurombe

Dissertation supervisor

Appendix 7: NWU ethics approval



ETHICAL APPROVAL LETTER OF STUDY

Based on approval by the Health Science Ethics Committee (FAST-HSEC) on 07/08/2018 after being reviewed at the meeting held on 07/08/2018, the North-West University Research Ethics Regulatory Committee (NWU-RERC) hereby approves your project as indicated below. This implies that the NWU-RERC grants its permission that, provided the special conditions specified below are met and pending any other authorisation that may be necessary, the project may be initiated, using the ethics number below.

Project title: The role of ethnomathematics within the indigenous cultural life of AmaNdebele women at Ekosini village in Mpumalanga Province.																											
Project Leader/Supervisor: Dr T. Saurombe & Prof S.A Materechera																											
Student: T.M Bhuda																											
Ethics number:	<table border="1"><tr><td>N</td><td>W</td><td>U</td><td>-</td><td>0</td><td>0</td><td>3</td><td>2</td><td>8</td><td>-</td><td>1</td><td>8</td><td>-</td><td>A</td><td>9</td></tr><tr><td colspan="3">Institution</td><td colspan="3">Year</td><td colspan="5">Status</td></tr></table> Status: S = Submission; R = Re-Submission; P = Provisional Authorisation; A = Authorisation	N	W	U	-	0	0	3	2	8	-	1	8	-	A	9	Institution			Year			Status				
N	W	U	-	0	0	3	2	8	-	1	8	-	A	9													
Institution			Year			Status																					
Application Type: Single study																											
Commencement date: 2018-08-08	Expiry date: 2021-08-07																										
Risk:	Minimal																										

Special conditions of the approval (if applicable):

General conditions:

While this ethics approval is subject to all declarations, undertakings and agreements incorporated and signed in the application form, the following general terms and conditions will apply:

- The project leader (principle investigator) must report in the prescribed format to the HSEC:
 - annually (or as otherwise requested) on the progress of the project, and upon completion of the project;
 - without any delay in case of any adverse event (or any matter that interrupts sound ethical principles) during the course of the project; and
 - Annually a number of projects may be randomly selected for an external audit.
- The approval applies strictly to the protocol as stipulated in the application form. Would any changes to the protocol be deemed necessary during the course of the project, the project leader must apply for approval of these changes at the HSEC. Would there be deviation from the project protocol without the necessary approval of such changes, the ethics approval is immediately and automatically forfeited.
- The date of approval indicates the first date that the project may be started. Would the project have to continue after the expiry date, a new application must be made to the NWU-RERC via HSEC and new approval received before or on the expiry date.
- In the interest of ethical responsibility, the NWU-RERC and HSEC reserves the right to:
 - request access to any information or data at any time during the course or after completion of the project;
 - to ask further questions, seek additional information, require further modification or monitor the conduct of your research or the informed consent process;
 - withdraw or postpone approval if:
 - any unethical principles or practices of the project are revealed or suspected;
 - it becomes apparent that any relevant information was withheld from the HSEC or that information has been false or misrepresented;
 - the required annual report and reporting of adverse events was not done timely and accurately; and/or
 - new institutional rules, national legislation or international conventions deem it necessary.
- HSEC can be contacted for further information via Lesetja.Motadi@nwu.ac.za or 018 280 2508.

The HSEC would like to remain at your service as scientist and researcher, and wishes you well with your project. Please do not hesitate to contact the NWU-RERC or HSEC for any further enquiries or requests for assistance.

Yours sincerely

Prof Lesetja Motadi
Chair NWU Health Science Research Ethics Committee (FAST-HSEC)

Appendix 8: Participate consent form in indigenous knowledge research



Title of Study: The role of ethnomathematics in the cultural life of AmaNdebele women at Ekosini village in Mpumalanga Province.

Description of the research and your participation

You are invited to participate in a research study conducted by Bhuda Monicca Thulisile who is doing masters in Indigenous Knowledge Systems. The study investigates the role of ethnomathematics within the cultural life of AmaNdebele women of Ekosini. There are no known risks associated with this research. There are no financial known benefits to you that would result from your participation in this research. Rather, this study will add to the current existing literature about the Ndebele culture and their history of ethnomathematics and also a copy of a published journal article will be issued to the local municipality in order to be distributed in local libraries.

As a researcher, I will do everything possible to protect your privacy such as not disclosing your identity in any publication resulting from this study. Your participation in this research study is voluntary. You may choose not to participate and you may withdraw your consent to participate at any time. You will not be penalized in any way should you decide not to participate or to withdraw from this study.

Contact information

If you have any questions or concerns about this study or if any problems arise, please contact the supervisors on +27183892453 during working hours and request for Dr T Saurombe (supervisor) or Prof S.A Materechera (co-supervisor).

Consent

I have read this consent form and have been given the opportunity to ask questions. I give my consent to participate in this study.

Participant's signature _____ Date: _____

Appendix 9: Participant non-disclosure agreement



Title: The role of ethnomathematics in the cultural life of AmaNdebele women at Ekosini village in Mpumalanga Province.

This Nondisclosure Agreement (the "Agreement") is entered into by and between _____ with intended participants' _____ ("Disclosing Party") and _____, located at _____ ("Receiving Party") for the purpose of conducting research on the role of ethnomathematics within the indigenous cultural life of AmaNdebele women at Ekosini village in Mpumalanga province.

Exclusions from Confidential Information: Receiving Party's obligations under this Agreement do not extend to information that is: (a) publicly known at the time of disclosure or subsequently becomes publicly known through no fault of the Receiving Party; (b) discovered or created by the Receiving Party before disclosure by Disclosing Party; (c) learned by the Receiving Party through legitimate means other than from the Disclosing Party or Disclosing Party's representatives; or (d) is disclosed by Receiving Party with Disclosing Party's prior written approval.

Obligations of Receiving Party: Receiving Party shall hold and maintain the Confidential Information in strictest confidence for the sole and exclusive benefit of the Disclosing Party. Receiving Party shall not, without prior written approval of Disclosing Party, use for Receiving Party's own benefit, publish, copy, or otherwise disclose to others, or permit the use by others for their benefit or to the detriment of Disclosing Party, any Confidential Information. Receiving Party shall return to Disclosing Party any and all records, notes, and other written, printed, or tangible materials in its possession pertaining to Confidential Information immediately if Disclosing Party requests it in writing.

Integration. This Agreement expresses the complete understanding of the parties with respect to the subject matter and supersedes all prior proposals, agreements, representations, and understandings. This Agreement may not be amended except in a writing signed by both parties.

Appendix 10: Benefit sharing agreement



Title of Study: The role of ethnomathematics in the cultural life of AmaNdebele women at Ekosini village in Mpumalanga Province.

Benefit sharing agreement (of indigenous knowledge)

between _____ and

1. User of indigenous knowledge associated with Ndebele ethnomathematics

The permit applicant is _____ as
registered company/ or natural person in terms of South African Laws
The relevant details of the company/ organisation/ institution are:

Contact details

contact person

2. Indigenous knowledge holder associated with Ndebele ethnomathematics

The indigenous knowledge holder is _____
as a (natural person or Indigenous Community) in terms of South African
Laws

The relevant details are:

**Name
person**

contact details

contact

State name of principal (If entering into agreement in a representative capacity)

3. Sharing of benefits

3.1 Monitory benefits: The researcher will not compensate
participants'/knowledge holder with money because this study is for
academic purposes and not for any financial benefits.

3.2 Non monitory benefits: The local municipality together with the
participants of this study will have access to research data for any clarity

or verification. After the study has been published, the municipality on behalf of the community will have access to the article and receive their own copy that can be sourced in local libraries.

4. Review of agreement

4.1 This agreement will be reviewed every _____ (fill in agreed timeframe), with a view to amending the agreement if necessary.

5. Third party

5.1 The applicant undertakes not to transfer the indigenous knowledge associated with Ndebele ethnomathematics to a Third Party, without the written authorization of the indigenous knowledge holder; and then only under a legally binding written agreement with the indigenous knowledge holder based on this Agreement.

6. Other matters

6.1 Any other matters or conditions which the parties to this agreement wish to record:

7. Breach of termination

7.1 If a party to this agreement ("the breaching party") breaches any material provision of this agreement, the other party ("the aggrieved Party") shall be entitled to deliver to the breaching party a written notice requiring the breaching party to rectify that breach within 30 days of receipt. If the breaching party remains in breach of such provision within 30 days after receipt of the notice, the aggrieved party shall be entitled (without derogating from any of its other rights or remedies under this agreement or at law).

7.2 To sue for immediate specific performance of any of the defaulting party's obligations under this agreement, whether or not such obligation is then due.

7.3 To cancel this agreement, in which case written notice of the cancellation shall be given to the defaulting Party, provided that the remedy of specific performance or damages would not adequately prevent the aggrieved party from being prejudiced.

_____	_____	_____
_____	_____	_____
Name of traditional holder/ Community representative	Signature	Date
_____	_____	_____
_____	_____	_____
Name of applicant	Signature	Date

Name of municipal authority

Signature

Date

Appendix 11: Material transfer agreement



Notes

1. This agreement must be entered into by an applicant for a permit and any stakeholders identified in terms of the regulations who provide or give access to indigenous knowledge resources.
2. If there is more than one stakeholder a separate agreement must be entered into with each stakeholder.
3. If insufficient space is provided in this form, additional information may be included by way of annexures. Alternatively, parties can elect to use their own forms with sufficient space provided for each Regulation, as long as those forms follow the general format of this form.
4. The parties to this agreement must sign the agreement in the space indicated and must initial every other page of the agreement, including any annexures.

Parties to the agreement

1. Recipient of indigenous art, if recipient is a juristic person:

1.1. Name of institution or body: _____

1.2. Registration no. of institution or body: _____

1.3. Contact details of institution or body (including postal/physical address, phone, fax and e-mail address): _____

1.4. Name of contact person in institution or body (attach a certified copy of ID document): _____

1.5. Capacity of contact person: _____

2. Recipient of indigenous art, if recipient is a natural person

2.1. Name of recipient: _____

2.2. Identity number of recipient: _____

2.3. Contact details of recipient (including postal/physical address, phone, fax and e-mail address): _____

3. Provider of access to indigenous art

3.1. Name: _____

3.2. Capacity: _____

3.3. If entering into agreement in a representative capacity, state name of principal: _____

3.4. Contact details (includes physical/postal address, telephone, Fax and e-mail address): _____

4. Indigenous art

The type, quantity and source of indigenous biological resources to which this agreement relates are –

Beaded artefacts	Painted artefacts

5. Current uses of the indigenous art

The present potential uses of the indigenous resources/ art to be used/collected are the following -

6. Purpose of export (if applicable)

The indigenous arts are to be exported for the following

Purposes –

7. Third parties

The recipient may only provide any such indigenous art or their progeny to third parties in terms of the following conditions (fill in detail below) -

The recipient agrees to take every reasonable precaution to prevent the identified indigenous art coming into the possession of any unauthorised third party.

8. Entire Agreement

This agreement constitutes the entire agreement between the parties in regard to the subject matter of this agreement and no addition to, variation or cancellation of this agreement or waiver of any rights under this agreement will be of any force or effect unless reduced to writing and signed by the parties to this agreement.

Signature of an applicant for permit: _____ Date: _____

Capacity of signatory: _____

On behalf of: _____

Signature of access provider of resource: _____ Date: _____

Capacity of signatory: _____

On behalf of: _____

Approved by the Minister of Water and Environmental Affairs

Signature

Date

DEPARTMENTAL CONTACT DETAILS

All completed documents must be mailed to:

THE IKS CENTER

Postal address:

North-West University

Mafikeng Campus

Private Bag X2046

Mmabatho

2745

FOR THE ATTENTION OF THE DIRECTOR: RESOURCE USE

Enquiries:

Miss. Lesedi Makapela (secretary) Tel: 018 389 2453

Fax: 0183892837

E-mail: lesedi.makapela@nwu.ac.za

Appendix 12: Approval from the Ndzundza Ndebele King



Permission letter to conduct a study at Ekosini village

Title of the study: The role of ethnomathematics within the indigenous cultural life of AmaNdebele women at Ekosini village in Mpumalanga province.

I, Sipho Etwell Mahlangu Ikosi of the Ndebele tribe provide Monica Thulisile Bhuda (Student no :24464937) who is doing Masters in Indigenous Knowledge Systems at the North West University, Mafikeng campus permission to conduct a study at Ekosini Village situated in Weltevrede JS Moroka Municipality, Mpumalanga Province. I am satisfied with all the information provided for this study and therefore, I permit this it to be conducted from December 2017 to March 2018.

For any enquiries, please do not hesitate to contact me on Tel: 012 336 4947 Cell: 071 461 0475 Email: Mahlangu.etwell@gmail.com

Yours sincerely,

Ikosi Sipho Etwell Mahlangu


Signature

07/12/2017

UMBUSO SITJHABA WENDZUNDZA MABUSA