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AN EXPLORATION OF ETHNOMATHEMATICAL APPROACHES IN THE TEACHING AND LEARNING OF GRADE 6 GEOMETRY

By

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BLOEMFONTEIN

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DECLARATION

I, Poo Freda Mmapula, declare that the study titled "*An Exploration of Ethnomathematical Approaches in the Teaching and Learning of Grade 6 Geometry*", hereby submitted for the qualification of Doctor of Philosophy at the University of Free State, is my own original work. All the references I have used or quoted were indicated and acknowledged by means of complete references.

I further declare that I have not previously submitted this work to another university of faculty for the purpose of obtaining qualification.

…..……………… 29 November 2024

SIGNATURE DATE

Student Number: 2019675046

ABSTRACT

This study aimed to explore ethnomathematical approaches in the teaching and learning grade 6 geometry. The study was prompted by alarming learner performance trends on national assessments and international evaluations, such as Trends in International Mathematics and Science Study (TIMSS). Results from these assessments, including the national assessment Diagnostic Report (DBE, 2014), revealed a persistent pattern of underachievement in geometry among learners, demonstrating a critical need for targeted support and an innovative approach to enhance teaching and learning in this content area. Scholars such as Abiam, Abonyi, Ugama and Okafor (2016) and Nkopodi and Mosimege (2009) identified that the high failure rate among learners might be due to methods used by teachers, teachers' inability to connect learners learning to cultural experiences, teachers limited knowledge of ethnomathematical approaches and how to integrate them into the teaching of geometry. In answering the research question: How can ethnomathematical approaches be explored in the teaching and learning Grade 6 geometry? The study explored: (1) Grade 6 teachers' understanding and experience of ethnomathematical approaches, examining their ability to integrate cultural practices into geometry instruction. (2) Grade 6 learners' familiarity with Ndebele cultural artefacts as teaching and learning resources, assessing their knowledge of the embedded mathematical concepts and their cultural significance (3). Women Knowledge Holders' expertise as custodians and designers of Ndebele cultural artefacts, uncovering their intuitive mathematical knowledge, its application in crafting the cultural artefacts, and most importantly, their collaboration with teachers in implementing ethnomathematical approaches. Vygotsky's theory of socio-cultural learning guided the study. A qualitative ethnographic design was employed. Two sampling procedures were used to select participants. Purposive sampling was used to intentionally choose teachers and learners with expertise and experience to answer the research questions, and convenience sampling was used to recruit Women Knowledge Holders who were readily available and willing to contribute their insights. The study engaged 24 participants, representing three groups: five Grade 6 teachers, 10 Grade 6 learners and nine Women Knowledge Holders. Data analysis was done through thematic analysis. The findings revealed that the teachers interviewed lack knowledge of ethnomathematical approaches, Women Knowledge Holders can forster deeper connections between learners’ culture and mathematics. It was also found that Women Knowledge Holders did not recognise their cultural crafting practices as mathematical endeavors. The study recommended teacher trainings on ethnomathematical approaches, partnership and collaboration with Women Knowledge Holders, acknowledging, recording and preserving their mathematical contributions**.** Future research should focus on developing a culturally relevant mathematics framework with particular reference to Ndebele culture so that teachers can explore and understand the relationship between Ndebele culture, mathematics, teaching and learning, facilitating the implementation of ethnomathematical approaches.

Keywords: Ethnomathematics, ethnomathematical approaches, Indigenous Knowledge Systems, Mathematical concepts and skills, Ndebele cultural artefacts, Ndebele mural art Women Knowledge Holders

DEDICATION

I dedicate this thesis to:

My late husband, Sello Joel Poo, who always encouraged me to be a lifelong learner, whose wisdom and resilience continue to inspire me and my beloved late father, Frans Moshikaro. May their souls rest in peace.

My mother, Lillian Moshikaro, and my four children, Lorato, Tumisho, Nkube and Tshepiso, whose unwavering support and encouragement were my guiding lights throughout this academic journey. Without them, this achievement would not be possible.

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Special thanks to principals, teachers, learners, and Women Knowledge Holders who volunteered to participate in this study and whose contributions were truly of great value to me.

I honour the memory of Mr TG Mtsweni, whose contributions to this research will never be forgotten.

My sincere appreciation goes to my family for their unwavering support, understanding and encouragement. Their belief in me kept me motivated during challenging times.

LIST OF ACRONYMS

ANA	Annual National Assessment
ATP	Annual Teaching Plan
CAPS	Curriculum and Assessment Policy Statement
DBE	Department of Basic Education
FGD	Focus Group Discussion
IK	Indigenous Knowledge
IKS	Indigenous Knowledge Systems
LoLT	Language of learning and teaching
MKO	More Knowledgeable Others
NCTM	National Council of Teachers of Mathematics
NDP	National Development Plan
RATP	Recovery Annual Teaching Plan
SC	School
TIMSS	Trends in International Mathematics and Science Study
WKH	Women Knowledge Holders
ZPD	Zone of Proximal Development

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ORIENTATION TO THE STUDY

1.1 Introduction

Ethnomathematical approach is the teaching approach that integrates cultural knowledge and mathematical concepts utilizing ethnomathematical folklore games from students' culture. (Fouze and Amit, 2017). Machaba and Dhlamini (2021:60), argued that it can be a teaching approach which focuses on students' background, their immediate environment integrated with the Eurocentric mathematics in a practical way. Ethnomathematical approaches build on learner's prior understanding, experience, role played by the environment on content, and past and present experience of their immediate surroundings (D'Ambrosio, 2001). The ethnomathematical approach is described by Mogari (2014) as a learner-centred activity. This focused teaching method centres on the mastery of mathematics concepts through appropriate, realistic activities known to learners. Ethnomathematical approaches use cultural artefacts found in the learner's local environment to teach geometry (Abiam et al., 2016:7). According to Rosa and Orey (2011:32), ethnomathematical approaches to mathematics are intended to make school mathematics more relevant and meaningful to students. This study sought to investigate the application of ethnomathematical approaches in geometry instruction and explored how teachers effectively integrate these approaches to create more inclusive, culturally responsive learning.

The research study aligns with the principles of the National Council of Teachers of Mathematics (NCTM, 1991), emphasising the significance of establishing meaningful connections between mathematical concepts, students' everyday experiences, and cultural background. Learners' understanding becomes more profound and lasts longer when they realise the mathematical connections within their own interests and experiences (NCTM, 2000). It further highlighted that people who can reason and analyse can note patterns and structures in both real-world and mathematical situations.

Teachers' experiences with using ethnomathematical approaches in teaching geometry were explored; mathematical concepts found in the Ndebele cultural artefacts were investigated to determine how they can aid learners' understanding of geometry. The research study examined how teachers in the Ndebele community relate what they teach in their classrooms to the

Ndebele cultural artefacts used in everyday life. Zuya and Kwalat (2015), Ozerem (2012) and Adolphus (2011) recommended that teachers should relate lessons to real-life situations to reduce the abstract nature of the subject.

The research study derived its significance from observed learner mathematics performance in Annual National Assessment (ANA) results. Evidence on learner performance is drawn from the data of three (3) years in ANA (2012, 2013, 2014). To gain a comprehensive understanding of learners' progression, I included Grade 9 in my discussion, which allowed for a detailed analysis of trends and patterns in performance between Grade 6 and 9 as the exit grades that participated in the ANA assessment.

Table 1.1: Grade 6 & 9 National average % for 2012, 2013 and 2014 ANA

Grade	2012	2013	2014
6	27	39	43
9	13	14	11

Table 1.2: Grade 6 & 9 ANA *Mpumalanga average* % for 2012, 2013 and 2014

Grade	2012	2013	2014
6	23.4	33.6	39.9
9	11.9	13.7	11.3

Table 1.3: Grade 6 & 9 ANA *Nkangala District* average%

Grade	2012	2013	2014
6	24.1	34.4	40.2
9	13.5	15.3	11.1

Tables 1.1-1.3 above demonstrate a notable trend: the three-year performance across all three levels, National, Provincial and District, falls short of expectations with averages consistently below 50%. However, the Nkangala District slightly improved compared to provincial averages

in all three years and both Grades 6 and 9. The results indicated that we are significantly off track from reaching the NDP 2030 target.

The ANA Diagnostic Report (2014) provided evidence of geometry challenges, errors, and common misconceptions from learners in the ANA test administered. Discussing errors and misconceptions in this study was crucial to facilitate targeted interventions and uncover language barriers that hinder learners' comprehension, allowing for more comprehensive support through culturally responsive teaching. Discussing errors and misconceptions can inform teacher training on targeted intervention strategies by the curriculum section using ethnomathematical approaches.

Table 1.4: Areas of Difficulty in Space and Shape

Grade	4	5	6	9
Areas of weakness	Symmetry of 2D Shapes, Properties of 2D shapes and 3D objects	Transformation of 2D shapes, Properties of 2D shapes and 3D objects	Similarities and differences between rectangle and parallelogram. Properties of 2D shapes and 3D objects	Congruency and similarity deductions, angles, opposite equal sides of a triangle, terminology and definitions in geometry, angle relationship in parallel lines, Theorem of Pythagoras.

(Dagnostic report, DBE, 2014)

The information in Grades 4, 5, 6 and 9 above proved that if problems are not addressed early, learners struggle to grasp foundational concepts, leading to difficulties in more advanced topics. Early intervention and support are crucial; hence, the research focused on Grade 6 and ethnomathematical approaches as part of mitigation to the identified problem.

The Department of Basic Education (DBE) provided schools with test exemplars to serve as guidelines for the standard of assessment required. Test exemplars were administered, and District officials conducted an error analysis. The analysis revealed a repeated pattern of errors and misconceptions.

Trends in International Mathematics and Science Study (TIMSS) is a trend study administered every four years and conducted by the International Association for the Evaluation of

Educational Achievement (IEA), intending to measure the country's overall performance. Contextual questionnaires are administered to school principals, mathematics and science teachers, and learners. In addition to collected contextual data, learners are subjected to mathematics and science assessments. TIMSS results were deemed relevant to the study and incorporated to inform our teaching practice to have a broader context of learners' performance. In these pinpoint-specific areas, learners struggle to provide targeted interventions. Evidence on learner performance is drawn from the three years of TIMSS (2015, 2019 & 2023).

TIMSS described four points on the scale regarding ability: Low (400 to 475) points. Intermediate (475 to 550) points, High (550 to 625) points and advanced (>625) points. The very low descriptor was included for scores less than 400 (TIMSS, 2019 & 2023).

Table 1.5: Trends in average mathematics scale score 2015, 2019 & 2023 South Africa Grade 5

Grade	Year	Average score
5	2015	376
5	2019	374
5	2023	362

(TIMSS, 2019 & 2023)

Table 1.6: Trends in average mathematics scale score Grade 5, 2019 and 2023 *Mpumalanga Province*

Grade	Year	Average score
5	2019	343
5	2023	337

Table 1.5 illustrates South Africa's Grade 5 performance for the 2015, 2019 and 2023 assessments, with a score of fewer than 400 points. Table 1.6 shows that Mpumalanga Province performed less than 400 points and less than the 2019 and 2023 National achievement. According to the TIMSS 2019 report, learners encountered difficulty in Measurement, geometry and several content domains (Content areas).

Examples of mathematics concepts and mathematics items (TIMSS, 2011) portrayed learners' errors and misconceptions in geometry. Diagnostic report ANA 2014 (Table 1.6) reported a correlation in performance because it also revealed that learners found it difficult to respond to questions on measurement and Space and Shape. Table 1.7 below illustrates the average %, on Geometry per the ANA 2014 Diagnostic Report.

Table 1.7: Average % marks for Space and Shape (ANA 2014 Diagnostic Report)

Space and Shape (Geometry)	
Grade	Average %
4	34
5	34
6	40
9	30

Abiam et al. (2016) assert that poor learning and low achievement in geometry are attributed to methods used by teachers. The same view was stated earlier by Achor, Imoko, and Uloko (2009), who noted that the current methods utilized are inappropriate for reversing the trend or changing learner performance. According to Nkopodi and Mosimege (2009:376), the high failure rate among learners might be due to the inability to see the connection between education at school and their everyday life experiences. Mathematics is taught in isolation from learners' cultural backgrounds (D'Ambrosio & Rosa, 2017; Mosimege, 2015). Teaching of mathematics is not contextualized to learners' everyday lives (Van der Walt, Portgier & Jagals, 2019). Traditional approaches to teaching mathematics led to a lack of basic mathematical knowledge, rote learning and underperformance (Machaba & Dlamini, 2021).

D'Ambrosio (1990) contents that Western Europe does not consider cultural identity and its potential influence on mathematical learning. Similarly, Machaba and Dlhamini (2021) alluded that conventional teaching approaches do not consider the learners' cultural background and role in enhancing teaching and learning. The focus of education in South Africa is on Western values, leading to learners from disadvantaged backgrounds being unable to see the connection between school mathematics and their everyday mathematics within their socio-cultural context (Nkopodi & Mosimege, 2009). Scholars' shared experience and findings on the lack of connectedness motivated the researcher to conduct investigations through interviews with teachers and learners and participant observations to explore using ethnomathematics approaches in the teaching of geometry.

Mosimege (2012) indicated teachers have limited knowledge of ethnomathematical approaches to teaching geometry. Anderson-Pence (2015) stresses that teachers' past beliefs on mathematics and how it is taught and assessed must be reexamined. Limitations in teachers' ethnomathematical knowledge and lack of training lead to a lack of confidence in using the approaches in their teaching (Naresh, 2015). Sunzuma and Maharaj (2019) concur with this study that teachers lack knowledge of ethnomathematical approaches and how to integrate them into geometry teaching. The researchers above advocated for integrating the ethnomathematical teaching approach into school mathematics classrooms and in-service training on the ethnomathematical approach for teachers. Aikpitanyi and Eraikkhuemen (2017), Adolphus (2011) and Achor et al. (2009) recommend that the government should send teachers for training and seminars in ethnomathematics and ethnomathematical teaching approaches for effective teaching and learning.

Bhuda (2019) and Mosimege (2000) found that mathematical concepts are embedded within Ndebele art and recommended further research. Bhuda's (2019) study investigated the role of ethnomathematics in the cultural life of Amandebele Women. Mania and Alam (2021) investigated Indonesian teachers' perceptions of using the ethnomathematics approach using a case study design. Literature is silent on the joint endeavour between Women Knowledge Holders (WKH) and teachers to incorporate cultural knowledge and cultural artefacts into geometry instruction.

Teachers, learners, and WKH as participants in ethnomathematical approaches were interviewed, lesson observations on mathematics instruction were conducted within the five schools sampled, and focus group discussions (FGDs) and participant observations were held with WKH.

1.2 Statement of the Problem

According to the Curriculum and Assessment Policy Statement (CAPS) (2011:294), Intermediate Phase learners are subjected to Term 2 and End of the Year examinations. In 2019, Grade 6 learners participated in the provincial assessment to evaluate their academic proficiency in mathematics and maintain educational quality standards. Learners' performance in geometry was below expectations. Subject advisors and teachers conducted error analyses for written examinations and suggested intervention strategies. Error analysis results revealed recurring patterns in ANA 2012, 2013, and 2014, including TIMSS 2015, 2019 on learner performance concerning geometry. In 2023, Grade 6 learners in Moretele Siyabuswa Sub- District, participated in the Mathematics competition and subsequent end of the year test, with item analysis revealing persistent challenges. Learners found it challenging to identify 2D shapes and angles, struggled with properties of 2D shapes and 3D objects, could not respond to the similarities and differences between rectangles and parallelograms, and could not identify transformations used and lines of symmetry in 2D shapes.

The study aligns with Ozerem (2012:725), who states that Grade 7 students had several misconceptions; they lacked knowledge related to Geometry, and learners could not recognize the properties of quadrilaterals and could not visualize nor assimilate them. Mamali (2015: iv) also indicated that many learners failed to understand geometrical concepts adequately and demonstrate sound reasoning and problem-solving skills. According to Nkopodi and Mosimege (2009:377), learners' high failure rate is attributed to a lack of correlation between teaching, learning, and real-life situations. Despite the implementation of various intervention strategies by mathematics district officials, learners' performance remained challenging.

1.3 Conceptual Framework for the Study

The conceptual framework (Figure 1.1) illustrates the relationship between ethnomathematical approaches (Independent variables), teaching and learning approaches (dependent variables) mediating factors and expected outcomes. It provided a clear structure and guidance for the study.

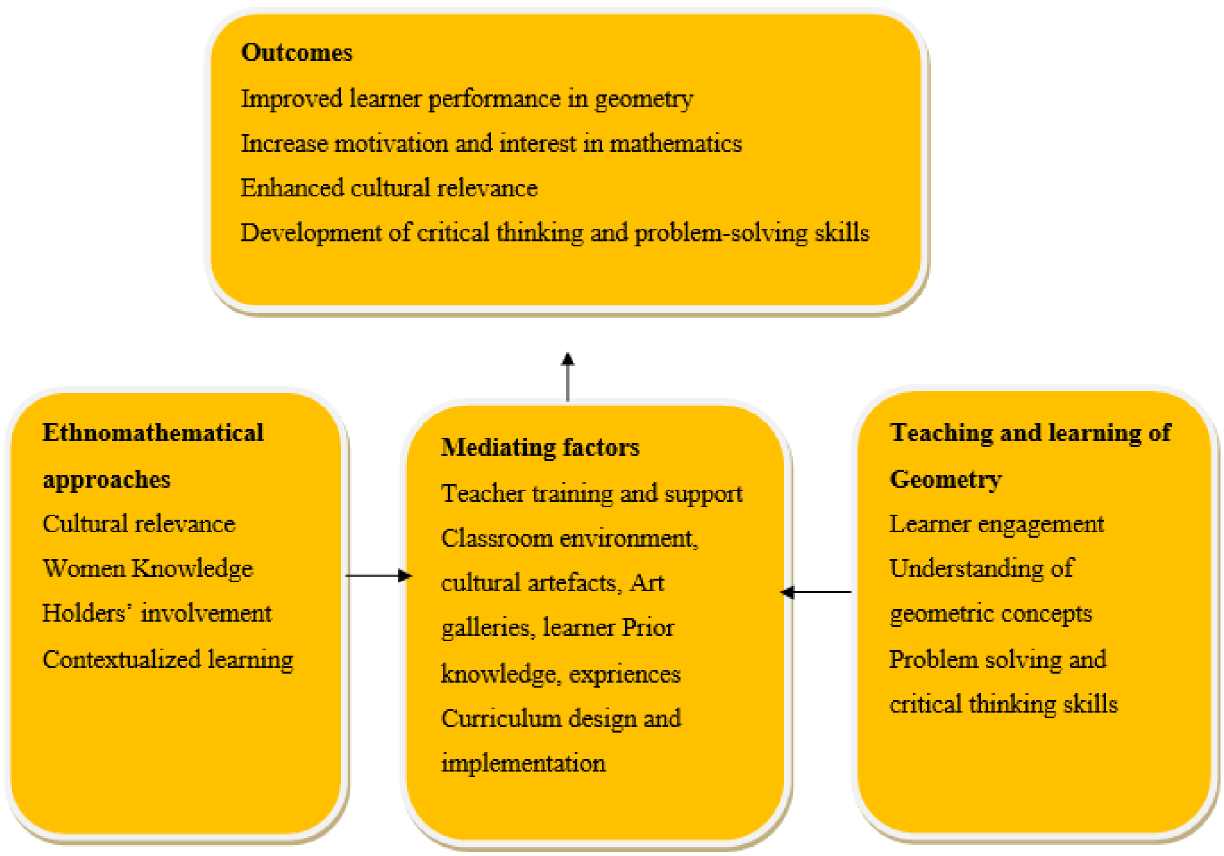


Figure 1.1: Conceptual framework

1.4 Theoretical Framework for the Study

The research study was guided by Vygotsky's socio-cultural learning theory, which explains how individuals learn and develop through social and cultural environments. It emphasizes the role of culture, language and social interactions in shaping learning and development. The identified theoretical framework justified the research study. It provided the rationale for conducting the research, informed the sampling procedure data collection, was used as the basis for analyzing and interpreting the results and assisted in comparing and constructing data across participants. Vygotsky (1978) firmly believes that social interaction and cultural influences significantly affect learning and how learning occurs. Theory suggests that learning is a product of a social interaction process. Vygotsky further argues that individual development cannot be understood without referencing the social and cultural context within which it is embedded.

This study focused on participants' meanings formed through interactions, understanding, and experiences with the phenomenon within real-life situations. Creswell (2009) says that in social constructivist theory, participants seek an understanding of the world they live in and work in, develop meanings of their experiences and that subjective meanings are constructed by human beings as they interact. The study sought to understand the experiences of participants on using ethnomathematical approaches to the teaching and learning of geometry to enhance deeper conceptual understanding and improved geometry performance, as well as to understand the social phenomenon from participants' perspectives, hence the utilization of the socio-cultural theoretical framework.

1.4.1 Constructivist Learning Theory

According to the constructivist learning theory, learners construct their understanding of mathematical concepts through active engagement and experience. The theory emphasizes the need for hands-on, inquiry-based learning approaches that allow learners to explore and discover geometric concepts meaningfully. The constructivist theory was introduced by Jean Piaget, with the notion that learners are not blank slates but creators of their learning. According to Piaget (2003), integrated networks or cognitive schemas are products of constructing knowledge; as learning occurs, networks are rearranged, added to or modified. People create knowledge based on prior knowledge (Van De Walle, Karp & Williams, 2010). The constructivist theory was relevant because ethnomathematical approaches promote active learning and encourage critical exploration through real-world contexts. Constructivist theory highlights the importance of meaning-making in learning, while ethnomathematical approaches connect geometric concepts to one's own cultural and everyday experiences, making learning more meaningful and relevant.

1.5 Purpose and Objectives of the Study

The purpose of the research was to explore the use of ethnomathematical approaches in the teaching and learning of Grade 6 geometry.

The objectives of the research study are as follows:

1. To explore the experiences of Grade 6 teachers in using ethnomathematical approaches to the teaching of geometry
2. To investigate Ndebele cultural artefacts that can be used to teach geometry in Grade 6.
3. To determine the mathematical concepts found in Ndebele cultural artefacts that may be used in the teaching and learning Grade 6 geometry.
4. To explore using mathematical concepts found in Ndebele cultural artefacts in teaching Grade 6 geometry.

1.6 Research Questions

The study was guided by the main research question and sub-questions presented below in its attempt to explore ethnomathematical teaching approaches.

1.6.1 Main research question

How can ethnomathematical approaches be used in the teaching and learning Grade 6 geometry?

1.6.2 Sub-research questions

1. What are the experiences of Grade 6 teachers in using ethnomathematical approaches in teaching geometry?
2. Which Ndebele cultural artefacts can be used to teach Grade 6 geometry?
3. What mathematical concepts are found in Ndebele cultural artefacts that may be used in the teaching and learning Grade 6 geometry?
4. How can such mathematical concepts be used to teach Grade 6 geometry?

1.7 Research Methodology

The research study employed a qualitative research approach. There was a must to gain a deeper understanding of the experiences of teachers, learners and WKH through interviews, FGDs and participant observations. McMillan and Schumacher (2001:391) explain qualitative research as a naturalistic inquiry that uses non-interfering data collection strategies to discover the natural flow of events and how the participants interpret them. The study was based on a naturalistic approach that sought to understand the phenomenon in real-world settings to understand the social phenomenon from participants' perspectives (Maree, 2013:78-79). Qualitative research methodology was mainly concerned with understanding the process, social and cultural context, explored the why questions of the research study, studied people by interacting with and observing the participants in their natural environment with focus on their meanings and interpretations in real-life situations (Maree, 2013:4). The research study adopted interpretive paradigm to uncover the cultural significance and mathematical concepts in Ndebele cultural artefacts, explored how teachers and learners experience and make sense of ethnomathematical approaches in geometry instruction.

The study used an ethnography research design. Qualitative research design was considered to be appropriate since the researcher aimed at obtaining an in-depth understanding of the phenomenon within the naturalistic context, sought to inquire on the knowledge of Ndebele artefacts and mathematical concepts embedded in them, how they are transferred, connected and used in ethnomathematical approaches for deeper understanding of geometry. The research study focused on real-life situations within the Ndebele cultural context. The study also followed the exploratory design. The research sought to explore the experiences of Grade 6 mathematics educators in a fundamental social and cultural context to get their understanding, interpretation and knowledge on using ethnomathematical approaches to teaching and learning geometry through interacting as a participant observer. The phenomenon researched was not interfered with or manipulated; hence, qualitative research was used.

1.8 Data Collection Methods

The primary data-gathering instruments were interviews, observations, and FGDs.

1.8.1 Interviews

The interviews took place as a two-way conversation whereby I asked the participants questions to collect data learnt about ideas, beliefs, views, opinions and their behaviours (Maree, 2013:87).

Cohen et al. (2018:26) define interviews as a two-person conversation initiated by the interviewer to obtain research relevant information. An interview aimed to obtain rich descriptive information or data to help the researcher understand the participants' construction of knowledge and social reality (Maree, 2013:87). The researcher used semi-structured interviews. Questions were predetermined, and probing and clarification of answers were allowed during the interview process (Maree, 2013:87). Interviews were seen to apply to the research study. They enabled the researcher to explore participant's ideas, knowledge, and opinions on the ethnomathematics approach to teaching and learning geometry. The researcher met the participants, interacted with them, observed the respondents' non-verbal communication, and recorded the results accordingly.

The researcher interviewed teachers and learners, including WKH within the community, who are custodians and entrepreneurs in Ndebele mural art and beadwork.

1.8.2 Observation

Observation is the systemic process of recording the behavioural patterns of participants, objects and occurrences without questioning or communicating with the respondents (Maree, 2013:83-84). Observations assisted the researcher in gathering live data from live situations to discover things that participants might not freely talk about in the interview situation (Cohen et al., 2018:26). The researcher used participant observations. The focus was on recording the constructed realities as demonstrated by the participants in their non-verbal cues and social interactions (McMillan & Schumacher, 2001:40). The researcher observed teachers' interaction with learners, collected data on using ethnomathematical approaches to see how cultural artefacts and their mathematical concepts are utilized to aid retention and achievement. WKH were also observed when making cultural artefacts.

1.8.3 Focus group discussions

The researcher used FGDs with WKH. Group interactions were productive in widening the range of responses and activating forgotten details of experience (Maree, 2013:90). Participants built on each other's ideas and comments. They provided an in-depth view, which the researcher could not obtain from individual interviews.

1.9 Sampling

According to Maree (2013:79), a sample is defined as the process used to select a portion of the population for study. The researcher utilized purposive sampling and convenience sampling. McMillan and Schumacher (2001:397) define purposeful sampling as selecting information-rich cases for study to increase the utility of information obtained from small samples; researchers search for information-rich key informants' groups. Maree (2013:79) emphasizes that in purposive sampling, the decisions are made to obtain the richest information to answer the research question. Maree (2013) further stressed that purposive sampling means that participants were selected because of some defining characteristics that make them the holders of data needed for the study. Participants were chosen intentionally based on characteristics or experiences that make them uniquely relevant to provide data required for the study; they possess specific knowledge or expertise, have experience in a particular aspect of research, and belong to a specific population or group. The aim was to collect in-depth data from participants who could provide detailed insights, experiences, and perspectives relevant to the research question.

Purposeful sampling enabled me to focus on a particular population of interest with shared characteristics that can best answer the research questions. More information with fewer errors was collected from eligible participants, and time was saved. Participants in this research study were five Grade 6 mathematics teachers and ten Grade 6 learners.

Initially, the plan included five WKH, the team leader and four other ladies. Unfortunately, the plan was altered because of the unavailability of the team leader identified and her team. I had to look for other WKH within Dr JS Moroka municipality, which led to snowball sampling, also known as chain referral sampling. Maree (2013:80) defined snowball sampling as a method whereby the researcher contacts participants and refers the researcher to other participants within their social networks who could participate in the study. Snowball sampling expanded the scope beyond a single team, including individual women and a team of women, resulting in nine WKH. The number was adequate because it enabled me to gather in-depth information and diverse perspectives from Women of different age groups who shared unique insights and experiences.

Teachers were sampled because they teach Grade 6 mathematics and are responsible for implementing the curriculum using different teaching approaches. Learners were selected because they know their own culture, which they acquired through observation, direct involvement, and interaction with parents and WKH within the community. Younger members of the society may be found to be knowledgeable in ethnnomathematical activities (Mosimege, 2017:669). According to Bhuda (2019), girls at puberty wear embroidered attire made with hands. Professor Mosimege, in his research on Indigenous mathematical knowledge, reported that ladies learned most of the skills at a young age, between 10 and 14, from parents, grandmothers and sisters. Learners were selected based on their mathematics performance, focusing on high-performing learners. High-achieving mathematics learners were purposively selected for this study, assuming their advanced understanding and proficiency in the subject would enable them to provide rich, insightful responses and meaningful data.

Nine WKH within the community were sampled because they are practitioners and entrepreneurs in Ndebele Art and Craft and have extensive knowledge, experience, and broad information about the Ndebele cultural artefacts. Women who create beadwork have an exceptional understanding of bead making and numerous years of experience (Bhuda, 2019:86). WKH are custodians of Ndebele art. They are relevant to best answer the research questions.

1.10 Ethical Issues

The researcher adhered to the standard ethics of research. Ethical clearance was applied to conduct this study, and the Ethical Committee of the University of the Free State granted permission. The researcher also sought and was allowed permission by responsible stakeholders to collect data (District CES, Circuit manager, Principals of sampled schools. WKH and parents of learners from the selected schools).

Participants were informed of all the aspects of the research study and assured of confidentiality and anonymity. Information received from the participants will not be known to the public (Cohen et al., 2002:61-63) and Maree (2013:41-42). All participants signed consent forms, including parents of learners. They were informed that they could withdraw without penalty or prejudice for participation in the research study—the principles of being caring and fair prevailed. Participants received a full explanation of the benefits, rights, risks and dangers involved due to their participation in the research study (Cohen et al., 2018:50; Maree, 2013:41-42).

1.11 Validity, Credibility and Trustworthiness

Validity is essential to effective research and requires qualitative research (Cohen et al., 2018:108). They further indicate that in qualitative data, validity may be addressed through honesty, depth, richness, and scope of data achieved, as well as participants' approach and prolonged engagement in the field. This applied to the research study because participants were approached to collect data. I spent a protracted amount of time in the schools, e.g., one week of regular visits, and I familiarized myself with the schools before the data collection process.

Lincoln and Guba, as cited in Cohen et al. (2018), suggest that credibility in naturalistic inquiry can be addressed by prolonged engagement in the field, persistent observation, member checking or respondent validation. Member checking was done to allow respondents to provide additional information and check the adequacy of data analysis.

Engaging multiple data collection methods such as observations, interviews, and FGDs led to trustworthiness (Maree, 2013:80).

1.12 Data Analysis

Qualitative analysis is a systematic process of selecting, categorizing, comparing, synthesizing and interpreting data to explain the phenomenon of interest (McMillan & Schumacher, 2001). Maree (2013) defines it as an interactive approach to understanding participants' meaning of the phenomenon by analyzing their perceptions, attitudes, understanding, knowledge, experiences, and others to approximate their construction of the phenomenon under study. Coding was applied to identify frequently used words, concepts and expressions, and patterns and categories were determined to constitute emerging themes (Cohen et al., 2018). Thematic analysis was used to analyze data from in-depth and focus group interviews. Thematic analysis is a method for identifying, analyzing, and reporting themes within data (Braun & Clarke, 2006:6). The six steps of Braun and Clarke (2006) were followed that is I familiarized myself with the data collected through reading, re-reading transcripts and presenting transcription of verbal data from interviews in a written form, generated initial codes to data collected by grouping similar items, searched for themes by sorting different codes into potential themes, reviewed themes to refine them, themes defined, named and the final report was produced.

1.13 Significance of the Study

The study is considered necessary because it revealed the mathematical concepts embedded in the Ndebele Cultural artefact and the incorporation of cultural context into learning mathematics to enhance learner performance in geometry. It contributed insights into effective teaching strategies aligned with learners ' cultural backgrounds and experiences. It further sheds light on working collaboratively and cooperatively with WKH as stakeholders with in-depth information on Indigenous Knowledge (IK).

The research study is anticipated to bridge the gap between abstract geometric concepts and learners' everyday mathematics found in their culture, leading to a deeper understanding of geometric concepts. It served as a resource for professional development, offering teachers insight into their teaching practice and ultimately improving the instructional quality. ANA 2012 proposed practical activities to enhance learners' spatial awareness, which this approach will make possible. The findings of this study will add value to existing literature on ethnomathematics and ethnomathematical approaches. It is important to other stakeholders within the education system, such as provincial and district curriculum managers, mathematics subject advisors, teachers, parents of learners, and WKH.

1.14 Delimitations of the Study

The research study was restricted to Ndebele mural art and Ndebele cultural artefacts. The focus was on the space and shape (geometry) content area and its integration with the other content areas. The study confined itself to interviewing, participant observations and FGDs.

1.15 Limitations of the Study

The research study had some limitations even though there were precautions in place. Limitations included sample size and representativeness, data collection methods such as observational techniques, time constraints and resource constraints. The study was limited to

Grade 6 Mathematics teachers and their learners within five schools, Ndebele culture and WKH only. Grade 6 was sampled because it is an exit Grade for the intermediate phase; analysis of results is based on it; learners are expected to have mastered the basic geometric knowledge before going to the senior phase.

Time limitations and resource constraints affected the time scheduled for lesson observations and COVID-19 arrangements and regulations, making it challenging to access participants. Mathematics is taught 6 hours a week; participants were responsible for mathematics and other subjects. Arrangements were made for interviews to be conducted during free periods, in the afternoon and during weekends in consultation with participants and with their permission. It wasn't easy to access WKH due to their other programmes. The original plan for sampled participants was tempered with because of unavailability.

Financial and transport problems to reach the schools around Weltevrede were another challenge. The research study was not funded; therefore, there was a need for the researcher to include its expenditure in her budget, which included the trips and cash for payment or incentives to participants. Purposive and snowball sampling decreased the generalisability of findings. Snowball sampling can lead to biased samples as participants are recruited from existing social networks. While purposive sampling may satisfy the researcher's needs, it does not pretend to represent the broader population; it is selective and biased (Cohen et al., 2018:104).

1.16 Organization of the Study

The study consists of five chapters.

Chapter 1: Orientation to the Study

Chapter 1 served as a roadmap. It established the context of the study and outlined the background information on ethnomathematics and ethnomathematical approaches. It also provided the rationale of the study, the problem statement, which articulated the research problem, aim and objectives, the research design and methodology, conceptual framework, theoretical framework, the significance of the study and how it has contributed to existing knowledge, justified the need for the research, the scope and limitations.

Chapter 2: Literature Review

This chapter outlined a comprehensive review and synthesis of existing literature relevant to the research topic and elaborated on the conceptual and theoretical framework guiding the study. It summarized the key findings of previous studies related to the research topic. Trends, patterns, and gaps were identified to justify the need for the current study.

Chapter 3: Research Methodology

This chapter typically focused on the methodology of the study and outlined how the research was conducted, the research design, participants, data collection instruments and data analysis, ethical considerations, validity and reliability, and limitations.

Chapter 4: Presentation of Results

Chapter 4 focussed on the study's results and presented the findings based on data collected during research.

Chapter 5: Discussion, Implications, Summary and Conclusions

This chapter synthesized the study's findings, discussed their implications and resolved the research questions or objectives. It synthesized the entire research process and provided avenues for future research, conclusions and recommendations.

1.17 Summary

Chapter 1 introduced the topic of the research study. It started with an overview of the literature review on ethnomathematics and ethnomathematical teaching approaches, including the theoretical framework that guided this study. The background information highlighted the current gaps in knowledge and the need for future research. Research objectives and questions were presented, setting the stage for subsequent chapters. An overview of the research methodology and the rationale behind the chosen approach was given.

CHAPTER 2
LITERATURE REVIEW

2.1 Introduction

This chapter aims to provide a comprehensive overview of existing research and literature related to ethnomathematical approaches in teaching and learning Grade 6 geometry. The background to the study was discussed in the previous chapter (Chapter 1).

A literature review on ethnomathematics, ethnomathematical teaching approaches and IK was conducted to understand existing studies on the research topic, including the theoretical framework underpinning the research study. The literature review is arranged into seven main sections: (1) definition of concepts (2) Ethnomathematics and mathematics education (3) Mathematics concepts and processes from analysis of ethnomathematical activities (4) Women, Indigenous Knowledge Systems (IKS) and ethnomathematics (5) Mathematics, ethnomathematics and IKS (6) Mathematics performance and its' relation to ethnomathematics. (7) Theoretical framework.

2.2 Definition of Concepts

2.2.1 Culture

Zimmermann (2017) defines culture as the characteristics and knowledge of a particular group, encompassing language, religion, social habits and arts. It includes social behaviour, knowledge, beliefs, laws, customs, capabilities, and arts of individuals and their group members. It is the arts and other manifestations of human intellectual achievement, the customs, institutions and achievements of a particular nation, people or group (Oxford Concise Dictionary, 2012:286).

2.2.2 Art and Craft

Art expresses or applies creative skill and imagination through visual mediums such as painting or sculpture. Craft is an activity involving the skill of making things by hand (Oxford Concise Dictionary, 2012:60).

2.2.3 Mathematics

Mathematics is defined in CAPS (2011:8) as a language that uses symbols and notations to describe numerical, geometric and graphical relationships. CAPS (2011) further describes mathematics as a human activity involving observing, representing and investigating patterns and quantitative relationships between mathematical objects in physical and social phenomena. Mathematics is the by-product of human ideas, creativity, problem-solving, beliefs, values and survival (Van De Walle et al., 2010:103). According to the definitions, mathematics helps develop mental processes that enhance logical and critical thinking, accuracy and problem-solving, contributing to good decision-making.

2.2.4 Geometry

According to Jones (2002), the word geometry comes from two ancient Greek words, one meaning earth and the other meaning measure. According to CAPS (2011:10), general content focus and geometry improve the understanding and appreciation of patterns, precision, achievement, and beauty in natural and cultural forms. It focuses on properties, relationships, orientations, positions, and transformations of two-dimensional shapes and three-dimensional objects.

Geometry helps us describe, analyze, and understand our world (Zuya & Kwalat, 2015:100; Ozerem, 2012:721). Geometry and culture are interrelated, and this makes school geometry closely connected to the environment and culture within which it is taught (Sunzuma & Maharaj, 2019:1). A rich understanding of geometry has clear and important implications for other areas of the curriculum (Van De Walle et al., 2010:426). Teaching geometry well means enabling more students to succeed in Mathematics (Jones, 2002:122). Ozerem (2012:722) indicates that geometry allows students to analyze and interpret the world they live in and, as a result, gain more geometric skills.

2.2.5 Ethnography

Ethnography is defined as an analytical description of social scenes, individuals and groups that recreate their shared feelings, beliefs, practices, artefacts, folk knowledge and actions (McMillan

& Schumacher, 2001:427). Maree (2013:76) defines it as a description of a social group that focuses on social systems and cultural heritage. Ethnographic research was seen to be relevant to the research study because the researcher needed to understand participant's construction of thoughts, meanings, and actions in their natural context. Laridon, Mosimege and Mogari (2005) state that ethnographic research can make mathematics embedded in cultural practices and artefacts fully revealed or expressed without ambiguity.

The researcher spent time in schools with teachers and learners and the community with WKH, interviewing, observing, and recording data within their social and cultural contexts to understand their views on the Ndebele cultural artefacts that can be used to teach geometry. I selected to focus on Ndebele culture because of its prominence in Mpumalanga, where I reside. As a resident of Mpumalanga, I have had the opportunity to experience Ndebele culture firsthand despite not being a fluent isiNdebele speaker. My local connection and cultural exposure inspired me to explore it further through research.

2.3 Ethnomathematics and Mathematics Education

Ethnomathematics enriches mathematics education by offering cultural and contextual perspectives to teaching and learning mathematics. It emphasizes the cultural context in which mathematical concepts are embedded. It contributes to creating a more inclusive approach to teaching and learning mathematics.

2.3.1 Definitions of Ethnomathematics

D'Ambrosio (1984), in his earliest definition of ethnomathematics, defined ethnomathematics as Societies have due to the interaction of their individually developed practices, knowledge and, in particular, jargon and codes which clearly encompass how they mathematise, that is, how they count, measure, relate and classify and how they infer' Different cultures have own Jargon and codes. The jargon and codes in his definition refer to specialized language or terminology used within a particular group. Codes are symbols used to convey meaning, such as language codes, figurative language or behavioural codes like gestures. Cultural codes include norms, values or beliefs of a particular culture.

D'Ambrosio (1985:45) defined ethnomathematics as the mathematics practised among identifiable cultural groups such as national–tribal societies, labour groups, children of a certain bracket, and professional classes. He continued to say its identity depends on interest, motivation, specific codes, and jargon that do not form part of the realm of academic mathematics. The cultural groups described by D'Ambrosio (1985) can be identified according to ethnicity, share similar experiences and practices, and have their own language and specific ways of doing things. Cimen (2014:534) argues that D'Ambrosio used the term cultural groups, which refers to social groups such as carpenters and street sellers, which have their own language and specific ways of obtaining mathematical estimates and measures.

D'Ambrosio (1989) divided the concept of ethnomathematics into components (ethno + mathema + tics) and explained that 'we use the term ethnomathematics for the art or technique of understanding, explaining, learning about, coping with and managing the natural, social and political environment using a process like counting, measuring, sorting, ordering and inferring from well-identified cultural groups. The process of counting, measuring, sorting, ordering and inferring in D'Ambrosio's definition relates very closely to Bishop's (1988), which are the characteristics of every culture. The six activities were counting, locating, measuring, designing, playing and explaining. The six fundamental activities of Bishops are identifiable in different cultures.

D'Ambrosio 1990 further shed more light on the prefixes *ethno* and *mathema.* D'Ambrosio stated that ethno describes a group's cultural identity, such as language, codes, values, jargon, beliefs, habits and physical traits. In contrast, mathema includes measuring, classifying, ordering, inferring and modelling. The suffix tics is said to have the same root as the technique. People developed strategies for survival that were synthesized into three words: *tics, mathema, and ethno.* The word *tics* refers to ways, styles, arts or techniques developed for *mathema*, for explaining learning, understanding, knowing and coping with their *ethno,* which is their natural fact, social and imaginary environment. Etymologically motivated D'Ambrosio to construct the concept of tics of mathema in ethos to ethno + mathema + tics. D'Ambrosio rearranged words to the ethnomathematics concept. (D'Ambrosio & Rosa, 2017).

Gerdes (1994:20) defines ethnomathematics as the field of research that studies mathematics in its relationship to the whole cultural and social life, further indicating that ethnomathematics may be defined as the cultural anthropology of mathematics and mathematical education.

A common thread among the definitions is the recognition that learning is most impactful when connected to learners' lived experiences, socio-cultural practices and real-world applications. Connections make learning more relevant, engaging and memorable.

According to Gerdes (2005), Ethnomathematics started to emerge in the 1970s and 1980s among educators and researchers on the mathematical marginalisation of people, particularly the poor during the Third World War and people of African descent and other minorities in the First World War. D'Ambrosio (1990) proposed an ethnomathematical programme to track and analyse the process of generation, transmission, diffusion and institutionalization of (mathematical) knowledge in diverse cultural systems). The origin of ethnomathematics is attributed to D'Ambrosio, hence referred to as the intellectual father of ethnomathematics (Gerdes, 2005:49).

Ethnomathematics refers to a broad cluster of ideas ranging from distinct numerical and mathematical systems to multicultural mathematics education (D'Ambrosio, 1990). It involves studying mathematical knowledge and practices in different cultures and integrating this knowledge into the teaching and learning of mathematics. Similarly, Machaba and Dlhamini (2021) defined ethnomathematics as an instructional approach recognising learners' previous knowledge, background, and environment when solving problems.

Gerdes (2014:31-37) argues that mathematics existed and continues to exist beyond the imported school in Indigenous mathematics. He says mathematics is a cultural product as every culture develops its own particular mathematics. Indigenous mathematics refers to the mathematical knowledge, practices, and traditions of Indigenous peoples that evolved long ago, often in connection with their cultural, spiritual, and environmental contexts. Traditional mathematical practices include counting informal measurements in solving problems. Members of cultural groups develop activities that involve mathematical thinking; they construct mathematical knowledge by developing ideas, procedures and standard practices available within a particular cultural group (Rosa, Shirley, Gavarrete & Alangui, 2017:544-548). Cultural influences have a significant impact on the development of mathematical thought for individual learners and society in general; hence, mathematics is understood as a cultural product (Anderson-Pence, 2015:52). These statements are in agreement with Chahine (2013: 8) that all people are capable of doing mathematics in their own unique and personal perspective.

D'Ambrosio (2001) and Gerdes (1996, 1986) defined ethnomathematics as a field that explores the relationship between mathematics and culture. It tries to study mathematics in its relationship with cultural and social life (Gerdes, 1994:20). According to Van De Walle et al. (2010:103), it combines culture, mathematics and education activities. Zhang and Zhang (2010:152) defined it as research on the relationship between social and cultural backgrounds in mathematics that shows how mathematics is produced, transferred, diffused, and specialized in different cultures. Rosa and Orey (2011) argued that it is a study of the cultural aspects of mathematics. The definitions given in this paragraph emphasize cultural mathematical connection as the core. The emphasis is on highlighting the cultural influences on mathematical knowledge, practices and beliefs.

Gerdes (1986) refers to ethnomathematics as the frozen mathematics. In Gerdes' context of frozen mathematics, it refers to the study of mathematical concepts and practices preserved within a particular culture. Mathematical ideas were developed and passed down through generations as part of the community's cultural heritage. Cimen (2014), Asher (1991) and Bishop (1988) reported on the mathematical ideas of the non-literate cultures. Much emphasis is on exploring mathematical concepts and practices within cultures that do not have a tradition of written mathematics. The rationale is to value knowledge embedded in non-literate societies and recognise diverse ways mathematics is expressed across different cultures.

Ethnomathematics embraces mathematical ideas, thoughts, concepts, procedures and practices developed by cultures; it studies mathematical ideas, anthropology and history, the cultural artefacts, mathematical concepts embedded therein, the people who made them and how they learned to make them form part of history (Barton, 1996).

Machaba and Dlhamini (2021) argue that ethnomathematics attempt to shift from formal and conventional academic mathematics to mathematics within the immediate environment practices and Indigenous culture. Based on the definitions given by D'Ambrosio, one can deduce that ethnomathematics links teaching and learning to learners' cultures to help them understand mathematics content better as it is related to what they do in their daily activities. It assists us to gain insight into how mathematics is embedded in different cultural contexts. It promotes inclusivity in mathematics education and fosters a deeper understanding of mathematics as a human endeavour.

Different scholars shared their perspectives on defining ethnomathematics. Most importantly, across various studies, a consensus emerged in ethnomathematics definitions that it refers to mathematical practices, ideas, and concepts within cultural contexts. Ethnomathematics recognizes the importance of valuing and respecting different mathematical traditions and knowledge systems. It aims to promote cultural inclusivity and broaden understanding of mathematics as a human endeavour shaped by various cultural perspectives. Mathematical knowledge is not universal but influenced by the cultural context in which it develops.

2.3.2 The importance of ethnomathematics in mathematics classrooms

Learners enter the classroom with knowledge shaped by their sociocultural background, which may be helpful in teaching and learning mathematics (Van der Walt et al., 2019).

Some scholars developed a theory of culturally relevant pedagogy that reinforces connections between learners' culture and school mathematics (Rosa & Orey, 2011; D'Ambrosio, 1990), and it is, therefore, essential to integrate a culturally relevant curriculum into mathematics curriculum (Rosa & Orey, 2011:33). Ethnomathematical approaches ensure that meaningful learning takes place, improve learners' as it connects learners' experiences gained from their culture to school mathematics. Kukahiko (2014) states that integrating culture and mathematics can increase learner involvement in the classroom. It makes mathematics education more culturally relevant and inclusive. Through exploring mathematics practices from their own culture, learners will see the connections between mathematics and their cultural backgrounds, which can enhance engagement, interest in learning mathematics and improved performance.

According to Gerdes (1996), ethnomathematics can contribute to a more inclusive and culturally responsive approach to teaching and learning mathematics. Similarly, Mahpudin and Sunanto (2019) attest that learning mathematics through ethnomathematics can bring mathematical concepts closer to learners' daily lives and will assist them in having a better understanding of the learning outcomes. Learners' own cultural and historical knowledge will be incorporated into the classroom. Mahpuding and Sunanto (2019), Abiam et al. (2016), and Gerdes (1996) stressed the importance of incorporating an ethnomathematical teaching approach in mathematics.

Abiam et al. (2016) recommended an ethnomathematics-based instructional approach in geometry teaching. Learners exposed to ethnomathematical approaches performed better than their counterparts taught using conventional methods. The study investigated the effects of an ethnomathematics-based instructional approach on learners' performance in geometry. Two groups of learners participated in the research study, one being the control group and the other in the treatment group. The treatment group was taught using an ethnomathematics-based instructional approach, while the control group was taught using a conventional instruction approach. The results revealed that the ethnomathematics-based instructional approach was superior to the conventional method in improving learners' performance in geometry. Learners' high performance was attributed to effective communication in learning geometry and self-confidence in solving problems using cultural artefacts in their local environment. Learning was practical; geometry was brought to real-life situations, which led to meaningful learning and learners' improved achievement in geometry.

As the learners' interest in ethnomathematics grows, they will be better positioned to see that mathematics extends beyond the classroom. Brandt and Chernoff (2015:31) further gave examples of ethnomathematics with patterns, symmetry, games, measuring and counting shapes. Ethnomathematics highlights the practical applications of mathematics in everyday life. It demonstrates how mathematical concepts and skills are used in various cultural contexts. Nkopodi and Mosimege (2009), Laridon et al. (2005) and Cherinda (2002) also highlighted the importance of cultural aspects in mathematics and the role of ethnomathematics in teaching mathematics.

D'Ambrosio (2016) stated that the purpose of introducing ethnomathematics was to demystify school mathematics as a final, permanent and unique form of knowledge. D'Ambrosio (2016) further argued that the traditional form of teaching mathematics brought upon the current misconception that good performance in mathematics is for more intelligent people and that they are superior to others. Ethnomathematics is introduced to show the achievements of different cultures, people, and genders to eliminate intolerance, inequity, or discrimination.

According to Brandt and Chernoff (2015:31-32), Ethnomathematics will develop the learners' interest in mathematics. It is anticipated that the interest in mathematics will lead to improved performance and more learners registering for mathematics in Grade 12. The interest and improved performance in geometry will also assist in reaching the schooling target. Vision 2030 (DBE) states that the schooling targets for 2024 Grade 3, 6 and 9 mathematics aim to have 80% of learners perform at 50% and above. Brandt and Chernoff (2015) contend that ethnomathematics will enable teachers to empower voices and ideas traditionally marginalized to engage, inspire and empower Aboriginal children in ways that traditional school mathematics has failed. Aboriginal students have a lower pass rate as compared to non-aboriginal counterparts. Showcasing the mathematical achievements and practices of diverse cultures promotes the idea that mathematics is for everyone regardless of cultural background**.**

Mathematics educators need to get involved in reinventing mathematical knowledge hidden in cultural artefacts (Cherinda, 2015). Gerdes (1986) emphasizes the necessity of encouraging an understanding that our people were capable of developing mathematics in the past, and therefore, by regaining cultural confidence, we will be able to develop and use mathematics creatively.

The reason for bringing ethnomathematics into the classroom practice, fostering using IKS in teaching and learning mathematics, is for learners to know that Western mathematics resulted from contributions of IKS of different civilisations along history (Cherinda, 2002). Cultures provide many examples of ethnomathematical activities in the classroom, such as games and symbols in artwork such as symmetries, geometrical shapes, numeric patterns, counting, and others. Any of these examples could be translated into the classroom with the hope that using outside-school mathematics will help learners build their learning on an understanding of situations rather than algorithms.

Mosimege (2016), in his plenary closing address for the Association for Mathematics Education of South Africa (AMESA) Congress, stated that teachers should take the teaching activities as part of the Africans who are engaged in the formidable task of reclaiming their heritage, as the process of restoring their African pride, attaining mathematical knowledge for them to have an entirely new meaning to mathematics teaching and learning.

2.3.3 Studies in which ethnomathematical activities were used in classrooms

Several studies were conducted to explore the role and use of Indigenous activities in teaching and learning school mathematics in the classroom.

Moloi (2020) conducted the study with a team of Grade 10 learners and three Grade 10 mathematics teachers at the school in the rural area of Qwaqwa in the Thabo Mofutsanyana Education District using the *Diketo* game. The teacher responsible for the grade prepared the lesson on linear functions. Findings revealed that learners fully participated in the lesson presentation; using the *Diketo* game in teaching derivations of linear functions contextualized the content and made it easily accessed by learners. Concepts and skills include linear functions, patterns, geometric shapes, factors and non-factors of 10, and relationships between variables.

A study conducted by Achor et al. (2009) in Nigeria reveals that students taught using an ethnomathematical approach showed superior attainment than those taught using the traditional approach.

Abbas (2000) conducted a study in Nigeria at the Riruwal Primary School in Doguwa Local Government of Kano state. Learners were divided into two groups: the control group and the experimental group. In the control group, learners were taught concepts of cuboids, cylinders, circles and rectangles using suggested activities, whilst the experimental group was first subjected to the treatment of ethnomathematics. Mat was used to teach them concepts of rectangle and cylinder, and round hat and rectangular house used to teach rectangle and cylinder; afterwards, the group was taught the content of the curriculum as expressed in the curriculum. Findings revealed that the experimental group performed better than the control group and therefore recommended that teachers reflect on the contributions of cultures.

Cherinda (2002) invented a weaving board. Twill weaving board was explored in Mozambique classrooms during the teaching and learning of mathematics. The study also examined the relationship between weaving patterns and mathematical ideas such as number sequence. The idea was that mathematical ideas produced by learners in weaving can be applied to stimulate new mathematical concepts and create new patterns in basket weaving.

Basket weavers from the North of Mozambique produced a pyramid funnel called 'eheleo' Gerdes (2005). The funnel mouth has the form of an equilateral triangle. Gerdes (2005) wrote that he displayed eheleo to his students in his Geometry course and asked them to explain what they could learn from the artisans' productive technique. Students transformed the funnel into a pyramid; others constructed equilateral triangles and different regular polygons and felt proud of the *eheleo* method of constructing regular polygons, which made them realise that not all mathematical ideas come from the West.

2.3.4 Ethnomathematical approaches in the teaching and learning of mathematics

According to D'Ambrosio (1985:43), before and outside school, almost all children in the world become math literate, meaning that they develop the capacity to use numbers and quantities, the capability of qualifying and quantifying and some patterns of inference. Rosa and Shirley (2016) asserted that the embeddedness of mathematics in culture must be examined, drawing from the body of literature that takes students' cultural base of knowledge production into the mathematics curriculum.

The goal of ethnomathematics studies, as outlined by Gerdes (2014:14), is to improve the quality of mathematics education, make it interesting, motivate learners and enhance their cultural confidence. An essential component of mathematics education today is to reaffirm and ensure that the cultural dignity of learners is restored (D'Ambrosio, 2001).

Ethnomathematical approaches help to create a connection between mathematics in the classroom and mathematics in the real world, serve as the basis for deeper conceptual understanding, and enable learners and educators to look at real-life applications from a socio-cultural perspective (Mosimege, 2018:8). Ethnomathematics can bring mathematical concepts closer to student's daily lives, enhance in-depth understanding, interpretation of geometric concepts and bring about improved learner performance. According to Mamali (2015: ii), teaching approaches must include awareness of the historical and cultural heritage of geometry in society. Learners must be able to recognize and apply mathematics in cultural heritage, religion, art, music, and traditional and daily life experiences (Shirley, 2001:86). Ethnomathematical approaches are intended to make school mathematics more relevant and meaningful to students to increase the quality of education and gain more culturally relevant views of mathematics (Rosa & Shirley, 2016:26).

Several ethnomathematical studies were conducted in different countries. For instance, Sunzuma and Maharaj (2019), Naresh (2015). In South Africa, some of the ethnomathematical studies that were undertaken are Mosimege (2018, 2017, 2012, 2000), Mogari (2014, 2002), Nkopodi and Mosimege (2009), Cherinda (2002) and Ishmael (2002). The research studies above provided numerous examples of how Indigenous activities can be used to improve learners' conceptual understanding and development in mathematics. Different Indigenous activities and cultural artefacts were analyzed to reveal the mathematical concepts and principles associated with them, such as games, wire cars, twill weaving, etc.

Incorporating mathematics and real-world context can help learners learn mathematics more effectively and close the contextual gap between school mathematics and mathematics outside the school (Mogari, 2002). Mogari (2002) suggested that mathematics in cultural practices could be identified to create awareness of the importance of ethnomathematical activities in improving mathematics instruction.

Nkopodi and Mosimege (2009), Laridon et al. (2005) and Cherinda (2002) pointed out the importance of ethnomathematics in the teaching and learning of mathematics and opportunities for connecting mathematics to cultural practices to enhance the teaching and learning of mathematics. Mosimege (2000) called upon teachers to link mathematics in cultural villages outside the classroom to academic mathematics. This approach will help learners see the practical application of mathematics and understand how it is used in different cultural contexts.

The approach will assist with the realization of specific mathematical skills (CAPS, 2011:8-9). Mosimege argued that educators are in a good space based on their knowledge of mathematics to create a connection. Similarly, Anderson-Pence (2015:56) asserted that teachers must see a classroom as the relevant space to mediate mathematics obtained through everyday experience and mathematics practised at schools. Mosimege (2017) indicated that there is a potential to make use of cultural artefacts in teaching mathematics. A common thread among the researchers above is the belief that infusing ethnomathematics into mathematics teaching and learning can help bridge the gap between mathematics and learners' cultural backgrounds, making the subject more engaging, meaningful and interesting.

D'Ambrosio and Rosa (2017) argued that ethnomathematics approaches enable teaching mathematics in context. Ethnomathematical teaching approaches emphasise that mathematics is a universal concept and culturally embedded. The approaches aim to incorporate cultural knowledge, culturally relevant examples, practices and perspectives into mathematics teaching and learning. This helps learners see mathematics's practical applications in their culture and increases engagement and understanding. (D'Ambrosio & Rosa, 2017) proposed an ethnomathematical teaching approach to mathematics.

Different ethnomathematical approaches, including storytelling and oral traditions, can be used to teach mathematical concepts. Connecting mathematics to stories and narratives can develop learners' deeper appreciation for cultural significance in mathematics. Ong and Hartley (2013) ethnomathematics and orality, narratives attached to beadwork, Zulu beadwork messages such as iNcwadi Zulu love letter which represent a message woven in beads by Zulu maidens to be given to their lovers as a symbol of love and affection, orally transmitted information systems as collective expressions of specialized knowledge of the particular community. Chahine (2011) notes that Indigenous technologies include mathematical structures such as folk games and puzzles.

D'Ambrosio (1985), in his approach, focuses on the cultural, historical and social context of mathematical concepts, such as using traditional weaving patterns to teach geometry or exploring Indigenous number systems. Many traditional cultures have a rich tradition of weaving using geometric patterns. In exploring the weaving patterns, learners will learn geometric concepts such as symmetry, tessellations, and transformations. In trying to incorporate this in the classroom, teachers can introduce learners to examples of Indigenous weaving patterns from different cultures. Learners can discuss, analyze, and identify various types of symmetry, repeated shapes, and transformations. Learners can also create their own weaving patterns using geometric concepts learned to apply their knowledge in a culturally relevant and creative way. This enables them to appreciate different cultures and their mathematical contributions better.

Eglash (1999) focuses on the intersection of mathematics and African culture. His approach involved using examples from African fractals and self-repeating geometric patterns in African art, architecture and hairstyles. His work focuses on the mathematical patterns and practices in African and African-American cultures, highlighting the interconnectedness between mathematics, culture and technology.

As curriculum implementers, teachers must see a classroom as the relevant space to ensure that ethnomathematics is practised by incorporating mathematics obtained through everyday experience and mathematics at school (Anderson-Pence, 2015). Anderson-Pence further asserts that for this to be possible, teachers passed beliefs on the knowledge of mathematics and how it is taught and assessed must be re-examined. I concur with the scholar that learners' experience of mathematics outside the classroom needs to be embraced, and that could only be possible if teachers were trained on how to do it. Teachers with a cultural perspective of mathematical knowledge will help learners connect with mathematics inside the classroom. Moschkovich (2002) suggested that there must be a balance between everyday mathematics and academic mathematics to help learners see the usefulness of mathematics in everyday life as it is connected to school mathematics. Abiam et al. (2016) recommended an ethnomathematics-based instructional approach in geometry teaching.

2.3.5 Teachers experience on using ethnomathematical approaches in teaching mathematics

Many researchers and educators are hesitant to promote ethnomathematics in the classroom because of fear that some will put much emphasis on mathematics practices of ancient empire cultures such as Chinese, Mayan, and Hindu, and have a false interpretation that mathematics is only a product of these great civilizations and that lesser-known Indigenous societies did not have mathematics (D'Ambrossio, 2001).

According to D'Ambrosio (2001), many educators may be unfamiliar with ethnomathematics. Still, they can expand their mathematical perceptions and effectively teach their learners if they have a basic understanding. He further alluded that teachers do not say mathematics and culture are connected.

According to D'Ambrosio (2001), much of today's curriculum is disconnected from learners' culture; classroom mathematics is unrelated to their daily real-life situations. The scholar suggested that society requires more than what is offered in traditional curricula for learners' cultural dignity to be restored. Traditional curriculum excludes the relevance of culture from content and instruction, leading to teachers and learners believing that there is no connection between mathematics and culture (D'Ambrosio, 2001). Koirola (1999) contends that learning mathematics through everyday life context could fascinate learners, but the challenge may be connecting their everyday experiences with academic mathematics. Similarly, Sithole (2004), as cited by Machaba (2017) in his investigation of practical experiences and challenges in incorporating everyday experiences into mathematics, argued that the social aspects rendered mathematics inaccessible, and context may be overly emphasized and deny access to mathematics.

Laridon et al. (2005) asserted that teachers respond differently to ethnomathematical pedagogy. Laridon et al. (2005) further explained that according to the findings on ethnomathematical research in South Africa, some teachers were anxious or fearful to use ethnomathematics in their classrooms because of lack of confidence emanating from limited mathematical knowledge, shocking classroom conditions such as lack of resources and overcrowding whilst some considered ethnomathematical activities to be practical as learners became aware of the mathematics embedded in their environment (RADMASTE Ethnomathematics Project). Mogari (2002) observed that some teachers displayed enthusiasm for ethnomathematical approaches to the extent that they requested more workshops for full capacitation.

The self-study research project (Kortjass, 2019) used cultural artefacts to teach foundation phase preservice teachers in the numeracy module. It was an integrated learning approach (ILA), which required critical awareness of how mathematical concepts are used in social, environmental and cultural relations. Cultural artefacts such as beadwork, jewellery and clothing yielded positive results. Turugari (2022) developed a policy framework to facilitate the integration of ethnomathematics in Zimbabwe, secondary school mathematics in the teaching of probability. The findings highlighted the importance of implementing an ethnomathematics instructional model in schools. Teachers could identify cultural activities to incorporate into probability teaching but struggled with how to incorporate them.

Heriyanto and Astutik (2021) distributed a questionnaire through Google Forms to describe teachers' knowledge of the ethnomathematical approach, its role, implementation and characteristics. Findings revealed that teachers were aware of the concept and knew its purpose; however, they had no idea about the advantages and disadvantages of the approach, had never implemented the approach in the classroom, had no idea of ethnomathematical learning strategies nor resources to be used and have never heard about the application of ethnomathematics knowledge.

2.4 Mathematics Concepts and Processes from the Analysis of Ethnomathematical Activities

The research on ethnomathematics unearthed different mathematical concepts. Many African objects used in daily life embody mathematical concepts and knowledge forms, shapes and symmetries (Tsindoli, Ongeti & Chang'ach, 2018:76). Areas of work in ethnomathematics include the identification of cultural artefacts and cultural practices such as games which are familiar to South Africans to analyse mathematics embedded in them. Some culturally specific games strongly connect with teaching and learning mathematics.

Nkopodi and Mosimege (2009:385) incorporated the Indigenous game of morabaraba (played on a game board) in mathematics learning schools in Limpopo and Northwest Province. Mathematical concepts include different quadrilaterals, similarities and differences, Ratio proportion between lines and squares, Symmetry, logical deductions, counting, addition and subtraction. It was also found that learners enjoyed playing the game, which can be used in the mathematics classroom to promote meaningful mathematics learning.

An analysis of the *malepa* game or string was conducted by Mosimege (2016) in a mathematics classroom at a school in the Mankweng township of Limpopo Province. Three high schools in Polokwane and neighbouring areas in Limpopo, South Africa, participated in the study. The aim was to determine the level of knowledge of Indigenous activities, the kinds of analysis that can be done on the activity, and how the identified knowledge can be integrated into teaching and learning mathematics concepts. Mathematical concepts found include a variety of geometric figures such as triangles, quadrilaterals, squares and rectangles, the relationship between different figures and generalizations drawn from these relationships, such as the No of triangles (y) is related to the number of quadrilaterals (x) by the formula $y = 2x + 2$ which is relevant for Senior phase mathematics. Different types of symmetry, such as bilateral symmetry, rotational symmetry, translational, various properties of symmetry, and lines of symmetry, are also relevant.

Purkey (1998), as cited in Machaba and Dhlamini (2021), used activities based on cultural activities such as the South African flag, architecture, and Ndebele mural art to unpack mathematical concepts embedded in them. Architecture activities were huts designed by different cultural groups such as Basotho and Ndebele; the focus was on measurements, construction of geometric shapes, and finding the area. Mathematical concepts are right angles, the Theorem of Pythagoras, the distance formula, translations, reflections and symmetry for Ndebele art.

Laridon and Presmeg's (1998) research study occurred in South Africa. The study aimed to discover and apply mathematical concepts related to mountain bikes. Their findings revealed congruent circles, radii, triangles and ratio concepts. The study highlighted instructional opportunities to assist in linking mathematics to cultural practices and the importance of integrating culture and mathematics for meaningful learning.

Gerdes (1999), in his book *Geometry from Africa*, included designs from Sub-Saharan African cultures, which are characterized by geometrical shapes and symmetry—the Theorem of Pythagoras in weaving designs, hexagonal weaving, diagonally woven baskets and twisted dodecahedrons. Gerdes illustrated how mathematical analysis of different Indigenous activities might be done, developed a methodology to uncover geometrical thinking in culture by looking into geometric forms and patterns in objects such as baskets, mats, pots, and houses and realized that the traditional forms on patterns in the objects reflect wisdom and experience of people who created them. Mathematical concepts include circles, angles, rectangles, squares, regular pentagons and hexagons, cones and cylinders.

Mogari's (2001) study involved using thick cotton, a newspaper page of tabloid size and bamboo to construct a kite. The preferred shapes for the kites were quadrilaterals and hexagons. Mathematical concepts embedded are geometrical concepts such as angles, congruency, parallelism, area, shapes, and properties of triangles, quadrilaterals and hexagons.

Mogari (2002) illustrated how the construction of a cultural artefact, such as a miniature car constructed by boys using a wire, can be used to teach and learn geometry. A group constructing a wire car was observed and interviewed in making the cultural artefact. The mathematical concepts identified during learners' construction of wired cars include rectangles and their properties, length, measurement, right angles, flat surface, circles, symmetrical, three-dimensional objects and two-dimensional shapes. Two experimental and one control group were used. The post-test revealed that the performance of the two groups who worked with wire car chassis differed. The group with the learner-centred approach performed better than the groups whose teacher dominated the session.

Mosimege's (2000) research study discusses the extent to which workers and cultural artefacts exhibit mathematical knowledge in cultural villages, focusing on how ladies engage in beadwork activities. It occurred at Lesedi cultural village in the Gauteng Province of South Africa. The findings revealed some mathematical concepts in such villages and how they can be used in mathematics classrooms in the context of the new curriculum in South Africa, i.e. counting, repetitive cycles, similarity in figures, geometric patterns, symmetry, mirror images, geometric shapes, estimation and straightness of lines,

Bhuda (2019) investigated ethnomathematics' role in Amandebele women's cultural life at Ekosini village in Mpumalanga Province. She identified that Ndebele women are custodians of Ndebele art with mathematical ideas and concepts. Ndebele women use mathematical ideas and concepts in constructing their art. The following mathematical concepts were found in the Ndebele art: estimation, triangles, squares and rectangles, circles, zig-zag patterns, diamonds, chevrons, horizontal shapes, perpendicular shapes, counting, addition and subtraction, division, estimation, angles, similarities in figures, symmetry.

Chahine and Kinuthia (2013) examined the role of ethnomathematics as a model for translating and interpreting mathematical structures found in Indigenous technologies that South African people use for survival and adaptation in different environments, with specific reference to the Zulu culture. The study took place in Durban, South Africa. The two Indigenous technologies in SA that prosper in the market, beadwork and basketry, were explored. Rotational order, repeated sequences, successive subtractions, bilateral symmetry, vertical and horizontal axis, measuring, counting, three 3-dimensional structures, depth (capacity), patterns, bending and folding according to dimensions, geometrical patterns, diamonds, and triangles were identified.

Dabula (2000) conducted a qualitative study with teachers from the College of Education in Eastern Cape Province in South Africa. The aim was to examine students’ ability to connect their classroom mathematical knowledge to their cultural heritage using beadwork artefacts. Students were engaged in the exploration of Xhosa beadwork artefacts from a city museum. Concepts identified were reflectional symmetry, translation symmetry, tessellation of squares, rectangles, rhombuses, hexagons, number patterns, and predominantly triangular numbers.

2.5 Women, Indigenous Knowledge Systems and Ethnomathematics

The study explored mathematical concepts and ideas incorporated in the patterns created by women through imagination and how they can be incorporated into teaching and learning geometry. Southern African women participated actively in cultural activities, creating patterns from the mat, basket weaving, ceramics, tattooing, string figures, beading and mural decoration (Gerdes, 1999, 1995). In support of Gerdes's work, Chikare et al. (2012) pointed out that women are custodians of IKS. This is also confirmed by the IKS Policy (Chapter 2); women were the custodians of IK, and recently, there has been a growing interest in the IKS and the role that women played in the development and custodianship of knowledge.

Mosimege (2000) explored how the two Ndebele ladies at Lesedi Cultural Village engage in beadwork activities and the mathematical concepts embedded in their cultural artefacts. It was found that ladies use various mathematical concepts in their beadwork. Grandmothers and mothers pass on knowledge to their daughters. Similarly, Bhuda (2019) investigated the role of ethnomathematics in the life of Amandebele women at (Ekosini) also known as GaMabhoko village in Mpumalanga Province, and her study revealed that women use mathematical ideas and concepts to construct their art, such as estimations and imaginations in most cases. Bhuda further mentioned that Amandebele women are custodians of Ndebele art.

According to Fouze and Amit (2017), Bedouin women practised traditional embroidery, including triangles, squares, rhombus, kites, objects, flowers, geometric shapes, numbers, and types of lines using their own hand or manually.

The geometry of the weaving of '*Sipatsi*' bags among the Gitonga-speaking population in Inhambane province and the making of *Sipatsi* with their decorations is traditionally said to be a female domain although some men recently learned how to weave them (Gerdes, 2005:56). Gerdes (2005) contends that market women in Mozambique who are illiterate were interviewed by lectures and students in the mathematics programme for primary schools to know how they determine sums and differences. Findings indicated that they use oral/mental computation based on spoken numerals, calculated mentally and used doubling when multiplying.

Several studies, such as Gerdes's (1998, 1996, 1995) study on women and geometry in South Africa, have investigated women's mathematical knowledge. For example, Gerdes (1995:4) argued that the main objective of his book, *Women and Geometry in Southern Africa*, is to call attention to some mathematical aspects and ideas incorporated in the patterns made by women in South Africa, intending to value, revive and develop traditions which may otherwise vanish.

Information on Dr Esther Mahlangu is included as one of the South African women who use natural mathematical skills to produce exquisite Ndebele cultural artefacts that showcase communities' rich heritage. Dr Esther Mahlangu is a Ndebele woman born in 1935 in Mpumalanga. Her passion for painting started at the age of 10 years when her mother and grandmother taught her mural painting. She is a multi-award-winning visual artist (The Melrose Gallery, n.d.). She is considered a visionary, disruptor, and the first person to reimagine traditional Ndebele design in contemporary mediums. She painted walls, ceramic pots, sneakers, cars, etc., leading to well-known global collaborations with Rolls–Royce, BMW, Fiat, John Legend, *Belvedere* Vodka, Freshpark Rooibos, etc. She collaborated with American singer, songwriter, musician and actor John Legend in a 2017 *Belvedere* Vodka advertising campaign to raise awareness and raise funds for the fight against HIV. Dr Mahalngu was presented with two honorary doctorates in 2018. She was the first artist in the world to be commissioned to paint an artwork for the gallery of a new Rolls–Royce Phantom named The Mahlangu to honour her (The Melrose Gallery, n.d.).

Dr Esther Mahlangu is one of the people who were honoured with three honourary doctorates from the University of Johannesburg (UJ), the Tshwane University (TUT), and Durban University of Technology (DUT). She is the first woman to participate in the BMW art car project. She painted her geometric patterns on the BMW525i in 1991. The car was exhibited at the British Museum London in 2017 (Maputla, 2019). She has painted the second BMWi5 Flow NOSTOKANA, which combines BMW's colour change technology with Mahlangus traditional visual colours, showcasing the intersection between art, culture and technology (BMW Group, D, Dixon). Her artwork can be found in cities like Washington DC, New York, Paris and London (Kerch, n.d.).

Dr Esther Mahlangu painted *Sneakers* with a chicken feather, which were unveiled at the 2020 Dubai Expo. She does not use measuring instruments to draw straight lines in her designs and uses chicken feathers instead of brushes. Sneakers customized worth R7.7m are not for sale but on a world tour. Showcasing fees will pay for scholarships at the Ayashisa Amateki Academy commissioned (Daniel, 2021).

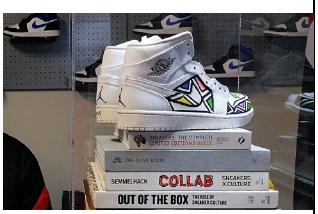
The work of Dr Esther Mahlangu	Painted BMW vehicles	*Belvedere* Vodka,	Clay pots
			
	Sneakers	Rooibos Freshpark container	All these are painted with a feather
			

Figure 2.1: Examples of Dr Esther Mahlangu's work (Sourced: The Melrose Gallery, n.d.; Maputla, 2019)

Dr Esther Mahlangu is a renowned South African artist and a cultural ambassador who contributes to her community in various ways: She started an art school in her backyard in Mabhoko, intending to preserve her cultural heritage, provides art training and workshops, mentors young artists in the traditional style of Ndebele design, teaching them how to draw straight lines, without sketches using their fingers or chicken feathers, ensuring continuation for future generations. As a pioneer artist, she inspires and empowers women to pursue art careers and take pride in their cultural identity. She participates in community development programmes, using her art to raise funds and support social causes such as education. In the interviews with

TC, it was found that she once donated R7500.00 to the school. Learners from TC visit her art centre after school hours to practice art (cf. Chapter 4).

Dr Esther Mahlangu partnered with Iziko Museums of South Africa on an exhibition, *'Then I knew I was Good at Painting: Esther Mahlangu, A Retrospective*', effective 17 February 2024. The exhibition highlights her long career of over 50 years, being a contemporary artist who is globally known. The monumental retrospective was opened in Cape Town at Iziko South African National Gallery from 18 February to 11 August 2024 (Brand South Africa, 2024).

2.6 Mathematics, Ethnomathematics and Indigenous Knowledge Systems

Mathematics includes ideas, procedures and practices found in Indigenous and non-western contexts; each cultural group has its own way of doing mathematics, such as how they quantify and use numbers, geometric forms and relationships, measure or classify objects in their own environment (Orey & Rosa, 2010:58). Ethnomathematics incorporates mathematical ideas and procedures practised by members of a distinct cultural group, not only identified as Indigenous societies but as groups of workers, professional classes and group of children of a certain age group (D'Ambrosio, 1985). According to Mosimege (2017), ethnomathematics is classified as one of the components of IKS based on D'Ambrosio's definitions. Ethnomathematics is the knowledge that is Indigenous to a particular culture as people within their cultural group use ideas of mathematics in their daily lives (Abiam et al., 2016:2). NCTM (2000) indicates that mathematics ideas can be considered necessary if they serve to illustrate the discipline of mathematics as a human endeavour.

Shirley (2001:86) states that ethnomathematics is the key to finding connections between mathematics at school and mathematics that form part of learners' everyday experience by ensuring that local mathematics is incorporated. Adolphus (2011) and Rosa and Orey (2011) support the statement by Shirley (2001) when they indicate that ethnomathematics studies the cultural aspect of mathematics, presents mathematical concepts of the school curriculum to students relating them to their cultural and daily experiences for meaningful connections and deeper understanding of mathematics. Connections between culture and mathematics are uncovered (Tauliili, 2015). A culturally relevant curriculum fully integrates students' cultural mathematics through ethnomathematics (Rosa & Orey, 2011:42). Naresh (2015) contends that a cultural approach to teaching mathematics in which students use their socio-cultural background will help them see the applicability to real-life situations.

IK refers to all-inclusive knowledge that covers technologies and practices that were in existence and are still utilized by Indigenous and local people for existence, survival and adaptation in different environments (Mosimege & Onwu, 2004:2). IK is local knowledge of a given culture acquired through experiences with the environment (Chikare et al., 2012). The definitions in this paragraph stress the significance of IK, which exists and is applied by local people in a specific culture. IK is passed from generation to generation, from mother to daughter; young ones are nurtured into Indigenous activities to sustain the activities and cultural practices (Mosimege, 2017:682). Cultural wisdom, experiences, and values are developed and passed down from one generation to another to maintain cultural identity. They give Indigenous communities a sense of belonging and identity, fostering cultural resilience and pride.

Mosimege (2012:64) indicates that community members have learnt how to count, measure and tackle many activities that indeed need one to use mathematical knowledge routinely. He says that learning occurs informally through regular engagement with different processes.

The significance of IKS is emphasized in CAPS (2011:5) on the principle of valuing IKS by acknowledging the rich history and heritage of South Africa. Incorporating IKS and creating a learning environment that respects and promotes Indigenous ways of teaching and learning mathematics will assist in effectively implementing these principles. The education system will help preserve Indigenous cultures, empower Indigenous learners, and foster an inclusive and equitable society. CAPS (2011:8) further states that in the teaching and learning of mathematics, the following specific aims, which form part of IKS and will be realized through IKS, are to be developed:

- a critical awareness of how mathematical relationships are used in social, environmental, cultural, and economic relations
- A spirit of curiosity and love for mathematics
- An appreciation for the beauty and elegance of Mathematics
- recognition that Mathematics is a creative part of human activity
- A deep conceptual understanding to make sense of mathematics

According to Mudaly (2018:70), the policy is silent on including such knowledge in geometry teaching; it is unclear how to develop learners' mathematical knowledge using social and cultural artefacts, practices and beliefs, IK within the community. CAPS (2011:21-23) indicates that learners should recognize, visualize and name 2Ds and 3Ds within the environment and describe patterns within our cultural heritage. IKS has been mentioned once in the CAPS document. Content specification and content clarification are silent on IKS. There are no guidelines on how to implement the principles related to IKS. Therefore, the teachers must look into the five content areas and use their knowledge and experiences with Indigenous activities to teach learners concepts and skills using ethnomathematics activities. The implication is that teachers' in-service developmental programs, teachers training institutions, and induction programs should focus on ethnomathematics to realise the principle.

According to Madudise (2015:12), for teachers to be able to incorporate mathematics in the real world in the classroom, they must investigate the mathematical ideas and practices of the cultural, ethnic and linguistic communities of the learners. This study explored the Ndebele cultural artefacts and revealed mathematical concepts inherent in them.

Mosimege and Onwu (2004:3) suggested that in integrating IKS into mathematics, learners can be given a small-scale investigation on how parents or grandparents use IK in their livelihood and sustenance as a possibility for the inclusion of IKS into the curriculum. They also emphasized that there are many opportunities, but we have not been able to take full advantage of them. This principle calls for teaching and learning of mathematics to prioritize IK (Mosimege, 2017), and for mathematics teachers to realize the principle of valuing IKS, there must be a consideration of the integration of ethnomathematics in different content areas, and without efforts, the principle would not be fully realized.

CAPS (2011:8) indicates that contributions to mathematics came from diverse people worldwide, including many women and people of colour whose contributions were overlooked. African IKS existed and had their education system long before Western education was introduced by the European colonialist missionaries (Tsindoli et al., 2018). IK was relegated to the realms of irrelevancy and rejected, whereas Western and European Knowledge was recognized as applicable (Mudaly, 2018:68).

Learners should know that what is termed Western mathematics resulted from the contributions of IKS of different civilizations throughout history (Cherinda, 2015). People can do mathematics in their unique culture, which is different from other cultures (Cherinda, 2015). Cherinda further explains that IKS must be integrated into teaching and learning for generations to own, feel confident, and develop mathematical knowledge to benefit everyone.

2.6.1 The connection between Ndebele mural art, Indigenous knowledge and Mathematics

A mural is a painting executed directly on the wall (Oxford Concise Dictionary, 2012:773). A mural is a painting applied to and made integral to the surface of the wall or ceiling (Encyclopedia Britannica, 2024). A painting is described by Encyclopedia Britannica (2024) as the expression of ideas and emotions using a two-dimensional visual language, with elements including shapes, lines, colours, tones and textures. Space and elements are combined into expressive patterns representing natural or supernatural ideas. It is considered one of the earliest forms of art, allowing us to learn about our history and can symbolise rebellion or a religious message (art and bonding).

Ndebele mural art is deeply rooted in IK and culture, reflecting the community's history, beliefs and values. Murals feature symbols and motifs that hold spiritual and cultural significance passed down through generations and are powerful symbols of cultural resilience and identity.

Ndebele mural art, a traditional art form of the Ndebele people of Southern Africa, has a solid connection to mathematics. It is characterized by intricate geometric patterns such as triangles, circles, and quadrilaterals, which are fundamental to mathematics. Ndebele murals often exhibit symmetry, where patterns are reflected and repeated to create a sense of balanced harmony. Pattern repetition in Ndebele art is reminiscent of mathematical sequences to create complex designs. It has tessellations whereby shapes fit together without overlapping. Spatial awareness ensures that artists visualize and execute their designs in a specific space. Ndebele artists use problem-solving skills to overcome challenges in designing and executing their murals, such as fitting patterns into a particular space or creating balance and harmony. The connection between Ndebele mural art and mathematics is a testament to the intrinsic relationship between art and mathematics, where creativity and problem-solving interact.

Societies have, due to the interactions of individuals, developed practices, knowledge and, in particular, jargon and codes, which clearly encompass how they mathematise, referring to how they count, measure, relate and classify and how they infer (D'Ambrosio, 1984), this is in line with D'Ambrosios' (1985:45), definition of ethnomathematics as the mathematics which is practised among identifiable cultural groups such as national tribal societies, labour groups, children of a certain age bracket, professional classes and others. The prefix Ethno describes the cultural identity of a group, such as language, symbols, codes, and values, while mathema includes measuring, classifying, and ordering (D'Ambrosio 1990). Dabula (2000:5) described mathematics as old as humankind, practised by all cultures in different settings as part of their daily activities. Bishop (1988) argued that all cultures demonstrate some mathematical practices, such as counting and other concepts.

It is essential to acknowledge and value the diversity of mathematics in cultures and understand the relationship between school mathematics, ethnomathematics and IK.

There is strong interconnectedness among Ethnomathematics, mathematics and IKS; the synergy was discussed in sections 2.2 and 2.3 above, emphasizing their reciprocal relationship.

2.6.2 Ndebele cultural artefacts and mathematics

The different types of beaded Ndebele cultural artefacts convey messages of social meanings, such as age sets and stages of growth from childhood to adulthood. Blankets sewn by southern Ndebele women have different beads that differentiate a newly married woman from an older one. Ndebele cultural artefacts serve a cultural purpose; for example, in ceremonial traditions whereby girls and boys initiates, their parents wear beaded garments to communicate the value attached to the initiation, such as *Umlingagobe* (tears) worn by women (South Africa Net, 2024). Iqhude (girls' initiation) is one of the occasions that is enunciated through beaded and decorative clothing; in wedding celebrations, the bride and her female relatives are dressed in beaded aprons and necklaces (South African History Online, 2024).

Ndebele cultural artefacts such as beadwork, murals and pottery exhibit mathematical concepts embedded in them (cf. Chapter 4). Therefore, this study focused on exploring Ndebele cultural artefacts as cultural tools that can enhance learners' more profound understanding of mathematical concepts, demonstrating the relationship between mathematics and IK and highlighting the beauty and elegance of mathematical thinking in cultural expression.

According to Zaslavsky (1999:318), the applications of mathematics in the lines 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 traded in architecture, beadwork, mural basket, hairlines.

2.6.3 The importance of Cultural Villages in Ethnomathematical research

We have several Cultural Villages in South Africa. Cultural Villages are used to showcase the cultural diversity of South Africa; they are tourist centres and can also be used for educational purposes (Mosimege, 2004). Madudise (2015) supports this as ural Villages can be used as contexts to mediate culture and mathematics. Madudise (2015) conducted a qualitative study with Grade 3 and 9 mathematics teachers to teach mathematics by connecting concepts with culture, using culturally based activities at the cultural village where two topics were indigenized. His findings revealed that experience designing, implementing and reflecting positively contributed to teaching. Teachers who participated saw the possibility of utilizing cultural villages as instructional resources for connecting mathematics education to learners' cultures.

Indigenous mathematical content knowledge is found in Cultural Villages. Some of the well-known Cultural Villages are Basotho Cultural Village in Qwaqwa Free State, Lesedi Cultural Village in Broederstroom, Gauteng, Isinamva Cultural Village at Mount Frere, Eastern Cape, Kaya Lendaba in Port Elizabeth, Eastern Cape, Shakaland in Eshowe, KwaZulu Natal (Mosimege, 2004). Different cultural activities and cultural artefacts at Lesedi and Botshabelo Cultural Village were analysed to explore the mathematical concepts used by workers and people staying in such villages, and several mathematical concepts were found. According to Mosimege (2004), Lesedi Cultural Village and Botshabelo Historical Town revealed the extent to which counting and numeration are used, showing that members have not attended school but can perform cultural activities and make cultural artefacts full of mathematical concepts and processes. Examples of mathematical knowledge at Lesedi Cultural Village include counting, repetitive cycles, similarities in figures, measurement and estimation of lines and angles and symmetry. Therefore, he suggested that teachers link what happens in cultural villages to mathematics curriculum requirements.

I have also found that we have the Kghodwana Cultural Village at KwamMhlanga, Mpumalanga Province, showcasing huts of different ages, different human lifestyle settlements, walls painted with geometric designs by WKH using a feather (cf. Chapter 4), stunning crafts made of beads such as bracelets, necklaces etc, embedded with mathematical concepts.

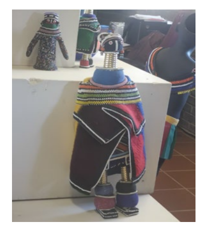
Figure 2.2: Huts of different ages at Kghodwana Cultural Village

Beaded hoops

Beaded bracelet.

Ndebele boy

Ndebele Beaded necklace,



Ndebele woman

Picture 2.3: Examples of Ndebele cultural artefacts from Kghodwana Cultural Village

Huts of different ages painted differently at Kgodwana Cultural Village (cf. Figure 2.1) demonstrate the changes and improvements in Ndebele mural art over time and across various generations while retaining its cultural significance. The older huts have more muted earth colours and natural-coloured white, grey, and black clays, while newer huts display brighter colours and vibrant designs. According to Gerdes (2005), Ndebele paints were originally white, red, yellow, natural, soot, ash and clay ochres obtained from the earth; the beginning of the 20th century saw the introduction of a new colour, blue, coming from commercial washing blue, powder paints followed and in more recently they use acrylic paints with their bright colours. Explanations of the cultural artefacts in (Figure 2.3) are given in Chapter 4.

2.7 Mathematics Performance and its Relation to Ethnomathematics

Learner performance in mathematics depends on teachers' support and the ability to connect home, community, and cultural experience of mathematics, everyday mathematics used at home, to school mathematics. (Anderson-Pence, 2015:57; Nkopodi & Mosimege, 2009). Integrating ethnomathematics in mathematics teaching can help learners make meaning and improve performance (Rosa & Orey, 2016). According to Dabula (2000:4), learners who learn without integrating old knowledge with new knowledge or experiences memorise concepts without meaning, leading to misconceptions and contributing to a high failure rate in mathematics. Rosa (2010) further argued that a lack of cultural coherence in the curriculum leads to underachievement in mathematics. Similarly, Mabotja (2022) indicated that teaching and learning in South Africa lacks cultural relevance, leading to poor mathematics achievement. According to Machaba and Dlamini (2021), mathematics performance in South Africa is poor, which could be attributed to disconnection and disregard of learners' everyday real-life experience with mathematics at home. The studies in this paragraph further contended that cultural experiences shape learners' perspectives and understanding when learning mathematics at home.

Mooney et al. (2018:5) suggest that learner's common mathematical errors and misconceptions must be recognized and that there must be a way to prevent and address them. Ozerem (2012: 725) indicates that misconceptions are connected to how teachers handle the subject and that lack of conceptual knowledge is due to rote learning approach. A high failure rate is attributed to a lack of correlation between teaching, learning and real-life situations (Nkopodi & Mosimege, 2009:377).

Learning geometry has challenged many secondary school learners (Mamali, 2015: iv). Similarly, Abiam et al. (2016:3) indicate that learners and teachers generally identify the planes and solids shapes, polygons and geometrical transformations as challenging to learn and teach in primary schools, leading to mass failure in geometry. Abiam et al. (2016) further allude that methods used by teachers to teach geometry are implicated as one of the factors responsible for poor learning and low achievement in geometry, aligning with Mosimege (2017) that learners in schools struggle with several mathematical concepts because of how concepts and topics were introduced, developed and elaborated, leading to poor performance. According to Mamali (2015: iv) and Adolphus (2011:145), poor performance in geometry has been a concern for mathematics educators, parents, and the government. According to Mabotja (2022), underperformance is currently known and suggested that further research should explore possible solutions to mitigate it. Therefore, this research study is necessary to address the gap identified by different scholars and researchers in the literature review conducted.

Despite the various intervention efforts provided by the Department, the learner's poor performance in geometry is still persistent (Adolphus, 2011:145). Given all these challenges, this research study focused on geometry performance and the errors and misconceptions that led to the failure of learners and suggested that ethnomathematical teaching approaches should be part of intervention strategies to mitigate the challenges outlined.

International assessment bodies such as TIMSS are used to assess learner's achievement of Mathematics in Grades 4, 8 or 9 in various countries worldwide. TIMSS is a large-scale international project managed and funded by the International Association for Evaluation and Educational Achievement (IEA). It is implemented after every 4 years. TIMSS started in 1995. IEA developed TIMSS to allow participating countries to monitor their educational achievement and compare learners' achievement in key subjects, which are Mathematics and Science. The DBE collaborates with the Human Science Research Council (HSRC) to conduct TIMSS

TIMSS 2019 was the seventh assessment cycle. It was conducted in 64 countries. TIMSS cycles are essential as they set up a trend line for achievement in Mathematics. The trend shows that we cannot meet the expectation. In 2019, the country that achieved the highest level was Singapore. South African learners perform far below the international mean; our performance is poor compared to other countries. South Africa falls within the three countries with the lowest achievement. Concerning achievement by provinces, nine provinces in South Africa and the Mpumalanga Province obtained the eighth position. The province has strategies in place to support learners in improving their results.

TIMSS was administered from the 4th to the 20th of September 2023, focusing on Grades 5 and 9 in South African public and independent schools and Grades 4 and 8 in other countries. Sampled schools were selected from the DBE list of schools. Mpumalanga Province has 35 schools sampled from the four Districts (DBE, 2012). In the year 2023, South Africa remained one of the

Countries with the lowest performing learners with the score of 362 (DBE, 2023). Mpumalanga Province obtained 337, showing improvement with regard to achievement by Province.

2.7.1 Learner performance in TIMSS

TIMSS assessments neglect ethnomathematical contexts. The assessments reflect the Western bias, prioritizing Western mathematical concepts and methods. The assessments are not adequately representing diverse perspectives and cultural groups, particularly indigenous and minority populations. Despite our efforts, Trends in International Mathematics and Science Study (TIMSS) assessments continue to pose significant challenges which hinder our success, such as:

Linguistic and cultural factors: Learners who are non native speakers of the language of instruction face difficulties in understanding the test questions which impacts negatively on their performance. According to TIMSS, learners who frequently use Language of Learning and Teaching (LOLT) at home perform better. The language of Learning and Teaching in South African schools is English and Afrikaans. The majority of learners attending schools which offer Afrikaans as (LOLTA) have Afrikaans as their Home language, in contrast the majority of learners attending English medium schools are second language English speakers. Afrikaans medium schools have highest achievement in Mathematics than English medium schools, which clearly demonstrated the advantage of learning Mathematics using Home language (TIMSS, 2023:20)

Inequitable distribution of resources: The emphasis on standardized testing can aggravate existing inequities in education as schools with more resources are better equipped to prepare learners for the test. The results are influenced by systemic factors such as poverty, inequality, acces to resources. Schools quintiles are a way of grouping schools based on their socio economic status, quintile 1 representing the most disadvantaged schools and quintile 5 representing the affluent. According to mathematics achievement by quintile category, learners in quintile 1 schools have less average score of 307, with schools in quintile 5 achieving the highest average of 492 (TIMSS, 2023:18)

The international comparison can be misleading as education systems and cultural contexts vary significantly across countries. The higher socio- economic status the higher average achievement score (TIMSS, 2023).

Table 2.1: Percentage of learners reaching the benchmark

ITEMS	PERCENTAGE OBTAINED
Apply knowledge and understanding in a variety of complex situations	1%
Apply knowledge and understanding to solve problems	5%
Show and apply basic mathematical knowledge to solve problems	16%
Show some basic mathematical knowledge	37%

(TIMMS, 2019)

According to the DBE (2012) results above, 63% of learners had not acquired basic mathematical knowledge; it has also been indicated that SA still has a way to improve their mathematics performance. The TIMSS results revealed that learners in primary schools lack basic mathematics concepts and skills to solve problems. Adler and Pillay (2017) declared that the Basic Education system demonstrates poor teaching and learning in early grades. Adler and Pillay (2017) further attributed learners' underperformance to teachers' inadequate knowledge of the subject and pedagogies. Similarly, Mosimege and Winnaar (2021) stated that learners' performance is often used to indicate the quality of teaching provided.

2.7.2 Errors and misconceptions leading to underperformance

The results demonstrated that learners who lack basic knowledge of geometry concepts and skills struggle with vocabulary (ANA 2012, 2013 and 2014).

Misconceptions occur when learners fail to assimilate and accommodate new information. Error analysis refers to examining the errors made by learners when completing assessment activities. It involves analyzing the types of error patterns and finding reasons behind the errors. It helps us to obtain insight into learners' understanding and provide targeted, individualized feedback to inform instructional decisions and interventions. Error analysis is conducted to determine the sources, reasons and explanations for the errors committed. Errors indicate what learners know and how they learn it (Mavundla, 2022:26).

According to Olivier (1999), as cited by Mavundla (2022), teachers should understand errors committed by learners and the misconceptions developed in an attempt to learn mathematical concepts. Mathematics difficulties and misconceptions not addressed at early grades could make it difficult for learners to understand mathematics at higher grades (Mabotja, 2017). The recent study conducted (Mudhefi et al., 2024) revealed that Euclidean geometry remains one of the most challenging, if not the most difficult, topics for learners; learners have poor conceptualization of properties of shapes, visualisation skills, circle theorems and geometry terminology, resulting in learning difficulties

Cheng (2012) states that identifying errors in Geometry could help teachers provide relevant instruction focusing on the need or challenge experienced and help minimise learners' errors and misconceptions. Similarly, Mavundla (2022:12) suggests that teachers must devise strategies to eliminate errors and misunderstandings among learners. Findings from Mavundla (2022) motivated the researcher to investigate the assessment items. They identified errors and misconceptions that contributed to the underachievement of learners, with a particular focus on geometry, space and shape content area. The same errors were committed by learners under investigation when assessment items were given as practice exercises. The main intention is to understand learners thinking and develop mitigation strategies to support them intensively. Teachers must use errors and adapt their instructional strategies to address errors correctly. Misconceptions and errors lead to underwhelming geometry performance in primary schools, hindering learners' comprehension of geometric concepts in Senior secondary schools, whereby a marked decline becomes apparent from Grade 8 onwards.

2.7.2.1 Examples of errors from mathematics assessment items TIMSS 2011 Grade 4

a) Write the names of Shapes A, B, and C in the spaces provided

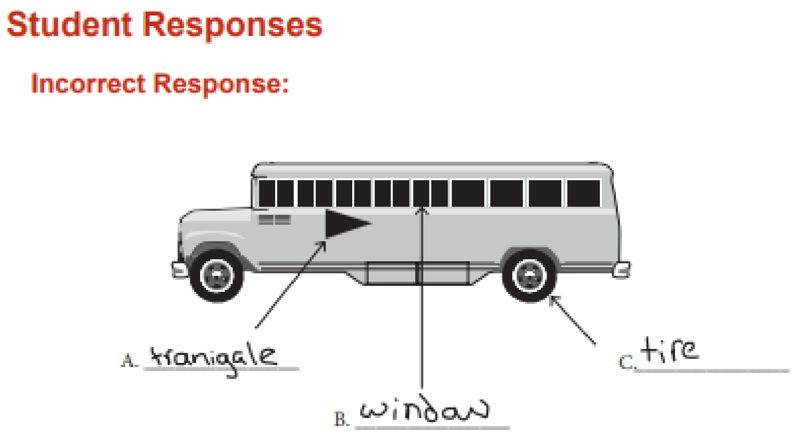


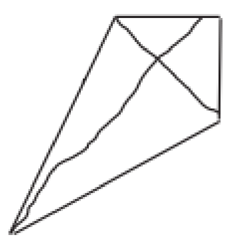
Figure 2.4: Grade 4 learner responses (TIMSS, 2011)

The Learner's responses to B and C are on recognizable objects from their everyday lives within the surrounding environment. The learners drew upon their familiarity with parts of the bus, perhaps their mode of transport or what they interact with or see daily. The response confirmed what (Rosa & Orey, 2011:41) claimed: that students come to school with concepts acquired from their sociocultural environment. This is further reinforced by Mavundla (2022:23), that learners enter the mathematics classroom with pre-existing vocabulary. Although learners possess knowledge of 2D shapes from their home or surrounding environment, their responses revealed a gap in connecting this familiarity to formal mathematics taught in school, and they lacked visual connections to illustrate mathematical relationships, hands-on activities to reinforce understanding and precise mathematical language to connect mathematics from previous experiences and knowledge to mathematics in the classroom.

Mathematical concepts used in geometry may be the contributory factor, and errors may be due to abstract concepts (Mabotja, 2017). Consistent with this idea, Mavundla (2022) states that sources of errors can be a lack of conceptual and procedural understanding and a lack of vocabulary required. One could, therefore, suggest a reinforced connection of prior knowledge to new knowledge to make learning meaningful through ethnomathematical teaching approaches. Currently, the focus on prior knowledge is only on concepts learnt from the previous grade. Mathematics learnt through cultural practices and traditions is often marginalized. Incorporating an ethnomathematical perspective calls for multiple turnarounds from how mathematics is taught in many schools (Zaslavsky, 1994:7).

According to CAPS (2011:60), learners should be able to identify a triangle, a square and a rectangle. It further says that in Grade 4, learners must recognise and name squares and rectangles and are exposed to different sizes of triangles but not expected to name them according to sizes. The learners' response above shows that they remember the name but struggle with spelling. Learners operating at level 0 according to levels of Geometric thought (Van De Walle et al., 2010:401) recognize and name figures based on the visual characteristics of the figure. It was further alluded that the physical appearance of a shape plays a vital role because visualization emphasises the shapes that learners can see and feel to determine their similarities to create rectangles, triangles and other shapes.

Item label: Draw the line of symmetry (TIMSS, 2011)



In the response above, learners could remember that the line of symmetry divides the shape into two equal parts that are mirror images of one another. They can also remember that some shapes have more than one line of symmetry; however, they fail to recognize that the line of symmetry must divide the shape into two identical halves that are mirror images of one another. Shapes may have one or more lines of symmetry and or may not have rotational symmetry (Van De Walle et al., 2010:103). Lines of symmetry are found in Ndebele cultural artefacts. If our learners are involved in drawing shapes at home, they will probably be able to connect mathematics in the classroom and everyday mathematics at home. WKH is drawing these shapes ideally using estimation skills without knowing they are a line of symmetry; this is justified in Chapter 4 of the study.

a. Complete the shape (TIMSS, 2011)

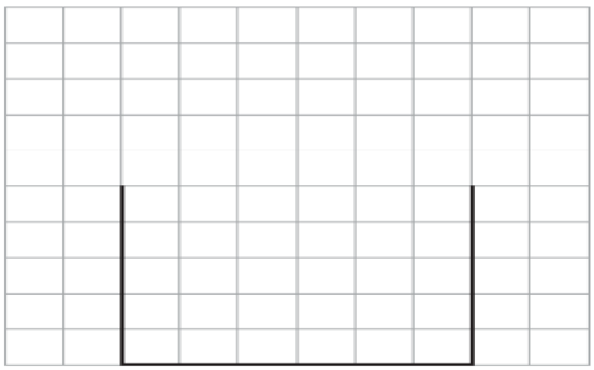
Jay has to draw a shape.

It must have 5 sides.

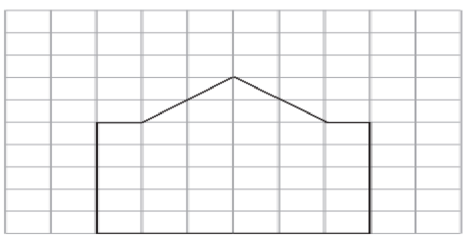
It must have one line of symmetry.

Jay has started to draw the shape.

Complete Jay's shape.

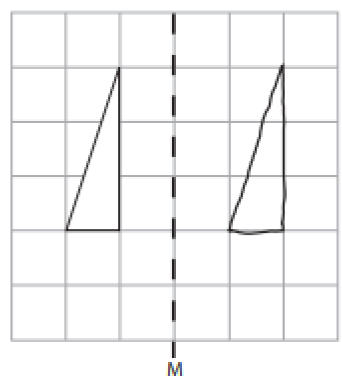


Incorrect Response:



b. Draw a reflection of the triangle (TIMSS, 2011)

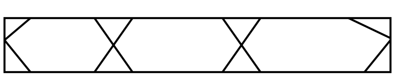
Incorrect Response:



Learners moved a shape left and performed translation instead of reflection. In a translation, only the object's position changes, and its size remains unchanged.

Which 2D shapes are used in the given tessellation?

c. (2013 ANA Grade 5)



Item analysis conducted by the official on the above assessment item revealed that some learners could identify K and X instead of 2D shapes.

2.8 Theoretical Framework

The study adopted Vygotsky's socio-cultural learning theory as a framework for the study.

This section provides reasons for using socio-cultural theory, its background and how it was used to guide the study.

2.8.1 Reasons why Socio-cultural theory was found relevant to the study

Vygotsky's Socio-cultural theory was relevant because it provided a theoretical framework aligned with the goals of exploring ethnomathematical approaches in teaching and learning Grade 6 geometry. It emphasises the importance of culture, cultural context, and social interaction in the learning process in shaping cognitive development. Learners' interactions, experiences with real-life situations and own culture facilitated interactions and communications within different teams during the mathematics instruction.

Bishop (1991) stated that experiences should be encouraged rather than seen as irrelevant. Experiences that we have are embedded in our social and cultural backgrounds. Learners refer to those experiences during learning in their construction of meaning (Dabula, 2000:4). Building on Dabula's (2000) work, Allahmagani, Gani, Ibrahim and Abdulkareem (2017) claimed that learning is a product of a social process which involves interaction and cultural influences. In this study, learners' experiences with the environment, things they interact with in their everyday life, experiences of their culture concerning Ndebele cultural artefacts, their naming and the process of crafting them were incorporated into the research. Such experiences are essential in connecting everyday mathematics and mathematics in the classroom.

Vygotsky's sociocultural theory of learning describes learning as a social process originating from human intelligence in society or culture. The theory emphasizes what the learner brings to the learning situation as the person actively makes meaning by connecting knowledge obtained from society with new knowledge in solving problems (Esther et al., 2017). The development of learning is explained through social interaction. Zhou and Brown (2015) argued that in this theory, social interaction culminates in a continuous, systematic change in learners' thoughts and behaviour influenced by their culture. Mogari (2002) emphasized the importance of contextualized teaching approaches to enhance logical and critical thinking in problem-solving skills. The study claimed that learners' experiences obtained during the mother-daughter training on cultural activities would improve their ability to recognise and apply mathematical principles in a school setting when solving problems.

The theory views a learner as an active participant in the learning situation and an active problem solver (Allahmagni et al., 2017). Learners' potential and social context are considered (Zhou & Brown, 2015). Vygotsky's theory pays much attention to the interrelationships between macro and micro social factors that impact learners' cognitive development and learning (Zhou & Brown, 2015). Zhou and Brown (2015) described macro social factors as elements that include culture and history, whilst micro factors include interpersonal relationships. The theory viewed macro social factors as significantly impacting learners' development because of guidance and support from a more capable person, such as the teacher. Vygotsky framed his theory around relationships between the social world and cognitive development. Culture, history and language considerably impact the development of learners' potential.

Knowledge is obtained through connecting the unknown to the known. It is dependent on prior knowledge. Mogari (2002) maintained that mathematics learning would remain enjoyable and interesting if mathematics is taught in a context familiar to learners. Learners bring their ideas and experiences about mathematical concepts gained from their socio-cultural context into the classroom. Similarly, Piaget's (2003) and Vygotsky's (1978) theories of learning assert that the construction of knowledge is done by relating new knowledge to existing or prior knowledge.

Bruner (1966) highlighted that learning is a social process that occurs through interactions with others and the cultural tools available in the environment. Bruner further argues that learners play an active role in constructing their understanding through experiences encountered. The theory influenced teaching practices by promoting collaborative learning, problem-solving, and using real-world contexts in instruction. Social interactions were integrated into the study to enhance understanding and engagement among teachers, learners and WKH.

2.8.2 Essential components of Vygotsky's theory

Allahmagani et al. (2017) state that Vygostky's theory is based on three essential components: More Knowledgeable Others (MKO), ZPD and social interaction. Vygotskys ZPD suggests that learning occurs most effectively within a range of difficulty where learners need guidance.

2.8.2.1 More Knowledgeable Others

Silalahi (2019) contends that in Vygotsky's theory, learners learn to do something by collaborating with more knowledgeable others. Collaboration, language and imitation are used. He believed that learners learn the most and contribute to their own cognitive development through MKO. According to Silalahi (2019), MKO refers to a person with more skills and understanding than a learner.

In Vygotsky's sociocultural theory, the MKO concept refers to individuals with a greater understanding or particular expertise in a subject. MKO can provide learners with guidance, support, and scaffolding, helping them advance their understanding and skills. In the context of mathematics, the role of MKO is crucial. Within a cultural community, some individuals possess a deeper understanding of mathematical knowledge and practices specific to that culture. These individuals can be elders, community leaders or experts in a particular field. They play a significant role in transmitting knowledge to learners and guiding their learning. MKO in ethnomathematics can teach traditional mathematics techniques and share cultural stories that involve mathematics rooted in their culture. They can engage learners in mathematics rooted in their cultural practices. By so doing, they facilitate the transfer of mathematical knowledge within the community and ensure its preservation and continuity.

In this study, MKO included participating teachers who were transferring knowledge of properties of 2D shapes to learners during lesson observations. Some learners also served as MKO because they shared their knowledge of cultural artefacts with others, particularly learners in the TC classroom, who brought the cultural artefacts to be explored. Learners could explain the cultural artefacts and their uses and explore the mathematical concepts inherent in them.

Vygotsky's socio-cultural theory emphasizes the role of social interaction and cultural context in cognitive development. Vygotsky's theory stresses the social and cultural aspects of learning and that cognitive development is a collaborative process within a sociocultural context. Some critical aspects of Vygotsky's theory are ZPD, Social interaction, Cultural tools and Scaffolding. Bruner (1966) highlighted the importance of social interaction, language and scaffolding.

2.8.2.2 Zone of Proximal Development (ZPD)

ZPD refers to a range of knowledge that may be out of reach for a person to learn independently, but it is accessible with the support of peers or MKO (Van De Walle et al., 2010:21).

Understanding the cultural context in ethnomathematical approaches can help identify suitable tasks within the ZPD for Grade 6, promoting optimal learning. Vygotsky's theory says ZPD is the level of potential development where the learner needs assistance from the MKO; it is the stage where learning occurs (Allahmagani et al., 2017). In the ZPD, the teacher or peer who is more capable aids learners in learning. In the context of this research, the WKH formed part of the MKO with their knowledge of cultural artefacts. WKH will work collaboratively with the teachers who have previously transferred cultural expertise to schools. During ZPD, there are interrelations and interdependent elements such as participants, artefacts, and interaction experience (Silalahi, 20I9). In this theory, the school context, the broader socio-cultural context, the culturally produced mathematics, goals and objectives play a critical role. Teachers play a crucial role in the learners' cognitive development. How teachers present and interpret lessons, as well as their attitudes, beliefs, strategies, and practices within their cultural communities, play an essential role. Through guidance and support from MKO within their cultural community, learners can bridge the gap and develop their mathematical skills and knowledge.

As individuals engage in social interactions and participate in cultural activities that involve mathematics, they enter their ZPD. They are exposed to new mathematical ideas, strategies and problem-solving techniques beyond their current understanding. Ethnomathematical approaches recognize that learning takes place within the cultural context. The ZPD provides a framework for understanding how learners can progress in their mathematical understanding with the help of elders, parents, WKH, and teachers (MKO). Socio-cultural perspectives highlight the fundamental requirement of working together in an educational context to make sense of collective and personal experiences.

According to Vygotsky's theory, the ZPD is not a fixed and static concept but a dynamic zone that can change over time. ZPD is influenced by factors such as an individual's cultural background, educational experiences, and social interactions. He believed that cultural tools and societal influences shape cognitive processes and that social interaction plays a crucial role in cognitive development. The transformation space is created through active interaction.

2.8.2.3 Social interaction

The study on Ethnomathematical approaches recognizes that mathematical knowledge is embedded in cultural practices through social interaction with the WKH to share and transmit mathematical concepts, problem-solving strategies, and geometric understanding, which contribute to the construction of knowledge.

The theory guided the study through ethnomathematical approaches, often involving collaborative problem-solving based on cultural practices. Integrating such social interactions into geometry lessons can enhance understanding and engagement among learners. Vygotsky believed that social interaction plays a vital role in cognitive development. He argued that learning occurs through collaboration and communication with exceptionally knowledgeable individuals. Through social interactions, learners gain more knowledge and internalize it. Vygotsky believed that learners learn through interactions with others, exceptionally more knowledgeable individuals. Learning is not solely an individual acquisition but is shaped by cultural practices and social relationships within the environment. These interactions help them acquire new knowledge and skills they could develop independently. Ethnomathematics, a study exploring the relationships between mathematics and culture, recognizes that cultural and social factors influence mathematical knowledge and practices. Ethnomathematics emphasizes the importance of social interactions and cultural contexts in understanding and learning mathematics. New knowledge is formed through social interaction (Potgieter, 2020). Learners will value the importance of social interactions in the classroom.

2.8.2.4 Cultural tools

Grade 6 learners may find geometry more engaging and relatable if it incorporates examples from their cultural context. Ethnomathematical approaches acknowledge using cultural artefacts as tools for learning. Learners engage with the cultural artefacts through social interaction to understand geometric concepts. The shared use of cultural artefacts facilitates the construction of knowledge within the community and in the classroom. Socio-cultural theory encourages teachers to consider learners' backgrounds and experiences, aligning with the ethnomathematical approach that seeks to connect mathematics with cultural practices. Vygotsky emphasized the significance of cultural tools such as language, symbols and artefacts in cognitive development. These cultural tools mediate learning and shape how learners think and solve problems. Language, in particular, plays a central role in developing higher mental functions. Cultural tools in this research study are Ndebele cultural artefacts, symbols and the language utilized at home in everyday mathematics and at school in traditional mathematics. In this study, the cultural tools can serve as cognitive tools to facilitate understanding. Integrating cultural artefacts as tools into teaching geometry and learning can enhance learners' conceptual development. The research focused on mathematical concepts expressed in the local language inherent in Cultural artefacts. Communication and language play a crucial role in constructing mathematical knowledge.

2.8.2.5 Scaffolding

Scaffolding in the context of exploring ethnomathematical approaches in the teaching and learning of Grade 6 geometry was found to be significant because it involves providing structured support to learners as they delve into cultural aspects of mathematics. Gradual independence is provided, which means that as learners become more familiar with ethnomathematical approaches, they gain confidence and understanding and gradually reduce scaffolding to promote independent exploration to apply concepts autonomously. Vygotsky highlighted the importance of scaffolding, which involves providing temporary support to learners to help them accomplish tasks they could not do independently. Scaffolding gradually decreases as learners become more capable, allowing them to take on more complex tasks independently.

2.9 Conclusion

In conclusion, this chapter highlighted the significance of ethnomathematics in revolutionizing mathematics education, citing studies in which ethnomathematical activities were used in the classroom, illustrating that it is a practical approach, can yield positive outcomes and can be implemented. Through analysis of ethnomathematical activities, we have seen how cultural games and activities can develop spatial reasoning and problem-solving skills, the different mathematical concepts embedded in cultural games, and cultural artefacts. The chapter has woven together the role of women in IK, the significance of cultural villages in ethnomathematics, and the positive impact that ethnomathematical approaches can have on the longstanding challenge of poor learner performance in mathematics. Comprehensive information was given on the theoretical framework guiding the research study by drawing on the principles of Sociocultural Theory.

CHAPTER 3
RESEARCH METHODOLOGY AND DESIGN

3.1 Introduction

The study explored ethnomathematical approaches in the teaching and learning Grade 6 geometry. This chapter discusses the processes and steps used to collect and analyse data to answer the research question. This chapter overviews the research design, philosophy, and methodology employed. The methods utilised for this research are discussed, and the reasons why the particular research method was chosen with proper justification are explained. Aspects covered include the research paradigm underpinning this study, the research methods, the inquiry strategy, the research setting, the population, sampling, data collection tools and the data analysis strategy utilized. Detailed exposition of trustworthiness as quality criteria is discussed. The chapter ended up with an indication of the ethical considerations and limitations of the study.

3.2 Research Methodology

Cohen et al. (2018) defined the research approach as a systemic plan involving a rigorous procedure that begins with broad assumptions through data collection methods, data analysis, interpretation and findings of the study. This study adopted a qualitative research approach. The qualitative research approach was considered appropriate since the researcher wanted to understand the meanings the participants ascribed to their experiences on ethnomathematics and ethnomathematical approaches in teaching and learning geometry. The selection of the research methodology, as suggested by Antwi and Hamza (2015:218), was informed by the research paradigm adopted for the study. The research paradigm is a frame of reference for selecting relevant methods (Kivunja & Kuyini, 2017). The study adopted interpretivist research paradigms. Interpretivist philosophical assumptions, relativist ontology and subjective epistemology underpinned the study. Henceforth, the study employed a qualitative research approach.

The qualitative research approach explores and understands the meaning individuals or groups assign to a social or human problem (Creswell, 2009). Similarly, Halloway and Wheeler (2002) refer to qualitative research as a form of social inquiry focusing on how people interpret and make sense of their experiences and the world in which they live. Atkinson, Coffey and Delamont (2001) define it as an interpretive approach to social reality, describing participants' lived experiences.

The qualitative research approach emphasises how people interpret and make sense of their experiences to understand the social reality of individuals (Haradhan, 2018). Qualitative research involves an interpretive, naturalistic approach to the world (Denzin & Lincoln, 2005) and occurs naturally, focusing on actual experiences (Gopaldas, 2016; Creswell, 2009). The outcome of this research study was not on a generalisation of results but on a deeper understanding of the experiences and perspectives of participants. In the context of this study, qualitative research allowed for the opportunity to use participant observation in lesson observations with teachers and participant observations with WKH while they were creating and painting clothes in the workshop. I was immersed in the participants' world and interacted with them in their natural settings: Mathematics classrooms and the W2 Art gallery (Workshop).

Qualitative research focuses on interpretation (Corbin, 1998); it focuses not only on the objective nature of behaviour but also on subjective meanings, attitudes, motivations, and behaviour (Creswell, 2009). The qualitative approach explored the perceptions of participants and unlocked their potential and experiences (Elhani & Khoshnevisan, 2022), discovered the inner experience of participants on how they construct meaning in culture (Strauss & Corbin, 2008), subjective views and experiences of individuals (Antwi & Hamza, 2015). This study focused on participants' experiences with cultural artefacts and how they made sense of ethnomathematical teaching approaches. It was on the study of individuals' lives, lived experiences, behaviours, emotions, and feelings, as well as organisational functioning, social movements, cultural phenomena and connections between countries, emphasising how individuals make sense of the world (Rahman, 2017:103). Qualitative research is about understanding, explaining, and discovering the experiences of participants on the problem being studied (Kumar et al., 2011). This study explored participants' experiences and knowledge of Ndebele cultural artefacts and the mathematical concepts embedded in them to find out how they can mitigate learners' underperformance in geometry. It also explored the mathematical concepts employed by WKH and uncovered their innate understanding of the mathematical concepts used when crafting cultural artefacts.

In qualitative research design, the study yields or provides findings and conclusions that cannot be obtained using statistical techniques or other quantifiable ways (Strauss & Corbin, 1990:11). According to Rahman (2017) and Corbin and Straus (2008, 1990), it is not statistical somewhat primarily concerned with diverse viewpoints and study things in their natural surroundings aiming to make sense of or interpret events in light of the meanings individuals bring to them. This is also supported by Haradhan (2018), who states that qualitative researchers are interested in individuals' beliefs, experiences, and meaning systems from their viewpoint. Flick (2014) further adds that qualitative research analyses the social production of issues, events, and practices by collecting and analyzing texts and images rather than numbers or statistics. The explanations above share that qualitative research focuses on words rather than numbers observes the world in its natural setting, and interprets situations to understand the meaning that participants make from their everyday life within their cultural and social context. The data collected is subjective and detailed (Corbin & Strauss, 2008).

Research findings and conclusions in this study are presented in the form of words or narrative in nature. Aspers and Corte (2019) and Mishra (2016) contend that it is a multi-method in focus, interpretive, and naturalistic studying things in their natural settings by making sense of the phenomenon in terms of meanings people bring to them.

I chose to use a qualitative approach to obtain more profound insight into the ethnomathematical approaches by exploring participant's behaviour, perceptions, feelings, ideas or experiences and understanding in real-life situations (Ugwu & Eze, 2023; Rahman, 2017:102; Punch, 2013), to gain a deeper understanding of participants' perception of teaching and learning mathematics through ethnomathematical approaches. The quantitative approach enabled me to delve deeper and more directly into the experiences, perspectives and contexts of teachers, learners and WKH as they make meaning of their daily lives. The approach involved observing how WKH understands and uses mathematical concepts daily. This was achieved through participant observation, being immersed in the participants' context to gain a comprehensive understanding of social phenomena in their natural environment (Ugwu & Eze, 2023), exploring how teachers and learners connect mathematical concepts to their cultural background and everyday lives, how WKH can share their knowledge of mathematical concepts embedded in the cultural artefacts with teachers and learners to improve geometry performance.

The research approaches are underpinned by different paradigms (Cohen et al., 2018). This study was located within the interpretivist research paradigm. The nature of inquiry was interpretive, with the primary purpose being to understand participants' meanings and experiences on ethnomathematical approaches to teaching and learning geometry.

3.3 Research Paradigm

Research paradigm is referred to as a philosophical perspective (Creswell, 2009), providing the study framework of the researcher defining the researcher's philosophical orientation (Kivunja & Kuyini, 2017). According to Kuhn (1977), as cited in Antwi and Hamza (2015), the research paradigm refers to a research culture with a set of beliefs, values, and assumptions researchers share regarding research. Similarly, Nickerson (2023), Kivunja and Kuyini (2017), and Aliyu, Singhry, Adamu and AbuBakarSing (2015) defined it as a set of ideas and beliefs that provide a framework or model to be followed. Nickerson (2023) further elaborated that the research paradigm deals with ultimate principles, defines existing knowledge, the nature of research problems, relevant methods to collect data and how data should be analysed and interpreted.

A paradigm is a conceptual framework shared by a community of scientists. It provides them with a convenient model for examining problems and finding solutions Kuhn (1962) cited in Kivunja and Kuyini (2017). The research paradigm indicates the researchers' worldview (Aliyu et al., 2015) on how to conduct the research study, acts as a frame of reference guiding the researcher on the research topic, relevant methods to collect and interpret data, how meaning will be constructed based on individual participants' experiences and methods to communicate research findings. Kivunja and Kuyini (2017:26) defined the worldview as the school of thought, perspective, and beliefs that guide the understanding and interpretation of data collected. Thus, worldview influences personal behaviour, professional practice and the researcher's position. Kivunja and Kuyini (2017:26) emphasized that paradigm is a lens through which the researcher sees the world, helps to examine methodological aspects of research, determines research methods to be used, and determines how data collected will be analysed. Worldview influences personal behaviour, professional practice and the researcher's position (Aliyu et al., 2015).

3.3.1 Philosophical assumptions

Philosophical assumptions in qualitative research guided researchers in conducting in-depth explorations, capturing rich narratives and generating a nuanced understanding of human experiences. Each research is founded on underlying philosophical assumptions (Antwi & Hamza, 2015:217) of valid research, which guides the appropriate research method to develop knowledge in a particular research study. Qualitative research is guided by several philosophical assumptions that shape its methodology and approach, reveal assumptions about design choices, methodology and methods, data analysis and interpretation (Moon & Blackman, 2017).

Lincoln and Guba (1985), cited by Kivunja and Kuyini (2017), assert that the research paradigm consists of four elements known as ontology, epistemology, methodology and axiology, which comprise the basic assumptions, beliefs, norms and values of the paradigm. Daniel (2016:19) defined a paradigm as a set of philosophical assumptions about the phenomena to be studied (ontology) and how they can be understood (epistemology). The four philosophical assumptions in qualitative research help the researcher to understand and study reality (Rehman and Alharthi, 2016; Antwi & Hamza, 2015; Guba and Lincoln, 1985, cited in Kivunja & Kuyini, 2017).

3.3.1.1 Ontological assumption

Ontological assumption refers to a foundational belief about the nature of reality, how one sees and views the world and reality (Aliyu et al., 2015). It is the fundamental belief about what exists, the study of being or existence, things that exist or may exist in some domain, and the form and nature of existence (Kivunja & Kuyini, 2017; Aliyu et al., 2015; Antwi & Hamza, 2015), what can be known about what is being researched. According to Heidegger (2013) and Mack (2010), ontology is defined as the essence of reality. Antwi and Hamza (2015) it is how truth and reality are determined, the philosophical study of the nature of being in existence or reality (Garad et al., 2020; Kivunya & Kuyini, 2017:27), concerned with what exists in the world (Moon & Blackman, 2017; Daniel, 2016:19; Mack, 2010).

Ontology is said to be the starting point of any research (Garad et al., 2020), examining and understanding the assumptions about the nature of reality that underlie the research questions, methods and interpretations. It is about the assumptions we make to believe that the phenomenon investigated makes sense and helps us understand how we make meaning of the data collected. Researchers have beliefs about the existence of reality and what can be known about it (Rehman & Alharthi, 2016:51).

Ontology helps the researcher determine the nature of knowledge generated (Garad et al., 2020). Ontological assumptions of interpretivism are that multiple people see social reality, interpret events differently, and learn numerous perspectives on one incident (Mack, 2010); reality is indirectly constructed based on individual interpretation, making the meaning of one's own events henceforth subjective. The ontological question related to this study was on the nature of reality and the knowledge available to be known. Therefore, in this study, ontology involved understanding the existence and nature of ethnomathematical approaches in the teaching and learning of Grade 6 geometry. Ontology seeks an answer or reality to a research question within the existing type of knowledge. Adopting ontology made it possible to consider how cultural beliefs, practices and perspectives shape the teaching and learning of geometry, allowing for elements of connection or intersection.

3.3.1.2 Epistemological assumption

Epistemology is the study of knowledge (Moon & Blackman, 2017), the study of the nature of knowledge and justification (Schwandt, 1997, cited by Kuyini & Kuyini, 2017).) It is concerned with how knowledge can be acquired, how we come to know something, how we know the truth or reality and how it can be communicated to other people (Cohen et al., 2018:7; Kuyini & Kuyini, 2017:27). Garad et al. (2020) and Creswell (2007) defines it as how knowledge from existence in which we live, can be obtained and understood, how the researcher knows reality. Epistemology is concerned with how the researcher has aimed to uncover knowledge to reach reality (Husan & Abraham, 2020), how the investigator comes to know the truth and reality (Kivunya & Kuyini, 2017; Antwi & Hamza, 2015), it is concerned with how the researchers are viewing the world around them, how one sees and views the world and reality, ability to distinguish between right and wrong, the relationship between the researcher and what is known.

It is a way of understanding and explaining how and what we know (Crotty, 2003) and provides philosophical grounding for deciding on the types of possible knowledge available and ensuring adequacy and legitimacy. Epistemology influences how researchers frame their research to discover knowledge (Moon & Blackman, 2017). Epistemology explores how knowledge is acquired, what constitutes knowledge and how beliefs can be justified Kivunya and Kuyini (2017). Furthermore, epistemology is the study of the nature of knowledge and justification (Kivunya & Kuyini, 2017; Moon & Blackman, 2017) and is concerned with all aspects of validity, scope and methods of acquiring knowledge. Moon and Blackman (2017) further argued that it has focused on how knowledge is produced and how its transferability can be assessed. Epistemological beliefs underpin the development and use of strategies and methods by empirical researchers. Epistemology is based on four knowledge sources: intuitive, authoritative, logical and empirical (Kivunya & Kuyini, 2017).

3.3.1.3 Methodological assumption

Methodology is the strategy, plan of action, process or design of the choice and use of methods directly linked to desired outcomes of the research (Crotty. 2003:3) to gather, analyse and interpret data in the study. According to Garad et al. (2020), principles, procedures, and practices control the research to achieve the objectives and answer the research questions. It includes data gathering, participants, instruments used to collect data and data analysis (Kivunya & Kuyini, 2017). Methodology is concerned with how in which we come to know the world. The methodology of a paradigm indicates the logic and flow of process followed in conducting research, including assumptions made, limitations and their mitigation strategies (Kivunya & Kuyini, 2017); they further emphasized a close relationship between the research paradigm and methodology of the research which allows for the research question, selection of participants, data collection instruments and data analysis.

In this study, the choice of methodology is aligned with the underlying paradigm or worldview. Paradigm guided the nature of reality and knowledge production, the role of the researcher and appropriate methods. The interpretive paradigm focuses on understanding individuals' subjective meanings and interpretations, and therefore, qualitative methods were employed.

3.3.1.4 Axiological assumption

Axiology refers to ethical issues to be considered when planning a research proposal (Kivunya & Kuyini, 2017:28), defining and ensuring that concepts of right or wrong behaviour are evaluated and understood. It is about how one acts in the world. Axiology is a philosophy that deals with values and ethics, looks at the role of values in the inquiry process, and plays a vital role in laying standards and requirements of acceptable research approaches and techniques for the study. Research is value-bound; the researcher is part of what is being researched, hence elements of subjectivity. It addresses ethical behaviour, respect for participants' rights and moral issues (Kivunya & Kuyini, 2017:28).

3.3.2 Interpretive philosophical perspective

The interpretive research emphasized understanding the Ndebele cultural context in which mathematical knowledge is developed and used, exploring how geometric concepts are understood and applied. The focus of the study was on the subjective experiences and meanings of participants. The study examined how teachers, learners, and WKH from different backgrounds made sense of mathematical concepts inherent in the Ndebele cultural artefacts. According to Nickerson (2023) and Rehman and Alharthi (2016:55), the interpretive paradigm asserts that reality is subjective, the phenomenon should be understood from the perspective of individuals, all research is influenced and shaped by the pre-existing theories and worldview of the researchers. It aims to explain subjective reasons and meanings behind social action (Antwi & Hamza, 2015) and evaluate and refine interpretive theories. According to Rahman (2017) and Creswell (2014), reality is socially constructed by humans, who are the product of traditions, beliefs, and social environments. It can be changed and understood subjectively. Interpretivists assume that access to reality happens through social constructions (Myers, 2008) of individuals and groups**.** These perspectives see the world as constructed, interpreted and experienced by people in their interactions (Antwi & Hamza, 2015).

The main aim of the interpretivist paradigm is to have a clear understanding of the subjective world of human experience Guba and Lincoln (1989), cited in Kivunya and Kuyini (2017), to understand and interpret participants' thinking or meaning-making of the context because the goal is to understand the social phenomenon in their research context (Rehman & Alharthi, 2016:55), understand the viewpoint of the participants' observed rather than the viewpoint of the observer (Kivunya & Kuyini, 2017:33). Interpretivism paradigm assert that reality is subjective and that phenomena should be understood from participants' perspective (Nickerson, 2023). These points are backed up by the earliest study of Cohen et al. (2018:21), which stated that interpretivism is crucial because individuals, as participants, are unique and have multiple interpretations of perspectives. Interpretive research sought to uncover how participant creates meaning from their experiences in ethnomathematical approaches.

This study was located within the interpretivist research paradigm. The Interpretivist paradigm was considered the most appropriate paradigm for this study to understand how realities are produced and maintained, focusing on shared values and standard practices, exploration of multiple subjective realities and participants' perspectives (Garad et al., 2020). Multiple subjective realities and perspectives of teachers, learners and WKH on ethnomathematical approaches were explored. Collaboration between participants in constructing meaning, knowledge and understanding of geometric concepts in ethnomathematical research was emphasized. Interpretive research highlighted the role of language and symbolism in shaping knowledge. It investigated the concepts used by Ndebele Women when referring to mathematical concepts to determine their relationship with concepts used in mathematics instruction in the classroom.

Interpretivist was chosen because of its naturalistic data collection approach, such as interviews and observations used in this study (Antwi & Hamza, 2015). I immersed myself in the context of the study, seeking to gain a deep understanding and make meaning of the social and cultural factors that influence participants' thoughts, behaviours and interactions. This research paradigm made it possible to observe WKH's use of mathematical concepts in creating cultural artefacts in the classroom's teaching and learning process to gather rich qualitative data that captures the complexity and nuances of the ethnomathematical approaches.

In this study, there was active interaction between the researcher and the participants in their natural setting. The context was vital for understanding how individuals make meaning within their natural setting. The interpretive paradigm focuses on understanding the world from the subjective experience of individuals (Antwi & Hamza, 2015:218-219). Adopting an interpretivist paradigm could direct her focus on understanding participants' subjective experiences and perspectives using ethnomathematics in teaching and learning geometry with the belief that realities are multiple and socially constructed. It was essential to appreciate and understand the differences between participants and seek to understand how these differences are making meaning. An understanding of how teachers, learners, and WKH understand mathematical concepts within the context of their cultural backgrounds and experiences was necessary to achieve the aim of the research. This understanding could inform the development of effective teaching strategies that are culturally responsive and promote meaningful learning experiences in Grade 6 geometry. Therefore, the interpretivist paradigm allowed me to delve into social and cultural factors that shape geometry learning through ethnomathematical approaches.

The interpretivist paradigm assumes a relativist ontology, a subjective epistemology, a natural methodology and a balanced axiology (Kivunya & Kuyini, 2017).

3.3.2.1 Relavist ontology

The relativist ontological perspective guided the study in collecting data from participants on ethnomathematical approaches. Relavist ontology posts that reality is subjective and context-dependent. Relativist ontology is based on the philosophy that reality is constructed within the human mind and that no one actual reality exists but relative to how individuals experience it at any given time and place. (Moon & Blackman, 2017). Relativist ontology determines the nature of reality, the social context in which we live, and how one sees and views the world and reality. It explains how we can understand the relationship between participants, reality and social context. Multiple realities exist within the situation researched and can be explored to construct meaning through interactions between the researcher and participants (Chalmers et al., 2005, cited by Kivunya & Kuyini, 2017).

The emphasis is that there are multiple valid ways of understanding reality. What can be considered real can vary based on individual perspectives, cultural contexts or social constructions. From the relativist ontology perspective, this study recognises that mathematical knowledge and practice are not universal or absolute but are influenced by cultural, social, and historical contexts. It contributed to a broader understanding of the diversity of mathematical knowledge and pedagogical practices, enriching mathematics education and cultural relevance. In the context of this study, elders believed in using non-standard measurements and feathers in mural art. They considered this process leading to authentic products while youth came in with their own perspective different from their elders.

3.3.2.2 Subjectivist epistemology

Subjectivist epistemology was sought to be relevant for this study because the study adopted an interpretivist paradigm (Cohen et al., 2018; Kivunja & Kuyini, 2017; Moon & Blackman, 2014). Knowledge was constructed socially based on personal experiences of real life in a natural setting (Mack, 2010), subjective to participants's experiences (Cohen et al., 2018; Moon & Blackman, 2014), knowledge depends on participants' perception and understanding of reality (Moon & Blackman, 2014). Subjectivist epistemology influenced how the research was framed in discovering how ethnomathematical approaches can be used in teaching and learning geometry. Knowledge is not only from observed phenomena but can also be derived from subjective beliefs, values, reasons and how people understand and make meaning within their social and cultural context. Knowledge is subjective and relative to each individual experience in a given time and place (Moon & Blackman, 2014). Truth or meaning arises from engagement with realities within our world to generate contextual understanding.

Interacting with participants in subjective epistemology allowed for a deeper understanding of the subjective experiences and perspectives of teachers, learners, and WKH regarding using ethnomathematical approaches to teaching and learning geometry. Subjective epistemology recognizes that mathematical knowledge is not solely derived from objective universal truth but is influenced by cultural and individual perspectives, uncovering ways in which the cultural background, personal experiences and social factors shape learners' and teachers' understanding of geometry. It helped establish faith in the data collected (Kivunya & Kuyini 2017) and affected how knowledge was revealed within the social context.

3.3.2.3 Naturalist methodology

Interpretive researchers employ naturalistic methodology to understand the world from the subjective experiences of participants (Kivunja & Kuyini, 2017:33) using interviews, discourses, text messages and reflective sessions and acting as participant observers (Carr & Kemmis, 1986 cited in Kivunja & Kuyini, 2017). It was necessary to use naturalistic methodology in exploring ethnomathematical approaches. Interviews, observations and FGDs were used to examine and understand social phenomena in their natural complexity, providing for a deeper understanding of how teachers engage with learners with mathematical concepts in a real-world context, how WKH use mathematical concepts in making their cultural artefacts, which can then be used to aid learning, how WKH can work collaboratively with schools in using ethnomathematical teaching approaches. Observing interactions with geometry within their cultural and everyday experiences provided insights into how cultural background and context can influence learning, reasoning processes, and unique and innovative problem-solving strategies.

3.3.3 Research design

This study employed an Ethnographic research design. Creswell (2007) defines ethnography as a qualitative research design whereby the researcher describes and interprets the shared and learned patterns of values, behaviours, beliefs and language of a group sharing a particular culture. Ethnography studies social interactions, behaviours and perceptions within groups, teams, organisations and communities (Reeves, Kuper & Hodges, 2008). Ethnography involves extended observations of people's behaviour and interactions at a close range through participant observation. (Ugwu & Eze, 2023; Brewer, 2000, Creswell, 2014, 2007). Brewer (2000) defined ethnography as the study of people in a natural setting to capture social meanings and activities, involving the researcher to participate directly in the setting. All the definitions above share the common fact that the researcher is immersed in the people's daily lives within a community or organization, observing and interviewing the participants to understand their shared culture, traditions and social dynamics comprehensively.

Ethnography is appropriate if the study seeks to describe how a particular cultural group works, exploring the beliefs, language, behaviours, resistance and dominance (Spradley, 1980, as cited in Cresswell, 2007). Ethnography provides a rich holistic insight into peoples' views, actions, and sites using observations and interviews to collect data (Reeves et al., 2008) to understand social meanings, world experience and people's activities in each setting (Brewer, 2000). Interpretivists collect qualitative data from participants over an extended period through ethnography (Rehman & Alharthi, 2016:55). This study, therefore, aimed at exploring how teachers teach geometry using cultural artefacts, how learners connect mathematics from their culture to school mathematics, how WKH use mathematics to create the cultural artefact, how do participants interact in their cultural groups within their contexts. The naming of cultural artefacts was part of language. The observed groups were together for extended periods, were culture-sharing groups, there was crucial information, and the study examined participants' interaction in a setting (Creswell, 2007).

The ethnographic research design was appropriate for this study because of its nature of conducting fieldwork and being immersed in the natural setting over an extended period through participant observation. The ethnographic research design allowed engagement in prolonged observations of the group's everyday life (Haradan, 2018). In this case, the natural setting was the classrooms where lessons were observed and the art gallery where cultural artefacts were made. I was immersed in the daily lives of teachers, learners, and WKHs, and I interviewed and observed the cultural groups. Creswell's (2007) ethnography focuses on an entire cultural group, which may be small, like a few teachers within the school as a whole.

Behaviours, values and interactions among group members are studied, described, and interpreted (Creswell, 2014). It involves investigating a few cases in detail (Reeves et al., 2008). Few teachers, few learners within the circuit, and few women within the community participated. Ethnography studies an entire group with a common culture (Reeves et al., 2008). Cultural perimeters include shared experiences, enabling observation of the actual teaching and learning practices as well as the cultural and social factors that influence them, using Ndebele cultural artefacts, identification and use of the mathematical concepts embedded in the cultural artefacts and most importantly interaction with the teacher and amongst learners.

The ethnographic design emphasizes the importance of understanding the perspectives and experiences of the cultural group. By adopting this approach, I gained insights into how learners as a cultural group perceive and engage in geometry concepts and how teachers incorporate ethnomathematical approaches into their instruction. Complexities and nuances of teaching and learning were captured. It allowed for identifying patterns, contradictions and unexpected findings that may not be evident through other methods. The holistic understanding provided valuable information on cultural artefacts and mathematical concepts for improving the teaching and learning of geometry so that students can be fully immersed in schools and observe how teachers use Ndebele cultural artefacts to connect mathematics in everyday activities to mathematics in schools.

The ethnographic design was pertinent since the study aimed at describing and interpreting shared and learned patterns of a culture-sharing group of WKH. Through ethnographic design, one could fully be immersed in the art galleries to conduct interviews and participant observation with WKH and collect first-hand information about their interaction in a specific context, their process of making cultural artefacts, mathematical concepts used by WKH, shared patterns of behaviour, language used to name Ndebele cultural artefacts and shapes drawn for decoration and the role that WKH can play in the teaching and learning of geometry for appropriate and easy connection. Ethnographic research studies beliefs, social interactions and behaviours of small societies involving participants and observation over a long period (Denzin and Lincoln, 2012). Being immersed in their social setting allowed me to access more accurate and relevant information to the research aim. It also made it possible to collect information and dynamics that I could not have collected through being disengaged and just asking questions.

Creswell (2007) outlined why ethnography is challenging to utilise as follows: The researcher needs to have a grounding in cultural anthropology, the meaning of a social-cultural system, and the concepts explored by ethnographers. Cultural anthropology focuses on the study of human societies, cultures and behaviour. It seeks to understand the diversity of human cultures and how Existing literature on cultural anthropology and its relevance to ethnomathematics was reviewed to understand the potential contributions of cultural anthropology to the study of how people live, think, and interact within their social and cultural context to mitigate this concern. Ethnographic methods such as interviews and participant observations were used to gain insights into how ethnomathematical approaches are used in geometry teaching. This provided a rich understanding of the cultural context.

Cultural sensitivity: ethnomathematics involves understanding and incorporating mathematical concepts from various cultural contexts.

The research was approached with cultural sensitivity to avoid misrepresentation of cultural practices. I work, reside, and interact with the community, teachers, and learners, understand their cultural norms, values, and practices, and have an excellent relationship and trust in them. I was mindful of the cultural context and ensured that the voices and perspectives of participants were accurately represented.

According to Ugwu and Eze (2023), observer bias is possible. Maintaining the required distance to analyse the group embedded was challenging because of the subjective interpretation. Ethnographic research relies on the researchers' interpretation and understanding of the cultural context and acknowledges the influence of the researcher's background, experiences and biases on the research process.

I was aware of my own positionality biases and preconceptions and how they can affect the interpretation of data and, therefore, strived to maintain objectivity and ongoing reflexibility throughout the research process. Extensive time was used to collect data involving prolonged time in the field (Haradan, 2018; Creswell, 2007). Prolonged immersion requires careful planning; one can plan for 6 weeks and end up having spent several months (Ugwu & Eze, 2023). It was time-consuming and called for a significant investment of resources in the field and observing and interacting with participants.

Detailed research plans outlining timelines and activities helped address the concern about prolonged time in the field. Clear objectives were outlined to help focus time and effort on relevant data collection.

Ethics must be considered when disclosing your role to the group or reporting sensitive information (Ugwu & Eze, 2023). Ethnographic research involves studying people in their natural settings. Brewer (2000) raises ethical concerns about privacy and informed consent.

Ethical guidelines were adhered to, and the rights and well-being of the participants were protected. Informed consent was obtained, and participants' privacy and confidentiality were protected (cf. Appendix F, G and H).

Obtaining formal approval from the research ethics committees can be complicated (Reeves et al., 2008). An application was made without complications, and formal approval from research ethics was obtained before commencing with data collection (cf. Appendix A).

3.3.4 Study area

The research sites comprised schools in Mpumalanga Province, from Nkangala District, within Doctor JS Moroka municipality at Ga-Mabhoko village. The five (5) schools were selected for this study because they are situated in the village where teachers and learners are familiar with Ndebele culture, are exposed to Ndebele cultural artefacts, possess Ndebele cultural knowledge and were willing to participate freely in the study. In addition, the researcher grew up in Mpumalanga province, resides within Doctor JS Moroka municipality, works with the sampled schools as the subject advisor for mathematics and is familiar with Ndebele culture. The schools are close to the art centre for Dr Esther Mahlangu and the art gallery for Ms W2. Schools within Ga-Mabhoko village fall under the eMthambothini circuit, formerly the Weltevrede circuit. Most schools within the village use Isindebele as the Home Language, whereas few have both Isindebele and Sepedi as the Home Language for two groups of learners, respectively. The language of learning and teaching (LoLT) is English. Schools from other villages around Dr JS Moroka, within Moretele/Siyabuswa Sub-District, could not be selected because they lack community resources such as Ndebele art centres or art galleries; they are dominated by other cultures such as Sepedi and Setswana, where the study was explicitly on Ndebele culture.

WKH were selected from Ga-Mabhoko and Matempule villages. The initial research plan was to interview Dr Esther Mahlangu and her team, focusing only on Ga-Mabhoko village because that is where she resides. Unfortunately, I was forced to adjust the plan because of her unavailability. I had to look for other women who knew about Ndebele cultural artefacts around Dr JS Moroka (cf. section 3.6). Fortunately, I found one woman in Ga-Mabhoko village and the other in Matempule village. Both villages are situated within Dr JS Moroka Municipality.

Ga-Mabhoko village was selected based on the following reasons: This village has a majority of Ndebele people who are still adhering to their cultural practices, most of the walls within the village are decorated with Ndebele shapes and painted with Ndebele colours, Dr Esther Mahlangu's art centre is situated at Ga-Mabhoko, Ms W2 stays at Ga-Mabhoko village, and her art gallery is also located within the village.

Matempule Village was included in this study because I found the second woman with knowledge of Ndebele cultural artefacts to participate there. The woman has her own art gallery in the yard; her house, art gallery, and walls are painted and decorated in Isindebele design, which is part of her culture. The aim was to collect data from various participants who may have unique perspectives and experiences that can enrich the research findings. Matempule village has a mixture of Ndebele, Sepedi and Setswana-speaking people.

Most people who reside in Ga-Mabhoko village are Ndebele people, who run businesses on beadwork and murals established by women. Bhuda (2019:161) contends that Ndebele women sell their art to make a living, and their livelihoods have improved because of the commercialization of art. They can financially support themselves and their families by creating and selling artwork. The two women selected have found a way to monetize their skills and passion for mural art and beadwork by selling their artwork directly to local customers in neighbouring villages abroad. They also participate in art exhibitions and collaborate with businesses or organizations interested in the Ndebele culture. Residents who are not making a living out of beadwork and mural art have alternative ways of survival. For example, established small businesses like selling fruits, food, or work in Pretoria, Marble Hall or Groblersdal.

Including the two WKHs and the people they work with led to a more extensive and diverse group of participants, which was found to be objective. There was a reduced chance of individual biases, which could have negatively impacted the results. The credibility and trustworthiness of the research were established and improved.

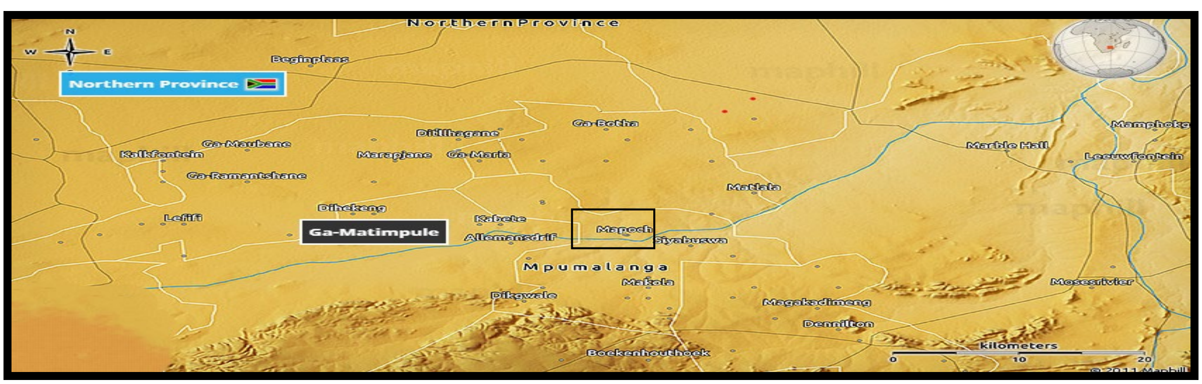


Figure 3.1: Map of Mpumalanga showing Ga-Mabhoko and Ga-Matempule Village (Sourced: Municipalities of South Africa)

Figure 3.2: Map of Ga-Mabhoko (Ga Mapogo/Weltevrede) Village (Sourced: Mapcarta)

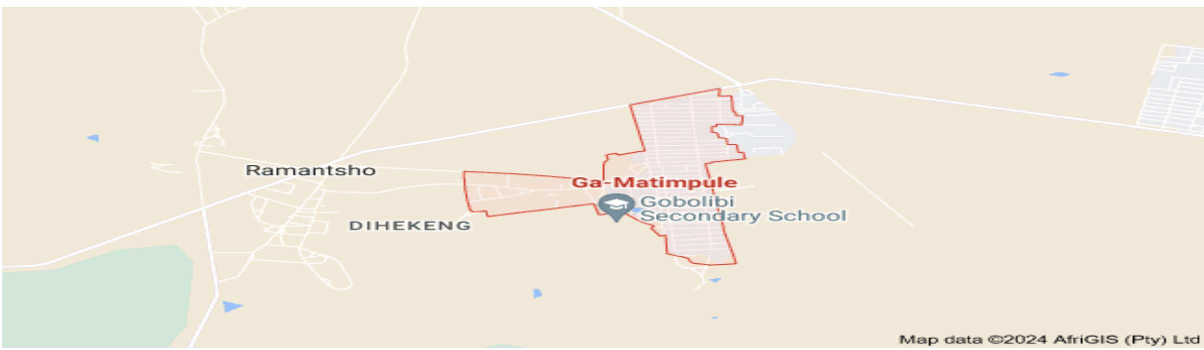


Figure 3.3: Map of Ga- Matempule (Sourced: Mapcarta)

3.4 Research Population

Creswell (2012) defines a population as individuals with similar characteristics. It refers to the entire group of individuals from whom the information will be collected to answer the research question or objects the researcher is interested in studying to gather information. The study aimed at exploring ethnomathematical approaches in the teaching and learning of Grade 6 geometry. The population comprised Grade 6 Mathematics teachers and their learners from schools within Mabhoko village in Nkangala District, under the eMthambothini circuit. WKH at Mabhoko and Matempule Village within Dr JS Moroka municipality situated in Mpumalanga Province. The snowball sampling procedure was used to identify WKH. Kghodwada cultural village suggested two well-known women, and both women suggested other women. Data was collected from the two WKH-renowned entrepreneurs and their team members. Each part of the population is explained below:

3.4.1 Grade 6 teachers

The Grade 6 teachers were identified as part of the study population for several reasons. Firstly, teachers are the ones who directly interact with learners' and deliver curriculum using different teaching approaches; their knowledge and experience could assist in answering the research questions and could provide valuable insights into the effectiveness of ethnomathematical approaches in the classroom. Involving teachers in the population ensured the findings were practical and applicable to real-world teaching situations.

Secondly, teachers deeply understand their learners' performance, errors and misconceptions in geometry and can provide valuable feedback on how ethnomathematics can be tailored to meet those needs. Teachers could offer insights into challenges and successes they have experienced while implementing ethnomathematical approaches in their classrooms. The information provided is crucial for researchers to refine and improve the ethnomathematical approaches, making them more effective for teaching geometry.

Lastly, involving teachers in the research process could empower them as professionals; it recognises their expertise, gives them a voice in shaping their educational practices and contributes to the overall improvement of geometry.

In this research study, information expected from Grade 6 teachers as the population participants would be crucial in answering the research questions. Here are some specific types of information expected: Grade 6 teachers could provide insights into their strategies for implementing ethnomathematical approaches in their geometry lessons. This could include details about specific activities, resources, and instructional methods employed. Teachers can share their experiences and observations of learner engagement, participation and learning outcomes when using ethnomathematical approaches in teaching geometry. They could provide insights into the feasibility, practicability, and effectiveness of the approaches and feedback on learners' attitudes, motivation, and perceptions of learning geometry through these approaches. Based on their experiences, teachers were expected to suggest recommendations for improving the implementation of ethnomathematical approaches in geometry instruction. The recommendations can inform future research and guide the development of instructional strategies that align with the needs of Grade 6 learners.

3.4.2 Grade 6 learners

The study explored learners' knowledge of the cultural artefacts and geometric concepts embedded with the hope that knowledge was passed on to them by women in community leadership responsible for community development or parents at home. It was essential to include Grade 6 learners as a population in this research study for several reasons: Grade 6 is a critical stage in learners' mathematical development because it is during this time that they start to build a solid foundation in geometry. By including Grade 6 learners in the research, we could gain insights into how ethnomathematical approaches can enhance their understanding of geometry; we can explore their perspectives, ideas and knowledge of cultural artefacts and mathematical concepts embedded in them, which can contribute to a more comprehensive understanding of how ethnomathematics can be integrated into the teaching and learning of geometry, Their inclusion could offer a unique understanding of how these approaches impact their engagement, motivation and understanding of geometric concepts. Data on the actual learning outcomes achieved through the assessment of geometry concepts and problem-solving skills can be gathered to provide feedback on the effectiveness of the approaches, which can help researchers refine and improve these approaches.

I expected to obtain in-depth information on learners' knowledge of cultural artefacts, how they use them to learn geometry and their experience, perception and understanding of geometry within their cultural context. This research aimed to investigate ethnomathematical approaches, how the ethnomathematical approaches can be applied in teaching geometry and the implications for classroom practice. The information provided answered the research questions.

3.4.3 Women Knowledge Holders

The Ndebele Women play significant roles integral to social and cultural practices, such as teaching children cultural practices (Bhuda, 2019:121). Ndebele women pass their knowledge of cultural expression from mother to daughter, from one generation to another, and women of different age groups. They are renowned for their artistic skills, intricate beadwork and mural painting. This study explored ethnomathematical approaches focusing on using Ndebele cultural artefacts which women make.

By including Ndebele WKH as a population, I gained insights into their cultural knowledge and practices that can be incorporated into the teaching and learning of geometry. Their expertise and experience shed light on how geometry intersects or connects with their cultural context, making geometry teaching and learning more meaningful and engaging for learners. Including WKH ensured that diverse perspectives and experiences were represented in the research, providing opportunities for their voices to be heard and their contributions to be recognized. This is crucial in challenging gender stereotypes and addressing any potential biases in the teaching and learning of geometry; for example, it was found that all the Grade 6 teachers at the sampled schools are males. WKH could serve as a positive role model for female learners and teachers and further inspire and empower girls to engage more actively in their culture and mathematics.

WKH shared knowledge on how geometry is applied and integrated into their everyday life when making the cultural artefacts, shared information on how to incorporate cultural artefacts into instructional methods, shared names and provided examples of cultural artefacts that teachers can use to teach geometry. WKH can help teachers and learners understand the cultural relevance of geometry within the Ndebele culture and offer insights into how geometry concepts connect with Ndebele culture. Their cultural knowledge and experience were essential in answering the research questions.

3.5 Sampling

Sampling is the process of selecting a small number of people to provide information that a larger population might give if the researcher asked every member of the larger population the same questions asked to the sample. Sampling is a critical component of qualitative research involving selecting a group of participants who can provide valuable insights into research questions. Most of the time, the entire population is too large to collect qualitative data, hence the necessity to sample. Qualitative research involves smaller samples (Maree, 2013).

3.5.1 The sampling procedure

This study used purposive and snowball sampling methods to select the participants. Patton (2002) asserts that qualitative inquiry focuses on purposeful, in-depth small samples. Purposeful sampling involves selecting participants based on their thinking and believing they might contribute something to the research study (Creswell, 2014). Purposive sampling improves the quality and accuracy of data collected because the participants selected have unique perspectives and experiences related to the research question.

Purposive sampling was relevant because participants possessed appropriate knowledge and understood the subject well enough to answer the research questions. Purposeful sampling allowed the researcher to collect more in-depth, focused knowledge and insight from the participants. The purposive sampling technique identifies appropriate and adequate participants who can best inform the study. According to Nicholls (2009), purposive sampling is based on the characteristics of participants. It can be done based on the researcher's judgement to obtain data related to the study's objectives. Bhardwaj (2019) also referred to it as judgemental sampling.

According to Bhardwaj (2019) and Creswell (2012), in convenience sampling, the researcher selects participants because they are readily available to participate in the study based on their convenient accessibility. Snowball sampling procedure or chain referral sampling is a distinct method of convenience sampling, proven to help conduct research in marginalised societies (Cohen & Arieli, 2011). Snowball sampling was used when faced with difficulties in creating a representative sample of the research population. It was used as my second best and helped me generate data cooperatively and collaboratively. It is the most effective method for accessing hidden or hard-to-reach populations (Valdes & Kaplan, 1999, as cited in Cohen and Arieli (2011). Cohen and Arieli (2011) further explained marginalized populations as being 'Hidden' from and hard to reach by outside researchers. I did not know of the other WKH. Secondly, the research was on marginalised communities in mathematics education (D'Ambrosio and Gerdes). This sampling procedure allowed for diverse participants with various backgrounds and experiences.

3.5.2 Participants' selection criteria

Purposive sampling was used when selecting teachers and learners, whilst convenience sampling was used with WKH. The study used a specific criterion relevant to the research aim to choose the participants. The information on criterion was shared with the five teachers and the WKH while explaining how data would be generated in the study. According to Creswell (2013:214), interpretivist research uses purposive sampling and selects information-rich individuals and sites. *The participants* were *selected using the following criteria:*

3.5.2.1 Grade 6 Mathematics teachers

Teachers teaching Grade 6 in the sampled schools at Ekosini village in Moretele Siyabuswa Sub-District. They should have taught mathematics for at least 3 years. Criteria were discussed with the Principal and the Departmental Head. Teaching experience was considered to be necessary based on the nature of the study, which expected them to share their experiences in ethnomathematical approaches in the teaching and learning of geometry, their knowledge of cultural artefacts and those that can be used to teach geometry, the mathematical concepts embedded in the cultural artefact and how they can be used to aid learners understanding of mathematics, their successes or achievements, advantages, challenges on using ethnomathematical teaching approaches. Teachers are to be voluntarily willing to participate in the study and to be available for interviews and lesson presentations.

3.5.2.2 Learner participants' selection criteria

Participants were Grade 6 learners from the five sampled schools, one boy and one girl from each. Learners sampled have obtained at least level 7 in term 4: 2021 results. It was assumed that the selection based on learner performance would help get in-depth information and varied views, perceptions, and experiences on using Ndebele cultural artefacts to learn Geometry. The teachers taught two learners who participated in the study, and lesson observation was conducted from the Grade 6 classroom. It was also suggested that learners should belong to Ndebele culture because the data to be collected was on Ndebele cultural artefacts.

A boy and a girl were sampled because regular classrooms contain both genders; the aim was to promote gender equality, challenge gender stereotypes and biases that may exist in mathematics education, and gain a better understanding of how different genders perceive and engage with mathematical concepts which lead to a more inclusive teaching strategy. The study connected knowledge gained from one's culture in making cultural artefacts to mathematics learned at school. Learners were expected to use mathematical concepts found in their own cultural artefacts in learning geometry. According to Bhuda (2019), boys are not allowed to participate in the making of cultural artefacts. Therefore, it was appropriate to find boys' level of prior knowledge, which is a prerequisite for a smooth connection when using ethnomathematical approaches. It was hoped that these would make a significant contribution to this study.

3.5.2.3 Women Knowledge Holders participants' selection criteria

Convenience sampling was used to sample WKH. Convenience sampling was not part of the research proposal. Still, it was decided upon during data collection because of the lack of access to the research site and its participants as per the initial plan. Some participants were selected for inclusion in the sample because they were available and accessible. This decision enabled me to continue the data collection process and gather information on the research topic from different people. It was found that besides Dr Esther Mahlangu, there are other prominent women with knowledge of Ndebele cultural artefacts, one residing at Ga-Mabhoko and the other at Matempule**.** I was informed and referred to the two WKHs by people from the Kghodwana Cultural Village at KwaMhlanga. I then contacted the WKH and made an appointment with them. Women at Matempule recruited her daughter to participate. Women at Ga-Mabhoko recruited her neighbour and her team members. One woman at Ga-Mabhoko was selected because she sells hats and other things decorated in IsiNdebele design. Cohen et al. (2018) maintained that convenience sampling is also called opportunity sampling, which involves choosing the accessible, nearest participant to the researcher.

3.5.3 The sample size

A sample is the number of participants who are selected from the population for the sake of collecting data. It is a subset of individuals with characteristics similar to those of a larger population from which they were selected. A good sample selection is critical to generalise the findings from the research sample to the population as a whole to enable the researcher to conclude. According to Patton (2002), there are no specific rules for sample size in qualitative inquiry. Similarly, Halloway and Wheeler (2002) said there are no guidelines for determining the sample size in qualitative research and further emphasized that the size does not influence the quality of the study; the sample may change in size and type during the research. Cohen et al. (2018:120) argued that there is no clear-cut answer for the correct sample size. Still, the purpose of the study and the population under investigation plays an essential role in determining the sample size. Studies above asserted that in qualitative inquiry, sampling continues until saturation is reached and no new information is generated or found by the researcher, implying that when there is no new information from the participants, the sample size is terminated.

The participants in the research study were prominent Women knowledge holders who have established art galleries inside their own yards, which attract tourists. They were selected because they are well-known custodians and knowledge holders of Ndebele cultural artefacts. They belong to Ndebele culture and have 10 years and more experience working with Ndebele cultural artefacts. The participants also included Grade 6 teachers and learners because the research aimed to investigate how ethnomathematical approaches can be used to enhance the teaching and learning of geometry in Grade 6 mathematics classrooms. Five (5) schools and one teacher from each of the five schools were sampled from a larger population of schools and teachers within the circuit. Ten (10) Grade 6 learners, one boy and one girl, were sampled from each of the five schools identified from a population of Grade 6 learners within schools in Ga-Mabhoko village.

Ms W2 assisted the researcher in selecting one participant (her neighbour), and Ms W3 assisted with one woman (her daughter) and one woman found at Mabhoko village residing next to the school, so there would be five interview participants. For the FGD, Ms W2 assisted with selecting five participants from her team to make a total of six women based on their experience and expertise. The FGD participants were selected based on their knowledge and understanding of participants making cultural artefacts. The selected participants are WKH, who works with her at her art gallery. She indicated that she has 15 team members, from which she selected a third relevant person to participate in an FGD.

Table 3.1: Sample size (interviews)

Category	Sample size	Explanation between Samples and their population
Grade 6 learners	10	The circuit has ten primary schools. Five schools situated within Ga-Mabhoko village were sampled. One class per

		school was identified. The total number of learners in each class from each school was different; however, it was between 40 and 50. School 1 had 48 learners, School 2 had 45, School three 50, School 4 had 47 and School 5 had 41 learners. Two learners from each of the five sampled schools, a boy and a girl with level 7 in mathematics, Term 4, 2021 results. The term 4 schedule for 2021 was used to identify learners. Gender equity was considered to determine the level of knowledge between boys and girls on the cultural artefact.
Grade 6 mathematics teachers	5	One teacher was selected from each of the five schools sampled.
Women Knowledge Holders	5	Information on the available WKH within Dr JS Moroka was obtained from the Kghodwana cultural village. One WKH was sampled from GaMabhoko and one from Matempule Village. Two WKH, Ms X and Ms Z, were sampled because they were available to have in-depth knowledge and experience on making Ndebele cultural artefacts. They have their own art galleries. The third woman works with Ms X, and the fourth has just started her own business. The fifth participant is the daughter of Ms Z, and she is one of those fortunate to inherit knowledge of cultural artefacts from her mothers.
Total	20	

Table 3.2: Sample size (observations)

Category	Sample size	Explanation between Samples and their population
Grade 6 classes from sampled schools	Five schools were selected, and one lesson observation was conducted from each of the five schools sampled, leading to a	The lesson observations were conducted in the same classes where two learners were selected for interviews. I took the role of a participant observer.

	total of five lesson observations.	
Team of Women Knowledge Holders	A team of six WKH at Mabhoko village	The team consisted of six women, including their leader, Ms W2, three women doing mural art, and two busy with beadwork.
Men	One gentleman	A gentleman painting dishes was not part of the sampled population but emerged during data collection. He was working alone outside the workshop.
Total Number of observations	**7**	Five classes, one team of WKH and one gentlemen

Table 3.3: Sample size (Focus Group Discussions)

Category	Sample size	Explanation between Samples and their population
Team of Women Knowledge Holders	Six women	Two teams are working with cultural artefacts within Mabhokovillage. The first was for Dr Esther Mahalngu, who was unavailable, and the second was for Ms W2 Mguni, who took part in FGDs because they were available. I facilitated the discussion and actively listened to what the women were saying to understand their perspectives. Probing questions were asked to delve deeper into the topic, and thoughts were encouraged to be shared among members and noted points and ideas.
Total Number of participants	**6**	Six WKH

3.6 Data Collection

Data collection is gathering information from various sources to answer research questions. It involved systematically collecting, organising and recording data using research instruments relevant to the research methodology and design.

3.6.1 Research instruments

This section describes the research instruments used to collect data, the reasons for their selection, how they were constructed and administered, issues of concern in data collection using the instruments and how issues were mitigated during data collection. The study is located within an interpretive paradigm, which is mainly concerned with understanding the world from the subjective experience of individuals with using oriented instruments like interviews and participant observations (Antwi & Hamza, 2015); interpretive researchers use interviews, observations (Cohen et al., 2018; Antwi & Hamza, 2015; McMillan & Schumacher, 2014) and FGDs (Antwi & Hamza, 2015) to understand the world through first-hand experience, report quotations from actual conversations, encourage participants to speak freely to obtain rich detailed thick descriptions. The study adopted a qualitative research approach and used ethnographic research design, hence the utilization of qualitative data collection instruments designed according to the objectives of the research study.

3.6.1.1 Interviews Schedule

The interview comprised two individuals discussing a particular human or societal topic to help the researcher get the viewpoint of the respondent by evaluating the significance of the given occurrences, allowing the interviewer and interviewee to follow a concept in more depth by expanding on it (Elhami & Khoshnevisan, 2022). Cohen et al. (2018) argued that interviews enable the participants to discuss their interpretations of the world from their own point of view. Similarly, Creswell (2013) maintained that seeing the world through the eyes of the participants is the primary purpose of the interviews.

Semi-structured interviews were chosen in this research study to help me gather rich qualitative data from participants, allowing for a deeper understanding of their experiences, perspectives and insights into the social and cultural contexts. Additionally, they would provide an opportunity to ask follow-up questions, clarify responses, and explore the nuanced aspects of ethnomathematics. Interviews were relevant to obtain information on individuals' feelings, opinions and experiences (Mack, Woodsong, Macqueen, Guest & Namey, 2005), allowing insight into how people interpret the world.

Moser and Korstjens (2018) advised that the interviews require a pre-selection of questions beforehand based on the information needed to better understand the participants in their responses. Interview questions relevant to the aim and objectives of the research were clearly formulated in advance to help answer the research questions. The construction of interview questions focused on the research topic, questions, and sub-questions that guided the research study (Elhami & Khoshnevisan, 2022). The literature informed some of the follow-up questions on ethnomathematics to get clarity on explanations of concepts further. Moser and Korstjens (2018) state that the interview guide and questioning method could comprise open and broad as well as subordinate or specific questions, probes and prompts. Crafting questions in advance was vital to being well-prepared, as good preparation pays off. Questions were reviewed and refined to ensure they were clear, concise, and relevant to the research objectives. They were then submitted to my supervisor to provide valuable insights, and an interview protocol was developed.

Interview appointments were made with participants to conduct interviews according to the interview protocol. The purpose of the study was explained to participants before commencing the interviews. Introductions were made, and consent forms were presented and signed by participants. Before the commencement of the interviews, learners' parents were invited to describe the research aim and process to them so that they could sign parental consent forms for their children below 18 years of age (cf. Appendix G and H).

The study administered semi-structured interviews in the form of face-to-face meetings with participants. Semi-structured interviews aimed to collect qualitative data and explore participants' thoughts, knowledge, and experience with Ndebele cultural artefacts and ethnomathematical approaches. An interview session took place like a normal conversation between two people, in the form of guided conversation using open-ended questions, neutrally posed questions, and attentive listening to participants' responses. Moser and Korstjens (2018) indicated that it must not be a fixed question-and-answer format. Throughout the interview, as the conversation developed, the researcher alternated between the questions because the research questions drove the research study.

Open-ended questions allowed participants to respond freely when explaining their knowledge and experience of cultural artefacts. Open-ended questions address issues in detail, provide personal thoughts, emotions, and ideas, and with less self-censorship (Elhami & Khoshnevisan, 2022). Follow-up questions were asked to elicit the participant's complete knowledge and experience of ethnomathematical approaches. Cohen et al. (2018) explained that prompts enable the researcher to ask the participants to elaborate, clarify and justify their responses. Phrases such as '*Could you elaborate more on that point*' were used for the participants to elaborate and obtain more details. Creswell (2010) recommended that prompts and probes should be used for participants to elaborate and give more clarity to their responses. Participants were probed to elaborate on their responses and share their knowledge about ethnomathematical approaches.

A comfortable and conducive environment was created for participants to share their thoughts and experiences. The researcher considered the language participants were comfortable with (Elhami & Khoshnevisan, 2022). In this study, the interview questions for the WKH were translated into Isindebele. Ga-Mabhoko Village is situated in Mpumalanga, which Isindebele-speaking people dominate. The lady who spoke the Setswana language indicated that she was Motswana by birth but then married an Isindebele-speaking man residing in the Ndebele area. She could speak both languages; however, she preferred Isindebele. WKH were allowed to respond in their home language or language of preference to ensure they were free and comfortable. The researcher was accompanied by a translator who knew Isindebele to translate or explain difficult words. I know Isindebele, but I am not at the level of the translating gentlemen. Teachers and learners used English because it is their LoLT, and it was easy for them to refer to geometric concepts and skills found in the cultural artefacts.

Body language and participant behaviours were observed and documented to confirm what was verbally indicated. Data collected was recorded with the participant's permission. Back-up notes were taken. Interviews with each participant lasted for at least an hour. Interviews were recorded and transcribed verbatim to ensure accuracy (cf. Appendix I, J and P).

a) Issues or concerns in the collection using interviews and how they were mitigated

Finding a private Venue: Securing a private venue free from external distractions proved a significant challenge. For example, learners and teachers who were not part of the participants wanted to observe the interviews because of curiosity; there was a desire among learners and teachers to be part of the interviews as observers.

Participants were invited to suggest a venue or place to mitigate this. The principals were also taken on board with research ethics and requested to address teachers and learners.

Subjectivity: Probing was utilized; participants were asked to elaborate on their experiences and encouraged to think critically when responding to questions. Member checking was done after conducting the interviews for participants to verify the accuracy and interpretation of their responses, provide feedback and clarify misunderstandings to reduce subjectivity. I critically reflected on my own biases and assumptions throughout the interview process.

Time constraints: Time constraints were optimised by carefully planning the number of interviews needed to achieve data saturation, prioritizing key participants, and using purposive and convenience sampling. For example, due to limitations in accessing the original participants sampled, convenience sampling was employed to collect data from readily available individuals who shared similar characteristics and met the study's criteria.

3.6.1.2 Focus Group Discussions

According to Lokanath (2016), FGDs are a kind of in-depth interview conducted with a group, with sessions exhibiting features dependent on the proposal, size, composition, and interview methodologies. Cohen et al. (2018) defined it as a collective of individuals with specific attributes brought together to discuss a topic. Focus groups are used when a researcher intends to explain a subject or problem in more depth (Akyıldız & Ahmed, 2021); they originated in the social sciences and are primarily used for qualitative research to bring together persons with comparable experiences. Cohen et al. (2018) further asserted that FGDs allow participants to discuss issues amongst themselves, bringing about more information, views or ideas within the group members. It is, therefore, regarded as a well-recognized method for gathering information from various people.

FGD was chosen in this study because the purpose was to obtain data from social groups, and it is said that a large amount of data could be achieved quickly with less expenditure (Akyıldız & Ahmed, 2021). A FGD was used to explore ethnomathematical approaches by bringing together persons with similar backgrounds or experiences (Lokanath, 2016), focusing on the group's meanings, practices and norms. The rationale was to discover new aspects, generate new ideas and information from all participants, explore a range of knowledge on the topic of discussion, and draw upon participants' attitudes, beliefs and experiences, which could not be feasible when using other methods identified for the study. Group ideas were generated that would not be possible in one-on-one interviews. It was conducted within a group at a given time and place rather than with individuals at different times and places.

A guide that outlined the topics and questions to be discussed was constructed as part of planning and preparation. The FGD consisted of semi-structured issues relevant to the research topic. Open-ended questions allowed for prompt probes and encouraged discussions.

The consent form was read in English and translated into Isindebele to embrace all participants. It was further explained using the preferred language, completed and signed before the commencement of the discussion. One WKH just signed a cross and presented to the researcher that she does not know how to write. All the participants indicated they had no problem exposing their names to the public in the final document; however, an agreement was made to use variables when writing a report on responses. Participants were allowed to ask questions (cf. Appendix F).

The researcher started by welcoming the participants, and introductions were made to establish rapport (cf. Appendix Q). The research purpose, objective and process were explained to the participants to enable common understanding and active participation. The researcher established the ground rules, such as no use of cell phones during interviews, one person to talk to at a time, and respect for all. Rules were necessary for the smooth running of the discussions. A comfortable and open atmosphere was established to encourage participants to share their thoughts and opinions. Permission was sought with the participant to record and take notes. Participants were assured of confidentiality.

In this study, the researcher held FGDs with WKH to gather in-depth understanding, shared perspectives, views and experiences on how the cultural artefacts can be used in the teaching and learning mathematics. FGDs consisted of six members, including Ms WPB, their manager. I facilitated the FGDs and guided participants through the topics and questions. Active participation was encouraged, with all allowed to speak, and the discussion kept focused and on track. Interaction within the group was the primary focus of research or the object of investigation because participants affect one another via their replies to the ideas and contributions made during the discussion (Lokanath, 2016); they build upon each other's ideas. The researcher created a safe and respectful environment that made participants feel their contributions were welcome and worthwhile.

The focus group setting was convenient and comfortable for participants, private, quiet and without distractions that could negatively impact the process (Akyıldız & Ahmed, 2021). FGDs were held with WKH inside the WPB art gallery at Ga-Mabhoko Village, Situated at Weltevrede circuit within Nkangala District in Mpumalanga Province. She has an oversized garage in her yard that is used as an art gallery**.** It is well painted with Ndebele colours using a combination of both Kwamanala and Ndzundza styles of mural art. The art gallery serves multiple purposes. It has a range of cultural artefacts for exhibitions, is used to showcase and sell exhibited artworks and is used as a workshop for making cultural artefacts. The research site was chosen by WPB, who described it as convenient, comfortable, private, and free from disturbances. The yard has a big concrete wall with decorations similar to the art gallery.

Typically, focus groups are filmed and often observed by a researcher other than the moderator, whose objective is to study how the group interacts (Lokanath, 2016). During FGDs, the researcher observed the participants' body language, facial expressions, and how they responded to questions and completed the observation tool. FGDs were recorded, and a notebook was used to capture detailed discussion notes (cf. Appendix F and Q).

a) Issues or concerns in the collection using FGD and how they were mitigated

The following concerns were identified and addressed during data collection to ensure effective FGDs, which will produce valuable insights into the exploration of ethnomathematical approaches:

Group dynamics: Three participants dominated the conversation while the remaining three hesitated to speak up. Group members often accept the answers or responses of other participants (Akyıldız & Ahmed, 2021), and there is a limitation to exploring the complex ideas of individuals. The participants are affected by their peers as they would be in real life (Akyıldız & Ahmed, 2021).

To address this concern, clear guidelines for participation were established, such as mutual respect, active listening and open communication. An inclusive environment was ensured so WKH would feel comfortable sharing their thoughts. Equal participation from all participants was encouraged so that all perspectives could be heard.

Bias and social desirability: Participants felt pressured to provide socially desirable responses in front of others. The importance of honest and open discussions was emphasized in addressing this concern. Some women did not want to disclose their level of education to others. A questionnaire was used to ask them to express authentic responses (cf. Appendix: S).

Limited representation: Participants sharing similar age, gender, and socioeconomic status may be underrepresented in specific experiences being underrepresented.

Mitigating limited representation involved proactive measures to capture diverse perspectives effectively. This concern was addressed by the focus group's composition, which reflected the diversity of the target population. Participants came from different backgrounds and different socioeconomic statuses and had various levels of literacy, different ages and relevant characteristics related to the research topic (cf. Appendix: S)

Language barrier: Some participants did not know or understand English.

The language used within the village, which all participants understood, was utilized. Questions were translated into IsiNdebele, and participants were allowed to respond in their desired language: Isindebele.

Time constraints: FGDs were time-consuming, and covering all relevant topics within the given time was challenging.

Mitigating time constraints involved the following s strategies: A detailed agenda outlining discussion topics with time allocations was planned and adhered to. Controlled discussion, gently steering it back on track when it became too long, and relevancy was maintained to avoid wasting time on irrelevant issues. Time management tools were necessary, i.e., a clock and a timer to inform participants of the time remaining for each topic. WKH were encouraged to express their thoughts concisely and avoid repeating points made by others. Time was extended, and participants were given short breaks to refresh themselves and maintain focus throughout the discussion.

3.6.1.3 Participant observation

This study is located within an interpretive paradigm underpinned by observation and interpretation. Observation is conducted to collect information to be interpreted and make meaning of it (Antwi & Hamza, 2015). Observation must have a central focus because it is impossible to observe everything; if not, one's attention may shift between each observation and lose focus. Each observation should answer the following questions: "Who are you observing?" "What are you observing?" "Where is the observation occurring?" "When is the observation occurring?" "How is it occurring?" and "Why is it occurring as it does?" (Moser & Korstjens, 2018). He further indicated that the observation process involves three stages: descriptive, concentrated, and selective. Moser and Korstjens (2018) defined descriptive writing as monitoring everything that happens in the environment based on general enquiries, concentrated or focused observation as paying close attention to a specific situation over a prolonged period, during which particular characteristics come into focus and selective as implying a sharp concentration on a few issues.

This study used participant observation to conduct exploratory research. According to Moser and Korstjens (2018), in active involvement observation, the researcher has access to a specific setting to examine the research participants and can move around and view many different circumstances in depth; participation observation happens whereby one observes an environment in which they are not employed within it, whereby they are not part of the employees; however, allocated to conduct research at that particular context, it is used when the researcher is not connected to the study's setting.

Participant observation was chosen because it mainly aimed to collect first-hand information about the participants in their cultural context. In the context of the classroom, it may mean working with learners in the activities assigned to them, creating an atmosphere for in-depth investigation of a particular area or problem (Nkopodi & Mosimege, 2009:383), which is one of the forms of assessment in mathematics (CAPS, 2011:294). The purpose of using participant observation was to access an opportunity to get immersed in mathematics classrooms and observe teachers' interaction with learners using ethnomathematical teaching approaches. It ensured intense observation of learners' behaviour when engaged in learning geometry.

Participant observation enabled it to generate data from teachers, learners, and WKH and observe and learn things they might not have shared in the interview. It fostered a deep understanding of the participants' beliefs, practices, and interactions with ethnomathematical approaches.

As the participant observer during Grade 6 lesson observations, I assisted educators in controlling learners' informal assessment activities and in conducting item analysis focusing on errors committed by learners and their misconceptions so they could be given corrective support. I took detailed notes on interactions among learners and teachers for each of the five schools observed. An observation tool was completed for the five schools observed (cf. Appendix K to O).

In the participant observations with WKH, I was actively engaged in their activities through practice to understand the local perspective better. I observed participants' behaviour and interactions to understand them in their setting, compared what was said verbally with what they do in real-life situations, and recorded their interactions and behaviour. The observation tool was completed (cf. Appendix T), and notes were taken to capture conversations.

I took part in mural art and beadwork. It first started with demonstrations by WKH on how to do mural art and beadwork, and later, I was given a chance to practice what I observed. Through imitation, I drew sketches with a pencil and a ruler under their guidance. Teachings by WKH included drawing a straight line without a ruler, using estimation to draw regular and irregular shapes, using a feather and a brush to paint, etc. Beadwork training included estimating the number of beads to be used, sorting beads according to colours, and picking up beads individually to create the shape in a cultural artefact. As the participant observer, I also interacted socially with WKH outside the research environment in their traditional celebrations. I observed their use of cultural artefacts such as *Umlingagobe* (tears) (cf. Chapter 4).

a) Issues or concerns in the collection using participant observation and how they were mitigated

Using participant observation in this study was beneficial; however, several concerns arose during the research and proactive measures were taken to mitigate their impact.

Researchers bias: The presence and involvement of the researcher may influence participants' behaviour.

A reflexive stance of regular reflection on one's own bias and assumptions was adopted to address this. A critical open mind and objectivity in data collection and analysis was maintained.

Participants may alter their behaviour when they know they are being observed, leading to results that do not reflect their typical practices.

To minimize this effect, trust and rapport were established with participants, and the importance of natural behaviour was emphasized. Sufficient time was spent in the research setting to allow the participants to become accustomed to my presence so that the observation process could be normalized.

Some people may refuse to participate in the study (Ciesielska, Bostrom and Ohlander, 2018). Their wish was respected as a form of mitigation to the challenge experienced, and other participants were sampled.

3.6.2 Data collection process

The researcher was granted permission to conduct the research by the General Human Research Ethics Committee (GHREC) (cf. Appendix A), the District Office (cf. Appendix C), the schools and the WKH. Teachers, WKH completed the participant informed consent (cf. Appendix F). Parents of learners completed consent forms to allow their children to participate in the research study as minor participants (cf. Appendix G and H). The purpose of the research study was explained to the participants so they could understand what would transpire clearly.

3.6.2.1 Interviews with individual teachers and learners

Interviews with each of the five teachers took place at schools. Each teacher was interviewed at their own school. Four teachers selected unoccupied classrooms free from noise and disruptions whilst one used his office. Interviews with each teacher were held during free periods, guided by the school timetable, as per teachers' and Principal's requests. Interviews with each learner were done on the same date as the teacher but from 14:00 to 16:00 to avoid interrupting teaching and learning or disrupting classes. Learners were interviewed in the same venue used by teachers. Transport arrangements were made with parents of learners and teachers for the safety of learners, as most learners they walk with to their respective homes departed the school at 14:00 (cf. Table 4.2).

3.6.2.2 Lesson observations

Observations occurred in August after conducting interviews with each of the five teachers. Observations of teaching and learning were arranged with schools informed by their respective timetables. A plan to conduct lesson observation was developed and effectively implemented (cf. Table 4.5). Five lesson observations were performed; one lesson was observed n in each of the five schools. Observation tools were completed (cf. Appendix K to O). The timing of the lesson observations was perfect because the study explored ethnomathematical approaches in teaching and learning geometry in Grade 6, which was the focus for term 3. Teaching and learning were not interrupted. According to the Recovery Annual Teaching Plan (RATP), learners were taught properties of 2D shapes, 3D objects and transformation, which form part of the content area known as Space and Shape**.** Every term in the RATP has topics to be taught, which are not repeated within the terms as in time allocation CAPS (2011:212). Properties of 2D shapes and 3D objects appear in all the terms in CAPS and within term 3 of the Revised ATP. It was, therefore, convenient to conduct lesson observations according to schools' timetables during mathematics periods. The aim was to see how teachers and learners interact, using the Ndebele cultural artefacts to link mathematics done every day at home with mathematics in the classroom, identification of geometric and other mathematical concepts embedded in the Ndebele Cultural artefacts in the teaching and learning of geometry.

3.6.2.3 Individual interviews with Women Knowledge Holders

Individual interviews with WKH were held at different dates, times and venues as per arrangement with participants. Individual interviews with five WKH took place as follows: One woman requested to use one of the schools as her venue, which is close to her home. Two WKH were interviewed at the art gallery in Ga-Mabhoko, and the last two were interviewed at

Matempule in their own yard. Participants felt that their confidentiality was protected entirely within their chosen locations. The participants decided upon venues used and time for interviews. The program was developed based on the arrangements done. Each interview with WKH was allocated an hour (cf. Table 4.8).

3.6.2.4 Focus Group discussions and Participant observations with WKH

FGDs were conducted in a location that afforded participants maximum privacy. The critical informant decides the venue, is familiar with the local area, and is familiar with the cultural context (Mack et al., 2005). FGDs and participants' observations were held at Mabhoko village in Ms X art gallery. The data was collected in two separate sessions on the same day to accommodate the preferences of the WKH. The morning session was scheduled for FGDs from 09:00 to 11:00, while the afternoon session involved participant observations from 12:00 to 17:00. The WK Holders indicated that they had a lot of commitments and insufficient time; however, they made time available to participate. The researcher recorded the interviewees and took photos with their permission. The recorded clips were saved for transcription. Participants' responses were arranged into themes presented in the next chapter, Chapter 4.

3.7 Data Analysis

Creswell (2014) describes data analysis as an attempt to organize data collected in a systematic way whereby specific statements are analyzed and categorized into themes. Data analysis is used to locate, recognize, and interpret themes and patterns in qualitative data (Ogwu & Eze, 2023:30). I found thematic analysis to be highly appropriate and suitable to be utilized in the context of my study's underlying theoretical and paradigmatic assumptions. The study is located within an interpretive paradigm, which requires an inductive approach to analyse data, discover patterns, and collapse into themes to understand ethnomathematical approaches (Rehman & Alharthi, 2016). Thematic analysis would allow for data collected to be analysed in a way that respects and represents participants' accounts.

The study collected participants' views, knowledge and experiences of ethnomathematical approaches using interviews, observations and FGDs, which required thematic analysis to make sense of the data collected. Lorelli, Nowell, Norris, White and Moules (2017) and Braun and Clarke (2006) defined thematic analysis as a technique used to identify, analyze, organize and report recurring themes or patterns within data collected. Thematic analysis reports on experiences, meanings, and participants' reality (Braun & Clarke, 2006) and minimally organizes and describes data sets in detail. The codes and themes were developed from the data collected.

The thematic analysis offers several benefits, including the need for an in-depth understanding of theory. It is highly adaptable and can be adapted to the demands of various participants. Examining the views of several participants of the research study, identifying similarities and variations within the data collected, and creating unexpected discoveries are facilitated using thematic analysis. Lorelli et al. (2017) maintained that thematic analysis is especially beneficial for summarizing significant characteristics of a vast data set since it requires the researcher to adopt a well-structured approach to data processing, facilitating the production of a well-organized final report.

Data emerged from interviews, FGD, and observations, which were manually analysed through thematic analysis using the six steps outlined by Braun and Clarke (2006:87).

3.7.1 Step 1: Familiarization with the data

The first step in thematic analysis involves familiarization with data by the researcher, which begins by thoroughly reading the data collected. In this phase, the researchers must immerse themselves in and become intimately familiar with their data, reading and re-reading it, listening to audio-recorded data and noting observations (Baun & Clarke, 2006).

I listened to the audio tapes several times and transcribed data generated through interviews, observations and FGDs in full to understand how participants reacted to the research questions. Transcription was done immediately after every session. A repeated careful reading of the transcripts was made. Transcripts were checked against the recording for accuracy and to ensure the information was authentic and original. While reading the transcripts, I noticed that all exciting information was highlighted in different colours. The main aim of going through all the data in such a way was to become fully immersed in the whole data set and collect initial points of interest (Chamberlain, 2015). Interactive cycles of reading generated further insight with each cycle. Familiarisation with data is achieved through reading and re-reading the entire set of data (Maguire & Delahunt, 2017; Braun & Clarke, 2006).

3.7.2 Step 2: Generating initial codes

The second step in thematic analysis involves the production of initial codes from the data (Braun & Clarke, 2006), and coding involves systematically identifying interesting features of the data across the entire data set at different levels. Generating initial codes comes after familiarizing with the data collected.

All transcripts were coded after carefully reading them several times. Initial codes representing patterns in the data set were produced from the data collected and organized into meaningful groups. Each data item was given equal attention during the coding process. The codes in this study were words, phrases and sentences that capture the essence of a particular idea or concept. Several codes emerged, some containing just one phrase and others one or more sentences. Various potential and relevant phrases/sentences were highlighted using different colours corresponding to different codes to indicate potential patterns. Each code described the idea or feeling expressed in the text. Extracts of data were copied from individual transcripts. All actual data extracts were coded and collated together within each code. Codes gave me a condensed overview of the main points and common meanings that recurred throughout the data. Data extracts and codes were represented in a table to help me understand the nature of the data in the study.

3.7.3 Step 3: Searching for themes

The search for themes comes after developing data codes. A theme is a coherent and meaningful pattern in the data relevant to the research question. Similarity in the data is identified. The step suggested by Braun and Clarke (2006) began with a long list of codes identified across the data set. At this stage, I had a list of codes identified as suggested. The focus was on analyzing the codes, sorting, organising and combining them into potential themes. Because of the explorative nature of this study, it was vital for me to return and re-read all the transcripts before clustering codes according to themes. Transcripts were re-read, different codes were combined into themes, and all relevant coded extracts were collated within identified themes. Several codes were combined into a single theme; codes that were irrelevant enough and did not appear often in the data were discarded; other codes became themes in their own right. Similar codes were combined to generate potential themes (Ansari, Panhwar & Mahesar, 2016)

Concepts and issues identified in the literature review were also considered. I found that some themes from the literature review were meaningful, and some codes could be subsumed under them. The themes identified are presented in Chapter 4 of this study. The data from interviews with teachers, learners, WKH, FGDs and observations were presented separately, and the codes were grouped into themes. For example, the codes for the data generated from teacher interviews were grouped into three themes, each having sub-themes (cf. section 4.2.2.2; Table 4.2). The findings in Chapter 5 were also presented and discussed under the themes found in Chapter 4.

3.7.4 Step 4: Reviewing themes

All the themes were combined to refine initially grouped themes and present them more systematically. I checked the themes defined to see how well they support the coded data extracts and the entire data. A reflection was done to check whether the themes tell a convincing and compelling story about data, defining each theme and the relationships between themes. All themes and sub-themes were clustered to check whether they could form a coherent pattern. It occurred practically as Braun and Clarke (2006:87) indicated that it might sometimes be necessary to split themes into two or more themes or discard themes to start with theme development.

3.7.5 Step 5: Defining and naming themes

Define and refine means pointing out the essence of each theme (Braun & Clarke, 2006) and the aspect of the data each theme captures. Emphasis is on ongoing analysis to refine the specifics of each theme, generating clear definitions and names for each theme. Themes were refined by reading through all the main themes and sub-themes, codes and extracts, and a final name was assigned to each theme. Braun and Clarke (2006:87) further emphasized that the names given to the themes should be concise to allow the reader to understand them and provide a clear sense of what the theme entails and means.

A final list of themes named and defined was generated, and defining themes involved formulating precisely what was meant by each theme and how it helped to understand data. I came up with an easily understandable name for each theme; for example, I looked at the name cultural object and decided to change it to cultural artefact, ethnomathematics approaches changed to ethnomathematical teaching approaches with the support, guidance and interaction with my supervisor.

3.7.6 Step 6: Writing up

Write-up is the last step of thematic analysis (Braun & Clarke, 2006). Braun and Clarke (2006) state that a thematic analysis report must convince readers of the merit and validity of the analysis. Producing a report is an integral element of the analytic process. I started with the writing process in phase one while taking notes of ideas and potential coding throughout the analysis. It involved weaving together codes, themes, and extracts from the original data that illustrate the findings and literature review, citing other previous research that helped frame the research question. Areas for future research that the themes support and which came to light during the research process were suggested.

3.8 Data Interpretation

Qualitative data analysis is based on an interpretative philosophy examining the meaningful content of qualitative data. It tries to establish how participants make meaning of the specific phenomenon by analysing their perceptions, attitudes, understanding, knowledge and experience (Maree, 2013). Data collected was interpreted to make sense of it, and patterns and themes were identified. The detailed process involved analysing data to identify relationships, trends and correlations, identifying patterns and themes from the data, and assigning meaning, considering the research context and the literature reviewed. Conclusions were drawn based on the data and interpretations.

3.9 Quality Criteria

Trustworthiness and credibility are vital considerations (Antwi & Hamza, 2015) and fundamental criteria for qualitative reports.

The interview schedule for teachers, learners WKH, observation schedules for lesson observations and WKH, and FGDs topics/questions were submitted to the Supervisor for his expert guidance, valuable feedback and validation. His input helped ensure they were clear and aligned to the research topics.

To determine whether the interpretation and meaning of the data collected were accurate and mutual, I interviewed participants using semi-structured interviews and open-ended questions, conducted observations and then compared the information articulated by participants. Draft of reports compiled were given to individual participants to check for elements of accuracy. I conducted follow-up interviews to validate the data collected. Participants' language and accounts were used verbatim with quotations to ensure validity. Patton (2002) asserts that triangulation within qualitative inquiry can be acquired through combining interviews and observations.

Lorelli et al. (2017) maintain that trustworthiness ensures that researchers and the public recognise and understand our findings as legitimate.

The study was located within the interpretivist paradigm, which uses the four criteria of trustworthiness and authenticity (Kivunja & Kuyini, 2017:34). Lincoln and Guba (1985), as cited by Lorelli et al. (2017) introduced the criteria of credibility, transferability, dependability and confirmability to refine the concept of trustworthiness, Rehman and Aharthi (2016) to judge the trustworthiness of interpretive research. According to Lorelli et al. (2017), quality criteria were applied in carrying out this study to ensure trustworthiness, as presented in the following sub-sections.

3.9.1 Credibility

Credibility is used in research within the interpretivist paradigm, referring to the extent to which data and data analysis are believable, trustworthy or authentic Guba (1991) as cited by Kivunya and Kuyini (2017). According to Stahl and King (2020), credibility is determined by the consistency of the results with reality in qualitative research. Credibility addressed the correlation between respondents' views and the researcher's representation of them. It determined whether the research study's findings were correct and accurate to the data collected.

Lorelli et al. (2017, citing Lincoln and Guba, 1985) state that there are several ways to address credibility, such as prolonged engagement, persistent observation, data collection triangulation, peer debriefing to provide an external check on the research process, referential adequacy as a means to check preliminary findings and interpretations against the raw data, member checking to test the findings and interpretations with the participants. As the participant observer, I spent a significant amount of time in the schools and at art galleries, consistently interacting with the participants to gain a deep understanding of the participants and to collect rich and detailed information to help answer the research questions.

Similarly, Stahl and King (2020) elaborated that numerous triangulation procedures are one way to increase trustworthiness in qualitative research. Triangulating refers to using many sources of information or procedures from the field to develop repeatable patterns (Stahl & King, 2020). In this study, credibility was achieved using multiple data sources. Data was generated from WKH, teachers and learners from each of the five schools sampled, and this allowed for a deeper insight into ethnomathematical approaches in the teaching and learning of Grade 6 geometry. Cohen et al. (2018) argued that methodological triangulation involves using different methods on the same object of study. Methodological triangulation included semi-structured interviews, lesson observations, FGDs and participants' observations to gather diverse perspectives and cross-validate the findings.

Credibility was achieved through purposive sampling; participants with diverse experiences could provide in-depth insights, perspectives and targeted information aligned with the study's objectives. Peer debriefing was done by discussing the research process, findings and interpretations with colleagues and other mathematics teachers. Their inputs helped identify biases and offered a fresh, objective perspective to the study. Reflecting on my own biases, assumptions, and preconceptions throughout the research process and how they might have influenced my findings led to a more objective and unbiased approach. They enhanced the credibility of the research study. Member checking was also conducted. The study findings were shared with participants, and I requested their input and feedback. This process allowed participants to validate the accuracy of interpretations and ensured that their voices were accurately represented.

Thick descriptions provided detailed and rich descriptions of the research context, methodology and findings, allowing the readers to assess the trustworthiness of the research. Data was collected until saturation was reached, where new data no longer provided significant insight. The research topic was thoroughly explored to increase the credibility of the findings.

3.9.2 Transferability

Thick descriptions of the setting, organizations, and significant research participants are included in transferability, along with any participants who could not participate for different reasons. Still, they would have impacted the data-collecting process and the length of the field study (Stahl & King, 2020). Transferability refers to the extent to which the study results are applicable and can be transferred to other contexts, situations, settings, or research participants (Korstjens & Moser, 2018). According to Lincoln and Guba (1985), cited by Kivunya and Kuyini (2017), transferability concerns researchers' effort to provide detailed contextual information on the research, allowing readers to relate findings to their own context.

The transferability of this study was enhanced by providing complete descriptions of ethnomathematics and ethnomathematical approaches, the participants involved in the research and how they were included (inclusion criteria), details regarding the context, the setting, the geographic location of the study were explained in-depth, the cultural background of participants and the educational or school context was presented. Detailed descriptions of the research methods, such as the data collection techniques (interviews, observations and FGDs) and data analysis procedures (thematic analysis), were provided.

Triangulation enhanced the credibility and transferability of the findings. Triangulation of data sources included collecting data from different sources using different data collection methods to improve the transferability of findings. Member checking was used as a collaborative approach. It enhanced the research's trustworthiness and increased the potential transferability of the findings. I acknowledged limitations or constraints such as sample size, research duration, specific contextual factors, how they impacted the transferability of the findings and suggested areas for future research. All of the above-mentioned aspects increased the transferability of exploring ethnomathematics in the teaching and learning of geometry, enabling other researchers to apply and adapt the findings in different educational settings and cultural contexts. The generalizability of an investigation is referred to as transferability (Lorelli et al., 2017). The results may be generalized to all schools and all learners within Ekosini village, which is the population as a whole, or readers may transfer the results to their own situation. The appendices include documents such as interviews and observation schedules used in the study to generate data.

3.9.3 Dependability

Dependability refers to the ability to observe the same outcome under the same circumstances (Guba, 1991, as cited by Kivunya & Kuyini, 2017). Dependability is directly linked to reliability. It refers to the extent to which the research study could produce the same findings when repeated by a different researcher. A detailed description of the research methods used to achieve dependability was given. Dependability was established through triangulation and member checks (Korstjens & Moser, 2018), triangulation of research instruments, and peer participation in data analysis. Researchers may ensure the study process is rational, traceable, and thoroughly recorded to attain dependability (Lorelli et al., 2020). Repetition was done with raw data, such as interviews, to identify similarities in data collected to improve the research findings and verify that findings are consistent with the raw data collected. Dependability was deemed necessary because it assisted in ensuring that the research findings were consistent.

3.9.4 Confirmability

According to Stahl and King (2020), confirmability refers to the existence of objective reality. Confirmability is concerned with proving that the researcher's interpretations and findings are derived directly from the data collected. Lorelli et al. (2017) assert that it emphasizes explaining how the researcher has reached conclusions and interpretations. It is about the extent to which others can confirm the research study's findings to minimize bias from data collected, for the findings to be the results of participants' experiences and ideas and not the researcher's preferences. The researcher needs to demonstrate that the data collected and interpretations of findings represent participants' responses during data collection. In this research study, the researcher ensured confirmability through direct quotes, recordings, notes, transcripts of interviews, and videos, which are kept safe for future reference.

In addition, Lokanath (2016) said that they may be used to extend, qualify, or query information collected via other methods.

3.10 Limitations of the Study

A limited number of participants may not be representative of the broader population. The study was conducted with five teachers, ten learners and nine WKH, limiting the generalisation ability.

3.11 Ethical Considerations

Ethical consideration relates to moral standards that the researcher should consider in all research methods and stages. Ethical considerations focus on four principles: privacy, accuracy, property and accessibility (Kivunya & Kuyini, 2017).

a) Privacy

The information given by participants about themselves, conditions and safety under which data will be gathered and analysed were considered. Participants were not forced to reveal information unprepared to share (Kivunya & Kuyini, 2017). Privacy included protecting personal information and ensuring confidentiality for participants involved in the study, as well as legal obligations to safeguard the privacy of individuals.

b) Accuracy

The principle of accuracy is about the authenticity and accuracy of information collected. Cross-checking participants during data collection ensures that data has been captured correctly (Kivunya & Kuyini, 2017). Data was accurately collected, analysed and interpreted to ensure the findings were presented honestly and transparently.

c) Property

This principle is about the owner of the data collected (Kivunya & Kuyini, 2017). Ownership of research data included determining who holds the rights to data collected or generated during the study and how it can be used or shared.

d) Accessibility

Accessibility is all about people who can access data collected, safe keeping of data collected and conditions of access (Kivunya & Kuyini, 2017). The research process, findings and outcomes are accessible to all people in alternative formats for written presentations

3.11.1 Ethical approval and access to participants

An application to conduct the study was done and submitted to the Research Ethics Committee at the University of the Free State (UFS). Approval was obtained on the 28th of February 2022 from the General Human Research Ethics Committee to conduct the study before data collection. Upon approval of the UFS Ethics Committee, I applied to request permission to access schools from the Nkangala District Office. Permission was granted from the District Office. A letter was written to the circuit manager and schools requesting permission to access mathematics teachers, mathematics lessons and Grade 6 learners. District approval was attached to the letter and submitted to the circuit office, schools and parents of learners, including WKH.

The circuit manager, school principals, and WKH permitted me to conduct the study. Each individual teacher from the five participating schools and the WKH were informed about the purpose of the research and the data-generating methods. Participants were given written information regarding the study, their rights, and their consent forms. Parents of learners were invited to a meeting to explain the research purpose, and data collection procedures were presented to them as well. The consent form was explained to the participants. Each of them was given the consent form to sign. Parents of learners also signed to allow their children to participate in the research study. Participants were treated with respect and dignity.

3.11.2 Informed consent

Participants were informed of the potential risks and benefits, ethical considerations, purpose, procedures, and their rights to enable individuals to make a voluntary and knowledgeable choice. They were provided with detailed information to ensure that they clearly understood the research project and could make an informed decision about whether to participate. This allowed participants to weigh the potential benefits against the possible risks and decide if they were comfortable and willing to participate in the study. Ultimately, it promoted transparency and respect for autonomy and protected participants' rights and well-being.

Parents /guardians of Grade 6 learners participating in the study were given information similar to that of other participants. The parent-guardian understood and consented to their children participating. They were given forms to sign to permit learners' participation. Learners were informed of the nature and aim of the study and their rights as participants. Learners were given a letter of consent to sign as evidence that they agreed to participate in the study. A clear explanation was given to all regarding their rights, such as the right to withdraw from the research without penalty being administered. The right to full disclosure was explained to the participants. The researcher thoroughly explained the nature of the research, the aim and purpose of the study, data collection tools and strategies. The right to privacy was also presented. Participants were assured that their real names would not be disclosed to protect their identity. Anonymity and confidentiality are upheld. They obtained an assurance that the data collected would be kept safe and that people not part of the research study would not access it except my supervisor.

Participants were allowed to ask questions for clarification regarding detailed information about the research study. All participants agreeing to participate were then given consent forms to sign as an assurance of a given consent to participate in the study.

3.12 Conclusion

Chapter 3 presented a comprehensive overview of the research methodology, design, philosophical underpinnings, and sampling strategies. It described the research paradigms, data collection techniques, and how they were constructed and implemented. Furthermore, the chapter outlined the thematic analysis approach used for data analysis and addressed the issues of trustworthiness and ethical concerns.

CHAPTER 4
PRESENTATION OF THE RESULTS

4.1 Introduction

This study explored ethnomathematical approaches in the teaching and learning of Grade 6 geometry to determine mathematical concepts found in the Ndebele cultural artefacts, which can be used to aid learners understanding. The main research question in this study was: *how can ethnomathematical approaches be used in the teaching and learning of Grade 6 geometry?* To respond to the main research question, the study sought to address the four research objectives relating to the sub-research questions, which are as follows:

- To explore the experiences of Grade 6 teachers in using ethnomathematical approaches to teaching geometry.
- To investigate the Ndebele cultural artefacts that can be used to teach geometry in Grade 6.
- To determine the mathematical concepts found in Ndebele cultural artefacts that may be used in the teaching and learning Grade 6 geometry.
- To explore using mathematical concepts found in Ndebele cultural artefacts in teaching Grade 6 geometry.

Chapter 3 provides an explanation and discussion of the research methodology and design used in the research study. A detailed description of the data sources and data collection methods to collect in-depth data to answer the research questions was also given.

The focus of Chapter 4 is on the presentation of the results. The results will be presented in three sections. The first section presents data from interviews with teachers, learners, and lesson observations. The second section of Chapter 4 presents data generated from interviews with WKH, the third section presents data generated from FGDs with WKH, and the fourth section is on participant observations with WKH.

The school principal of each of the five schools was requested to arrange a meeting with the parents of each of the sampled learners. The purpose of the meeting was to inform parents about the research study, provide their consent for their child's participation, collaboration, and engagement, and ensure transparency.

Table 4.1: Dates of meetings with parents of learners

Parents of learner(s)	Date
LA & LB	23/05/2022
LC & LD	24/05/2022
LE & LF	25/05/2022
LG & LH	26/05/2022
LI & LJ	27/05/2022

During the meeting with the parents of learners, the research purpose, procedures, and potential benefits were explained so that parents could make an informed decision. Parents, learners and teachers were informed that pictures would be taken during the interviews and lesson observations. Parents and teachers signed the consent forms on the meeting date (cf Appendix: F) for parent/guardian informed consent and (cf. Appendix G) for participant informed consent signed by teachers. Learners signed the child assent form (cf. Appendix H)

Table 4.2: Programme of interviews with teachers and learners

PROGRAMME OF INTERVIEWS	**Teachers**	**Date**	**Learners**	**Date**
	TA	10/06/2022	LA & LB	10/06/2022
	TB	13/06/2022	LC & LD	13/06/2022
	TC	14/06/2024	LE & LF	14/06/2024
	TD	15/06/2022	LG & LH	15/06/2022
	TE	24/06/2022	LI & LJ	24/06/2022

The interview process was more relaxed and casual, resembling regular conversations rather than formal question-and-answer sessions. The aim was to create a comfortable environment for the interviewees, allowing for more open, authentic, and productive discussions. Creating a relaxed and informal environment helped put the participants at ease and reduced nervousness or anxiety, leading to more genuine and authentic responses. Participants were free to share their thoughts, perceptions and experiences, allowing them to feel more relaxed, be themselves and produce more genuine responses.

The participant's body language was observed. It was essential to observe body language during the interviews using ethnomathematical approaches. Body language was observed to note non-verbal cues, emotions, attitudes, and the level of participants' engagement. Body language provided non-verbal cues that complemented the participants' verbal responses, revealing additional information that may not be explicitly stated, such as confidence, enthusiasm, or signs of discomfort.

The study's objectives were reviewed before the interview was conducted to help the researcher formulate follow-up questions during the interview. Data was collected through individual interviews with five teachers, each of the ten learners and the five WKH. FGDs were held with six WKH. Interviews were recorded.

4.2 Presentation of Results

The study used semi-structured interviews to generate data from teachers, learners and WKH. Participant observations were used to collect data from lesson observations and a team of WKH. FGDs were held with WKH only. I opted for semi-structured interviews because they offer flexibility in the questioning process, allowing for a more comprehensive exploration of the topic. Semi-structured interviews allowed the researcher to have detailed, in-depth conversations with participants. This form of interviews enabled one to understand the cultural and social aspects that influence the teaching and learning of geometry.

Participant observations were chosen because they were relevant and valuable to enable immersion in the learning environment, observation of the dynamics and interactions during geometry lessons, and provide an in-depth understanding of how ethnomathematical approaches are implemented and their impact on learning outcomes. Using participant observations with Women Knowledge Holders was critical to addressing the inclusive perspectives, promoting gender inclusivity, and allowing for enhanced learning outcomes and cultural relevance.

The first section of Chapter 4 is on results generated from interviews with teachers, interviews with learners and lesson observations. The results from lesson observations are organized into I, Learning content ii, using Ndebele cultural artefacts, iii, Learner participation, iii, and learner assessment.

The second section presents the results of interviews with WKH. The results are generated from data based on WKH's knowledge, views, experiences, and skills on the Ndebele cultural artefacts and how they can be shared with learners and teachers to improve teaching and learning geometry. The results were organized according to themes.

The third section presents data generated from FGDs with WKH and participant observations.

4.2.1 Interviews with teachers

This section presents the study results generated from semi-structured interviews with teachers. The section starts by presenting participants' information. The themes identified will be discussed.

Interviews were conducted with each of the five Grade 6 teachers. Participants were Mathematics teachers teaching Grade 6 in the five schools sampled. All teachers interviewed belong to the Ndebele culture; all spoke Isindebele and live within the Ndebele community. The researcher aimed to have equal representation of gender to determine the level of knowledge involvement between men and women based on the literature review conducted. However, it was found impossible to implement gender equity in teacher sampling due to the schools' allocation of subjects. Five teachers interviewed were all males. Males are placed at the exit grade(s) and females at lower grades as per schools' timetables. The reason given by the principals of the sampled schools was that experience taught them that female teachers can work better with learners in lower grades. Secondly, all schools identified had one Grade 6 class and one mathematics teacher for Grade 6.

Each teacher was given a pseudonym for identification. Pseudonyms were allocated to adhere to the ethical issues and to protect participants' privacy. Teachers were assigned pseudonyms based on the order in which they were interviewed using letters of the alphabet and the letter T representing 'teacher'. The first teacher who was interviewed is referred to as Teacher A (TA), the second teacher is Teacher B (TB), the third teacher is Teacher C (TC), the fourth teacher is Teacher D (TD), and the fifth teacher is Teacher E (TE). Four teachers, i.e. TA, TB, TD and TE, requested not to appear in the pictures for their own personal reasons. Teachers' preferences for not being included in research photographs were honoured. RQ represents the researchers' question in the report.

Each one of the five teachers was interviewed for a period of 50 to 60 minutes. Interviews were conducted with each of the five teachers on different dates at their own schools, and their responses were recorded and organized under respective themes. Data was collected during June (cf. Table 4.2). Interviews assisted in obtaining a deeper understanding of teachers' views and experiences on using Ndebele cultural artefacts to teach geometry.

Probing was utilized to go beyond surface-level responses. Follow-up questions were asked to seek clarification or more information, encourage reflection and elicit specific examples, such as *Can you give an example? What do you mean?* Teachers were encouraged to elaborate when responding to questions to delve deeper into their experiences, beliefs, practice and understanding of ethnomathematical approaches and geometry. The presentation used Direct participant quotations as raw information to give in-depth, detailed descriptions of teachers' viewpoints (cf. Appendix I).

Teachers' interviews were audiotaped and transcribed verbatim. I familiarized myself with the data collected by reading and re-reading transcripts and presenting transcriptions of verbal data from interviews in written form. Patterns were searched across the entire data set. Sentences describing similar ideas were highlighted and given codes. Initial codes were generated for data collected by grouping similar items. Codes were then organized to see the relationship across the data and between the participants. Several related codes across the data set were combined to make up themes and sub-themes. The themes and sub-themes that emerged are presented in Table 4.3 below.

Table 4.3: Themes and Sub-themes

THEMES	SUB-THEMES
Ethnomathematical approaches	❖ The teachers' use of ethnomathematical approaches ❖ Grade 6 teachers' experiences with using ethnomathematical approaches in the teaching of geometry
Ndebele cultural artefacts	❖ Teachers' knowledge of different Ndebele cultural artefacts ❖ Ndebele cultural artefacts that can be used to teach Grade 6 Geometry ❖ The link between Grade 6 geometry and Ndebele cultural artefacts ❖ Grade 6 geometry concepts and skills that can be developed using Ndebele cultural artefacts ❖ How can Ndebele cultural artefacts be used to aid learners' understanding of geometry
Mathematical concepts and skills	❖ Mathematical concepts found in Ndebele cultural artefacts ❖ Mathematical skills found in Ndebele cultural artefacts ❖ Using mathematical concepts and skills to teach Grade 6 Geometry ❖ Importance of using mathematical skills and concepts in Ndebele cultural artefacts in the teaching and learning of geometry

4.2.1.1 Ethnomathematical approaches

The theme of ethnomathematical approaches captures the teachers' experiences using ethnomathematical approaches to teach Grade 6 geometry. To explore teachers' experiences, the researcher asked if they had ever used ethnomathematical approaches to teach geometry in Grade 6. I further requested that if their response is yes, they must explain in-depth where and how they used them. If the response was No, they were asked to explain why they did not use them.

4.2.1.1.1 The teachers' use of ethnomathematical approaches

Participating teachers expressed unfamiliarity with ethnomathematics and ethnomathematical approaches, and subsequently requested clarification on the concept. Firstly, I explained the concept of ethnomathematics to each of the five teachers interviewed using information from

(D'Ambrosio and Gerdes) on the definition of ethnomathematics. I emphasised the significance of ethnomathematics, mathematical practices in cultures using relatable examples of ethnomathematics in action, such as traditional geometry in African textiles, and real-world applications showcased that ethnomathematics is the field of study that explores the relationship between mathematics and culture. I further explained to teachers that ethnomathematics recognizes that mathematical knowledge and practices are not confined to formal academic settings but are also present in various cultural contexts, including Indigenous communities, to challenge the notion that mathematics is a universal and objective discipline. I highlighted that mathematical concepts are examined within their cultural contexts in ethnomathematics to determine how knowledge is transmitted, used, and applied in cultural communities. The ethnomathematics field stresses the importance of integrating culturally relevant mathematics education in schools.

Secondly, the importance of incorporating ethnomathematical approaches in the teaching and learning of geometry was explained, such as ethnomathematics helps learners to develop a deeper understanding of geometry by connecting mathematical concepts to cultural and real-life contexts, enhanced learner engagement, a more profound understanding of concepts and improved problem-solving skills.

Thirdly, I briefly shared examples of mathematical practices related to geometry, focusing on how geometry is used in cultures and the traditional weaving patterns of Indigenous communities.

After my explanation, three (3) teachers, TA, TB, and TC, said yes; however, they did not know they were using ethnomathematical approaches. Two (2) teachers (TD & TE) said No even after the researcher explained the concept. All the teachers participating in the study indicated that they were hearing the concept for the first time.

RQ: Have you ever used ethnomathematical approaches to teach Grade 6 geometry?

a) **If you have used them, where and how did you use them?**
b) **If no, why did you not use them?**

TA: *I would say Yes, based on the explanation given on ethnomathematical approaches but I did not know that I am using the ethnomathematical approaches.*

The researcher's follow-up question: Can you explain where and how you used the ethnomathematical approaches?

TA: *I used it at Mabhoko Primary School when doing my work integrated learning; I tried to use the Ndebele painting as my teaching aid when teaching lines of symmetry.*

TB: *I can say yes as per the explanation given on ethnomathematical approaches, although I was unaware I once used bracelets and bangles here at school during this current term (term 2) to teach learners geometric patterns.*

TC: *Yes, here at school, last year whilst I was teaching properties of 2 Dimensional shapes and 3 Dimensional objects. I used necklaces and bangles.*

Researchers' follow-up question: Why did you use ethnomathematical approaches? Can you share your reasons? What was your aim?

TA: *To make learning concrete.*

TB: *For learners to understand geometry with using concrete objects.*

TC: *For learning to be concrete and not abstract.*

The three teachers who responded 'yes' said they used Ndebele painting, bangles, bracelets and necklaces as concrete objects for meaningful learning. None of them mentioned connecting or relating mathematics in culture to mathematics in the classroom using Ndebele cultural artefacts.

TD and TE shared similar responses that the resources are unavailable within the school. TD further indicated that it might be challenging to borrow resources from community members as they may be afraid they might get lost.

TD: *No, I don't have resources nor knowledge on how to use them to teach geometry.*

TE: *I have never used them before and am hearing the concept for the first time. I do not know how to use the ethnomathematical approaches, and even if I were trained, it was still going to be a challenge because the cultural artefacts are not readily available, they are expensive to buy unless we borrow them from parents, and it might be not possible because some will not agree for safety reasons.*

Researchers' follow-up question. Why did you not make use of ethnomathematical approaches?

> TD: *I could not make use of ethnomathematical approaches because of a lack of knowledge of ethnomathematics. I was never trained in ethnomathematical approaches, and the resources are not available.*
>
> TE: *I do not know how to use cultural artefacts and have never thought of using them to teach Mathematics. I was never trained on using ethnomathematics to teach geometry.*

Researcher's follow-up question: What do you think should be done to help you with ethnomathematical approaches?

> TD: *I need in-service training focusing on ethnomathematical approaches. We must be trained on the different cultural artefacts and how to use them to teach geometry.*
>
> TE: *Training on what ethnomathematics is, the ethnomathematical approaches, and the resources; the school must make resources available for us to use.*

TD and TE shared a common concern about their limited knowledge of ethnomathematical approaches, which they recognize as an essential and valuable tool to deliver content to learners,; however, due to a lack of training and resources, they have been unable to utilize the approaches effectively. They urge the department to offer resources and training to bridge this gap and enable them to integrate ethnomathematical approaches into their teaching practice.

4.2.1.1.2 Grade 6 teachers' experiences in using ethnomathematical approaches in the teaching of geometry

Each teacher was asked about their experiences on using ethnomathematical approaches in the teaching of Grade 6 geometry. Two teachers (TD and TE) said they have no experience using ethnomathematical approaches as they have never used them.

> TA: *It was interesting to Introduce my lesson of symmetry, trying to teach from the known to the unknown, to make learning concrete, interesting and meaningful, connecting them to their cultural practices, which have mathematics embedded in them. Learners can connect mathematics in everyday activities to mathematics learned at school. There was increased learner involvement or participation.*

TB: *I have limited experience with ethnomathematical approaches as I used the beads two times, but what I can say is that my learners demonstrated enjoyment, active involvement and understanding because they could remember the content learnt; it eliminates rote learning and teaches learners how to solve problems in context. It further brings about increased parental and community involvement brings about strong relationships between the school and parents of learners as we have to work together as partners in the education of learners.*

TC: *Lesson was interesting and meaningful. It helps learners to be creative, encourages them to explore more and think broadly and independently to be organized, brings about conceptual understanding, enhanced critical thinking skills and problem-solving skills. It encourages teamwork with the community and parents of learners as we have to borrow the cultural artefacts from them. Currently, we have a strong relationship with Dr Esther Mahlangu because our learners usually visit her art centre.*

Three teachers (TA, TB, TC) expressed that they found it fascinating to incorporate cultural artefacts into geometry lessons, noting that learners were fully engaged and enthusiastic and able to connect mathematical concepts learned at school in a formal context to their own cultural experiences at home, thereby making the learning experience more meaningful and interactive.

TC indicated that his school works closely with Dr Esther Mahalngus' Art Centre because the centre is not far from the school. Learners visit the centre to learn Ndebele painting on Saturdays or afternoons after school hours. He recalled that the school received a generous donation of R7500 from Dr Esther Mahlangu and that the art centre provides informal education.

4.2.1.2 Ndebele cultural artefacts

This theme captures teachers' knowledge of different Ndebele cultural artefacts and their ability to identify those that can be used to teach Grade 6 geometry. Teachers were also asked to discuss the link between Grade 6 geometry and Ndebele cultural artefacts. To explore the relationship further, the researcher asked teachers to describe the Grade 6 geometry concepts that can be taught and skills that can be developed using Ndebele cultural artefacts. Teachers were also asked to explain how they could use Ndebele cultural artefacts to aid learners' understanding of geometry concepts and skills.

4.2.1.3 Teachers' knowledge of different Ndebele cultural artefacts

Teachers' knowledge of the names of different Ndebele cultural artefacts differed. Some mentioned similar items, whilst others came up with various names altogether, which other teachers never mentioned. For example, similar items TA, TB and TC mentioned are Segoloane, beaded hoops, and beaded headband. TC and TD noted *Umlingakobe* [tears]. TA and TD mentioned *Umkhala* [beaded headband)]

RQ: What are the different Ndebele cultural artefacts that you know?

> TA: *Dancing Stick (Isitjhingwana), Umkhala* [beaded headband], *isirholwani* [beaded hoops and bracelets].
>
> TB: *We have thick beaded necklaces, long beaded neck hoops, headbands, and bracelets.*
>
> TC: *Ahhh! They are so many. Beaded ostrich egg, we have Iphotho* [beaded apron] *worn by women. Umlingakobe (tears), worn on the head by women when dancing during initiation of their sons, has two long sides (tails) decorated with 2D shapes. Two long tails symbolize tears, and they are crying for their sons to come back from initiation school; when it is over, they are no more wearing it. Iporyana* [a breastplate or traditional bib for men] *is worn by men on their chests during cultural ceremonies. Iporyana is made of animal skin cuttings that are polygons.*
>
> TD: *Umlingakobe* [tears], *beaded angle hoops, Umcala* [beaded headband], *Inyoka* [snake long], *ibhetji* [apron] *rope of honour which is a tie. Cultural utensils that are beaded, such as Isikurwani* [small calabash]*, Ostrich egg, Ikhapo* [small calabash], *Clothes with beads, Inaga* [skin worn by men cut in an oval shape].
>
> TE: *isirholwani* [beaded hoops]*, Ibetjha* [apron], *izipha* [beads] *for boys from initiation, Imrivathi* [beaded necklace] *for girls, Iphotho* [beaded apron]*, impalapala* [trumpet].

4.2.1.3.1 Explanation and pictures of some of the Ndebele cultural artefacts referred to by teachers

The following section presents a selection of Ndebele cultural artefacts referenced by teachers, accompanied by explanatory notes and images. I provided a brief explanation or description for each cultural artefact, information on materials used, craftsmanship and production, insights into its purpose or significance, people using or wearing it, and details on its geographic origin and accessibility. This comprehensive presentation aims to equip readers with a deeper understanding of the cultural artefacts, their importance and relevance to teachers' discussions and ethnomathematical study.

Figure 4.1: ***Iporiyana*** **[breast plate or traditional bib for man] (Sourced: Pinterest)**

Iporiyana is a traditional bib worn by male adults. It is also known as the breastplate, a clothing for men. It hangs from the neck. *Iporiyana* is made from animal skin and decorated with beads around the top. It is given to a young boy from initiation by his father as a symbol of manhood.

Figure 4.2: ***Impalapala*** **[trumpet] (Sourced: Pinterest)**

Impalapala is a trumpet blown by women to make a sound/noise during the Ndebele ceremonies or traditional celebrations.

Figure 4.3: ***Iphotho*** **[beaded apron] (Sourced: Pinterest)**

Iphotho is a beaded apron that covers the front part. It is worn by married women only. It is made of predominantly white beads. Blue and red beads were used for decoration, forming geometric shapes. The cultural artefact was found to be one of the fast-selling products in the W3 Art Gallery in Troya (GaMatempule) Mpumalanga Province.

Figure 4.4: ***Imrivathi*** **[beaded necklace] (Sourced: Pinterest)**

Imrivathi are colourful beads worn by the girls on the neck.

Picture 4.5: ***Inyoka*** **[Snake long beads] (Sourced: Kghodwana)**

Inyoka is a snake long beads/beadwork train worn by assigned women during the wedding.

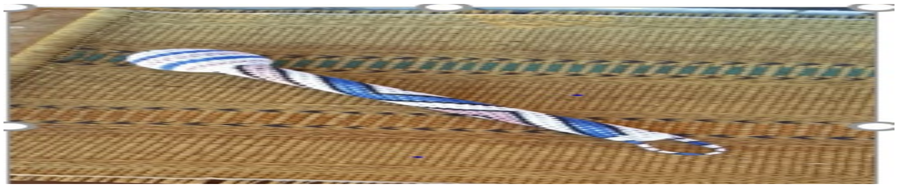


Figure 4.6: ***Isitjhingwana*** **[dancing stick]**

Isitjhingwana is a traditional beaded stick used for dancing. It is held up by married women when performing their traditional dances. It can be given to people as a gift and be used for decoration. The traditional dancing stick was found in the W3 Art Gallery, available at W2 Gallery and Kghodwana Cultural Village.

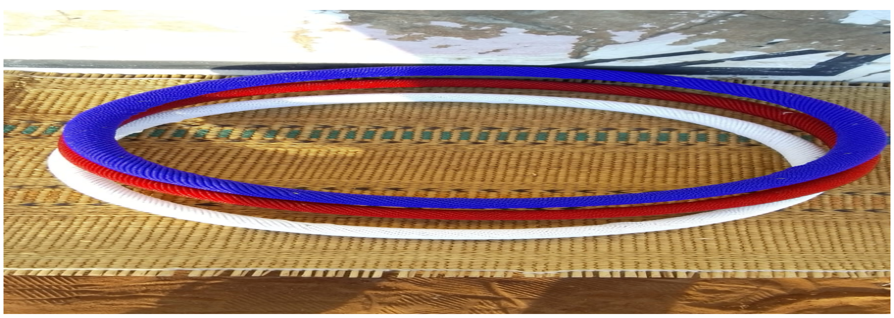


Figure 4.7: Isigolwani [Circular Waist hoops]

Married women wear hoops of dried grass twisted into a coil and covered with beads using substantial cotton and a needle. They are worn during ceremonial occasions. There are four types of circular hoops, i.e. i.) the arm hoops, ii.) neck hoops, iii.) and waist hoops, iv.), leg hoops. The Ndzundza and Manala circular hoops are different in thickness and colour. The pictures of hoops in this context belonged to the Manala tribe and were found in W3 Art Gallery.

Figure 4.8: Type of Grass used and *isigolwani* [circular beaded leg hoops]

The colourful circular beaded leg hoops are made by binding soft grass into a hoop tightly with strong cotton and covering it with beads. One or the same colour is used for each single bangle. The amount of grass and beads to be used is estimated. The hoop is boiled in sugar water and left in the hot sun to dry for a few days to preserve the grass and to enable the hoop to retain its shape and hardness. Eleven circular beaded leg hoops are worn on each leg, and as such, 22 circular beaded leg hoops are required for both legs. They were found in the W3 Art Gallery.

Figure 4.9: *Isirholwani* [Thick circular beaded Ndebele hoops] (Sourced: Pinterest)

Isirholwani, thick circular beaded Ndebele hoops above were made of grass and embroidered with beads. They are worn on the arms, legs, neck and hips. The hoops are worn by women belonging to the Ndzundza tribe. Maidens wear four in each leg, while married women wear two.

Figure 4.10: ***Isikurwana*** **[small calabash] (Sourced: Pinterest)**

A suitable calabash is selected from the garden and cleaned thoroughly; seeds are removed from its inside and soaked in water for some days to be soft. A sharp knife or sharp object removes the outer green layer, creating a smooth yellowish surface; the calabash is now shaped to the desired shape and allowed to dry. Small Calabash can be used to carry food or for decoration.

Figure 4.11: ***Inaka*** **[traditional blanket]**

The man is wearing *Inaka*, a traditional blanket of animal skin wrapped around his shoulders and *Iporiyana* on his chest. According to W3, men wear this attire during the King Makhosonke II KwaMjekejeke ceremony. Cultural artefacts can be found in the W3 Art Gallery, Troya (Ga-Matempula), Mpumalanga.

4.2.1.3.2 Ndebele cultural artefacts that can be used to teach Grade 6 geometry and their advantages

The interview excerpt below reflects teachers' views concerning Ndebele cultural artefacts that can be used to teach Grade 6 geometry. After collecting data on teachers' knowledge of Ndebele cultural artefacts, the researcher asked them to mention those that can be used to teach Grade 6 geometry.

RQ: Which Ndebele cultural artefacts can be used to teach Grade 6 geometry?

> TA: *Ndebele painting can work very well with geometry; beadwork has some patterns as well, which involve 2D shapes.*
>
> TB*: All types of beadwork and Ndebele Painting*.
>
> TC: *Actually, all of them can be used depending on the focus of your lesson on that particular day. Iphotho has lines showing a transformation, i.e. rotation, reflection, translation, and different types of 2D shapes. Iporyana is made of animal skin cuttings that are polygons, worn by men on their chests, Ndebele belts, Ndebele paintings, houses and wall painted.*
>
> TD: *All of them because they have mathematics.*
>
> TE: *Almost all of them.*

A striking consensus emerged from all teachers interviewed, TA to TE, uniformly expressed in their responses, that all the Ndebele cultural artefacts can be utilized to teach Grade 6 geometry because they possess mathematical concepts and geometric patterns. TA and TC supported their arguments with examples of the cultural artefacts and geometric concepts found or associated with them. For example, TA said beadwork has patterns and 2Ds. TC gave an example of *Iphotho* [beaded apron], which shows transformation and 2D shapes and *Iporyana* [breastplate or traditional bib for man] reflecting polygons.

RQ: What do you think are the importance or advantages of using Ndebele cultural artefacts?

> TA: *The cultural artefacts will make learning of geometry more interesting; learners will handle the artefacts to explore geometry concepts in them*.
>
> TB: *Cultural artefacts can help learners to understand how geometric concepts are used in their own cultural context in creating the cultural artefacts.*

TC: *Using cultural artefacts can help learners connect geometry to their own cultural background and experiences, making it more meaningful and relevant to their lives. They can help learners see the practical applications of geometry in their own culture, which will create love and curiosity for mathematics and eliminate fear that impact negatively on performance.*

TD: *They will serve as concrete objects.*

TE: *Learners will collaborate and cooperate, share ideas, and think critically.*

The teachers interviewed acknowledged the value and benefits of incorporating Ndebele cultural artefacts into geometry lessons, citing that this approach would make learning more engaging and interesting as learners will explore the concrete objects to find geometry in them, fostering curiosity, critical thinking, collaboration and cooperation among learners.

4.2.1.3.3 The link between Grade 6 geometry and Ndebele cultural artefacts

The interview excerpt below reflects on Grade 6 geometry's link with Ndebele cultural artefacts. It also reveals how teachers could recognize the link or the relationship. Teachers were asked to give their own views on how they perceive and understand the link between Grade 6 geometry and Ndebele cultural artefacts. Teachers (TA, TC and TD) referred to the ATP in their responses. The ATP is a document that outlines details about the content areas, topics, concepts and skills to be taught and assessed for the entire academic year (DBE, 2021). ATP has timelines for each topic and hours allocated following the weighting of content areas as per the Curriculum Assessment Policy Statement (CAPS). It helps teachers stay organized and ensures that all necessary content is covered within a specific timeframe and assessed per the skills indicated. For example:

TA: *Ndebele art painting links well with geometry through 3D objects, 2D shapes, transformation, Lines of symmetry, straight lines, sides of shapes*, *angles and others is appearing in the ATP.*

TB: *There is a link because there is measurement. Sorting paints involves measurement and counting, such as 36 beads each side. Woola* [wool] *is used for measurement.*

TC*: All concepts and skills in the Annual Teaching Plan are found in the Ndebele cultural artefacts, to an extent that one will even think that the Ndebele artists made use of the ATP when making their cultural artefacts or paintings*; however, *the person who made the artefacts was not* *aware that she is doing mathematics, because we once asked her and she was surprised to hear that she used mathematics taught at school. It was unbelievable to her that what she did related to Mathematics taught and learned at school, as she was just drawing. There is a lot of links. When the learner knows a triangle, it easy for the learner to identify it on the wall painting by counting its sides, numeric and geometric patterns. Learners can identify different 2Ds; learners will not forget as they see them at school and home; once they forget at school, they get reminded at home.*

TD: *The shapes embedded in the culture enable link with Mathematics. The link is made through the evidence of concepts and skills for 2-dimensional shapes and 3-dimensional objects in the ATP with the cultural artefacts displaying them practically in context.*

TE: *There is a very close link: Ipalapala* [trumpet] *can be used to teach 3D objects. Cultural artefacts have mathematics taught at school in them.*

Grade 6 geometry concepts that can be taught and the skills that can be developed using Ndebele cultural artefacts

The sub-theme explores geometry concepts that can be taught and skills that can be developed using Ndebele cultural artefacts. The rationale of the sub-theme was to explore ethnomathematical approaches deeper, looking at the relevance related to geometry content, such as in the ATP. This question was specifically posed to probe the earlier assertion by teachers further that all Ndebele cultural artefacts can be utilized to teach geometry, seeking teachers to identify the specific Grade 6 geometry concepts that can be taught and skills that can be developed through the incorporation of these Ndebele cultural artefacts in the classroom. The aim was to gather more specific information about using Ndebele cultural artefacts in teaching Grade 6 geometry.

RQ: Which Grade 6 geometry concepts can be taught, and which skills can be developed using Ndebele cultural artefacts?

TA: *Properties of 2D shapes, identifying and naming shapes, the patterns with different 2D shapes such as triangles, rectangles, parallelograms, similarities and differences between rectangles and parallelograms, Lines of symmetry, transformation, i.e. rotation, reflection and translation. Properties of 3D objects.*

TB: *Regular and irregular polygons, triangles, squares, rectangles and other quadrilaterals, Properties of 3D objects.*

TC: *Properties of 3D objects, Regular and irregular polygons, i.e., triangles, squares, rectangles, parallelograms, and other quadrilaterals.*

TC further added *Pentagons, hexagons, heptagons, octagons, Similarities and differences between rectangles and parallelograms, number of sides, length of sides, angles of different sizes such as acute, right, obtuse, straight angle and a revolution, Lines of symmetry, rotations, reflections and/or translations, enlargement and reduction.*

TD: *All the shapes, 2D shapes, triangles, parallelograms, pentagons, angles in a 2D shape, 3D objects, symmetry and transformation enlargement and reduction without measurement but through estimation.*

TE: *Enlargement and reduction to prepare them for congruency and similarity. Irasi can be used to teach about circles, radius, circumference, arches, polygons, 3D objects, symmetry, and transformation. Irasi can be used to teach them about patterns using a circle.*

All teachers (TA to TE) mentioned the properties of Two-dimensional shapes (2Ds) and Three-dimensional objects (3Ds), and TA and TC emphasized lines of symmetry and transformation. TC, TD and TE: enlargement and reduction, TE: congruency and similarity. TE further mentioned parts of a circle

4.2.1.4 Skills that can be developed using Ndebele cultural artefacts

The teachers (TA to TE) believe various skills can be developed using the Ndebele cultural artefacts. Those skills are critical, used and visible in real-life situations such as mural art, basketry and weaving, beadwork and jewelry.

TA: *Estimation, sorting, ordering, drawing, designing, identifying, locating & counting.*

TB: *Estimation, sorting, identifying, comparing, arranging and extending patterns.*

TC: *Recognise, estimation, identifying, designing, name, describe, comparing, sort, extending patterns, drawing.*

TD: *Measuring, estimation, recognize, naming, locating positions and visualizing, drawing, designing, extending patterns, counting.*

TE: *Naming, describing, recognizing, arranging, sorting, classifying, explaining, comparing and counting.*

Teachers' most frequently cited geometry skills were estimation, sorting, recognizing, naming, counting, identifying, and designing, while drawing, comparing, extending patterns and locating positions were mentioned less often. Notably, TD was the only teacher who highlighted visualization skills.

4.2.1.4.1 Teachers' views on using Ndebele cultural artefacts to aid learners' understanding of geometry

The interview excerpts below reflect on how teachers may use Ndebele cultural artefacts to help learners conceptualise Grade 6 geometry. This section creates a flow of information, confirmation and correlation with the indicated concepts and skills that teachers can develop using the Ndebele cultural artefacts in the previous question, and teachers use ethnomathematical approaches in question (1) of the interview schedule. Teachers were asked to explain how to use Ndebele cultural artefacts to aid learners' understanding of geometry. I asked TD and TE to share their input and seek their active contributions. The main reason was that teachers might bring new ideas; asking teachers to think outside their usual practices might stimulate innovative ideas and provide a more comprehensive understanding of the potential uses and benefits of Ndebele cultural artefacts in teaching geometry.

RQ: How can you use Ndebele cultural artefacts to aid learners' understanding of geometry concepts and skills?

> TA: *I can use it to relate new knowledge to everyday life experiences, to contextualize, and mostly when I introduce new concepts*, *to make learning concrete and interesting to learners.*
>
> TB: *I can use them as teaching resources to introduce my lesson of geometry and geometric patterns. I remember coming to the classroom wearing my clothes with beadwork decoration to use them as teaching aids. I showed my learners repeating patterns with circles and triangles, and asked learners to identify and name 2D shapes in them, asked them to identify angles in the 2D shapes.*
>
> TC: *Learner can be given investigation on different cultural artefact. They can identify 2Ds using information learned at school. Through inspection learners will be encouraged to see translation on pictures following one another, see reflection on pictures facing one another, realize that in reflection reflected picture must be of the same size and if not, it is not reflection. Learners can*

also be given investigation to look for transformation and describe patterns referring to reflections, rotations, and translations used in patterns. Using cultural artefacts as concrete objects can make learning interesting and meaningful to learners. I once gave my learners Ndebele painting to identify 2D shapes, transformation used, different lines. I asked them to measure lines on paintings and on walls to practice their measurement skills using different units of measurement and also practising the conversion of units.

In responding to the question on how they can use Ndebele Ndebele cultural artefacts to aid learners' understanding of geometry concepts, TA, TB, and TC shared common views that they can connect abstract concepts to real-life experiences with using concrete objects, creating rich learning experiences. TC mentioned that he can give learners investigations to encourage them to explore and discover geometric concepts in cultural artefacts. At the same time, TD and TE said they didn't use them in their teaching practice and were asked to elaborate.

TD: *I don't use them in my teaching.*

TE*: I have never used them before.*

The researcher probed TD's response and asked him to elaborate on what he meant to say, 'I don't use them in my teaching,' and he replied:

I said I don't use them in my teaching because it never came to my mind that they can be connected to teaching and learning. I have never looked at them critically, relating them to geometry. I just saw them as cultural artefacts.

TE: *I have never used them before.*

Researcher's follow-up question: In other words, are you saying that you have never considered using cultural artefacts in your geometry lessons?

TE: *Yes, that is true1*

Researcher's follow-up question to TD and TE: How can you use Ndebele cultural artefacts to aid learners in understanding geometry concepts and skills? Can you give us your ideas?

TD*: Actually, learners can be actively involved; I can tell them to look at the cultural artefacts to recognize, identify and name 2D shapes used. Learners can be given an investigation, they can also be given a project on beadwork to practice counting, addition and subtraction and be instructed to explain their projects.*

TE: *Learners can work together actively in groups of four to conduct an investigation, do hands-on activities such as models, identify 2D Shapes, name them, identify angles in 2D shapes, identify the transformation used. Learners can be given a project on painting using Ndebele style to practice drawing of 2D shapes, transformation, different lines such as parallel line,s perpendicular lines, measurement using mm, cm, and m, and be allowed to explain the mathematics used in their painting.*

TD and TE highlighted that learners can actively engage in teaching and learning through investigations and projects on Ndebele cultural artefacts.

Probing sought to explore the practical implementation of Ndebele cultural artefacts in geometry teaching, and probing assisted in deepening the conversation and promoting critical thinking. It encouraged the two teachers (TD and TE) to reflect and share their ideas on integrating the artefacts into lesson plans, activities, investigations or projects that align with specific geometry concepts and skills.

4.2.1.5 The mathematical concepts and skills found in Ndebele cultural artefacts

This theme captures teachers' knowledge of mathematical concepts and skills found in Ndebele cultural artefacts. It is organized into four sub-themes, which are: Mathematical concepts found in Ndebele cultural artefacts, mathematical skills found in Ndebele cultural artefacts, using mathematical concepts and skills to teach Grade 6 geometry and lastly, the importance of using mathematical skills and concepts in Ndebele cultural artefacts in the teaching and learning of geometry.

Teachers' knowledge of mathematical concepts and skills found in Ndebele cultural artefacts was explored. The researcher asked teachers to mention the mathematical concepts and skills in the Ndebele cultural artefacts. The teachers' general response to their understanding of this question was that it required similar responses to question 6, which responded above on *which geometry concepts and skills can be developed using Ndebele cultural artefacts*, which was clarified with them. The difference between the two questions is that, in this question, the focus was on identifying mathematical concepts found in Ndebele cultural artefacts. In contrast, the previous question specifically looked for geometry concepts and skills that can be developed using Ndebele cultural artefacts. In other words, teachers were expected to reflect on and mention all mathematical concepts found in the Ndebele cultural artefacts. The question on mathematical concepts embraced other content areas in CAPS beyond Space and Shape. Finding the mathematical concepts in Ndebele cultural artefacts addressed integration within content areas and integration of mathematical concepts by the elders while making Ndebele cultural artefacts.

4.2.1.6 Mathematical concepts and skills found in Ndebele cultural artefacts

In this excerpt from the interview conducted with the teachers' several mathematical concepts, other than geometry concepts, were identified in Ndebele cultural artefacts.

4.2.1.6.1 Mathematical concepts found in Ndebele cultural artefacts

TA: *Symmetry, transformation, i.e. rotation, reflection and translation, tessellations, straight lines, Different 2D shapes such as rectangles, triangles, zigzags, chevrons, diamonds, common fractions found in the arrangement of 2D shapes, in beadwork and in painting.*

TB: *Length that is measurement, numeric and geometric patterns, different 2D, shapes regular and irregular polygons for example, triangles, squares, rectangles and other quadrilaterals, 2Ds are packed in common fractions such as one shape at the top other three at the bottom proper fractions* $\frac{1}{3}$, *improper fraction* $\frac{3}{1}$ *especially in beadwork for Dr Mahlangu, Perimeter of 2D shapes lines of symmetry, transformations, composite shapes consisting of different 2D shapes looking like puzzles, geometry of straight lines.*

Numeric and geometric patterns. A numeric pattern is found when, for example, counting in twos, 2,4,6,8.10. A geometric pattern is a pattern made of geometric shapes.

TC: *2D shapes, different regular and irregular polygons, i.e., triangles, squares, rectangles, parallelograms, rhombus, and other quadrilaterals such as kites, pentagons, and hexagons. They portray number of sides in a shape, length of sides, measurement, and angles of different sizes such as acute, right, obtuse, straight, reflex and revolution. Similarities and differences between rectangles and parallelograms 3D objects in huts, Transformation, rotations, reflections and/or translations & symmetry.* ***Enlargement and reductions are shown in the shapes, counting, addition, subtraction, multiplication, and division in beadwork.***

TD: *Measurement, transformation, rotation, sliding, reflection, enlarging and reducing shapes are mostly used. All the shapes, different 2Ds such as triangles, parallelograms, pentagons, and circles, angles in a 2D shape such as obtuse, acute, right angle, reflex angle and revolution. 3D objects, Symmetry. Perimeter can also be found on 2D shapes. Counting forward in intervals such as 2,3, and, 5, etc.*

TE: *Properties of 2D shapes and 3D objects, regular and irregular polygons, triangles, rectangles, kites, different types of lines in geometry such as parallel lines, perpendicular lines, vertical and horizontal lines, circles, transformation, symmetry, counting, estimation addition, subtraction, multiplication and division, similarity and congruency, enlargement and reduction in both painting and beadwork. Clay pots and ostrich eggs can be used to teach learners 3D objects, surface area and volume.*

Mathematical concepts found in the Ndebele cultural artefacts, other than geometry concepts (Space and Shape), were commonly mentioned; for example, TA and TB mentioned common fractions, TB, TD and TE measurement (length, perimeter of 2D shapes, surface area and volume), TD mentioned counting, and specifically counting forward, TC and TE, counting, estimation, addition, subtraction, multiplication and division. Among the teachers interviewed, TB uniquely identified numeric and geometric patterns.

4.2.1.6.2 Mathematical skills found in Ndebele cultural artefacts

The interview excerpt below reflects on the mathematical skills found in Ndebele cultural artefacts. This question differs from the above: which geometry skills can be developed using Ndebele Cultural artefacts? Because this time, I was looking for broad mathematical skills found in the cultural artefacts going beyond a specific content area or topic, emphasizing the cultural artefacts' flexibility and adaptability to other content areas. It came out that various skills can be found in the Ndebele cultural artefacts.

RQ: Which mathematical skills can be found in the Ndebele cultural artefacts?

TA: *Sorting, ordering, designing, estimation, explaining, identifying and drawing*

TB: *Identifying, naming, describing, sorting, comparing, arranging, estimating, recognizing and extending patterns.*

TC: *Estimation that is they use free hand, no measurement using measuring instruments, sorting of beads according to colours and sizes, identifying the shape that they want to use, designing an artefact, classifying artefacts according to their uses, comparing involves big and small shapes drawn, arranging 2Ds using transformation, explaining, extending patterns. Skills on the cultural artefacts are the ones that learners must master in geometry.*

TD: *Transcribe by drawing, modeling, designing, extending patterns, explaining what they have used, recognizing, sorting, classifying according to shapes and colours counting, I am not certain that they can count, estimation might be used and a bit of counting. Learners must be able to understand and apply these skills hence they must be developed.*

TE: *Sorting according to colours, classifying, ordering, arranging, comparing, counting beads to form a shape eg rhombus.*

A skill is defined as persons' ability to do something well usually because they have practiced it (Oxford Dictionary), a particular ability or talent that someone has often developed through practice or training (Cambridge Dictionary). According to NCTM, 2000 cited by Van De Walle et al (2010:14), action verbs describe the authentic work of doing mathematics and are used in the principles and standards, such as investigate, solve, justify, represent, construct, describe and the others. Van De Walle et al, further stressed that the action verbs require higher level thinking, making sense and figuring out. The action verbs mentioned by teachers are found in CAPS (2011:21) in specification of the content for space and shape (geometry), are also found in the Annual Teaching Plan. Teachers are guided by the action verbs in developing quality assessment activities.

Action verbs most cited by teachers were estimation, counting, sorting, comparing, and arranging. Extending patterns and recognizing relationships were rarely mentioned, with TB, TC, and TD being the only teachers who mentioned them. TB mentioned describing. Van De Walle et al (2010:389) defined estimation as a skill used in almost every day.

4.2.1.6.3 Using mathematical concepts and skills found in Ndebele cultural artefacts to teach Grade 6 Geometry

The sub-theme explored how teachers can use mathematical concepts and skills to teach Grade 6 geometry. Teachers were asked to explain how mathematical concepts and skills identified during the interview can be used to teach Grade 6 geometry.

RQ: How can such mathematical concepts and skills be used to teach Grade 6 geometry?

> TA*: Give them the beads to count and create 2D shapes with beads counted, Find the perimeter of shapes created tell them to identify and names the 2D shapes, to count the triangles in rectangle, find the fraction of black to grey triangles, we can also go for educational excursions with learners to cultural sites, cultural villages, art centers or art galleries. Ensuring that the cultural artefacts, their significance and mathematical concepts are explained to learners.*
>
> TB: *Tell them to name and identify 2Ds, count the number of 2D shapes in a composite shape, count the number of beads used on the edges/sides of the 2D to find as to whether the sides are of equal length. Tell learners to extend the pattern in the beadwork or wall painting. Learners can be allowed to colour the 2Ds.*
>
> TC*: Learners can be given patterns in beadwork to extend (draw the fourth pattern), can be given patterns to recognize and describe lines of symmetry, rotations, reflection and translation in them. Ndebele paintings have enlargement and reduction in them. Learners can compare 2Ds as big bigger biggest and realize that they keep their form but get bigger to relate to enlargement and reduction, allow them to find and tell mathematical concepts and skills found in the cultural artefacts instead of telling them, can be given a chalk to draw own Ndebele painting and colour it relevantly, learners can be given a project such as making the model of the cultural artefact using their own creativity and mathematical knowledge.*
>
> TD: *Do excursions, visit to Ndebele museum.*
>
> TE: *Learners can count beads, create own cultural artefacts and ask them to present to the class.*

Teachers shared views on how mathematical concepts and skills can be used, such as giving learners beads to teach and practice counting, creating 2D shapes with beads and finding the perimeter of 2Ds created, developing the concept of common fractions using 2D shapes, count edges, sides of 2D shapes, compare sides (properties of 2D shapes), count shapes to identify number of shapes in a composite shape (as part of problem-solving), TB and TC, emphasized that learners can be given patterns in beadwork to extent, recognize and describe lines of symmetry and transformation which took place in patterns created. TA and TD suggested educational field trips to art centres or art galleries where learners can engage with cultural artefacts and receive guided explanations of mathematical concepts in the cultural artefacts.

4.2.1.6.4 Benefits of using mathematical concepts found in Ndebele cultural artefacts in the teaching and learning of Grade 6 Geometry

The sub theme below explores the importance of using mathematical concepts to teach Grade 6 geometry. The researcher asked teachers to mention the benefits of using mathematical concepts found in Ndebele cultural artefacts in teaching and learning Grade 6 geometry.

RQ: What are the benefits of using mathematical concepts found in Ndebele cultural artefacts in teaching and learning Grade 6 geometry?

> TA: *Learning and teaching is contextualized, improves understanding, learning is meaningful, arouses learners' interest to learn mathematics and helps learners to remember, learners will not forget what they have learned because they see 2Ds every day at home. Learners see 2D shapes within the environment on the community walls and houses painted, and I think some are directly involved at home when assisting parents in painting and beadwork.*
>
> TB: *It aid understanding, learners find geometry easy, they don't forget easily, new knowledge is linked to cultural knowledge which part of their everyday routine.*
>
> TC**:** *Lot of enjoyment, learners will not forget because is related to cultural artifact, learning is concrete, will be able to learn and study at home.*
>
> TD: *It encourages the love of Mathematics, curiosity, make mathematics meaningful, learners can relate Mathematics to real-life situations that they come across in daily basis, mathematics is taught in context and learning is concrete.*
>
> TE: *Creativity. Visualized learning improves understanding because of concrete representation. Learners become hands-on.*

All teachers who participated shared a similar view that Mathematics will contextualize, be meaningful to learners, there will be a lot of enjoyment, encourage a love of mathematics and curiosity, help learners to relate what they learn in the classroom to their real-life situations, everyday mathematics found in cultural artefacts, learning will be concrete and not abstract and most importantly will aid understanding and improve retention of mathematical concepts learned.

4.2.2 Interviews with learners

The section below presents the study results from semi-structured interviews with learners. The section starts by presenting learner participants' information, reporting on interviews with each of the ten learners, and themes and sub-themes identified will also be discussed.

Interviews were conducted with each of the ten (10) Grade 6 learners individually. Learners sampled were from each of the five schools for teacher interviews. Nine learners interviewed were Ndebele by culture; one said she is Northern Sotho. It was specified in the learner selection criteria that all learners should belong to Ndebele culture because data was to be collected on Ndebele cultural artefacts**.** Teachers confirmed that all learners suited the selection criteria; however, I found out about this particular learner during the interviews that she is a Northern Sotho learner. Referred to (L7) in this context, does not have knowledge of Ndebele cultural artefacts, could respond briefly to only four questions and was silent in the other eight questions even when asked probing questions. However, similar results were found from the other three learners of Ndebele culture (L8, L9 and L10), who indicated that they are uninvolved and no one is involved in making Ndebele cultural artefacts at their respective homes. The research study acknowledged and incorporated learners' cultural backgrounds to ensure that the data collected is authentic and reflects learners' real-life experiences.

All the learners reside within Mabhoko Village, and their schools are situated within the same village under the eMthambothini circuit, previously known as the Weltevrede circuit. The research focused on schools within the Ndebele village with art centres or art galleries. Two Grade 6 learners were selected from each of the five schools. Five girls and five boys were sampled. The researcher decided on equal gender representation to obtain in-depth information from both girls and boys on knowledge of the cultural artefacts, involvement in making the cultural artefacts, interaction with parents and learners' knowledge of mathematical concepts found in Ndebele cultural artefacts. The researcher was motivated by what the literature review said about the role played by girls and boys in making cultural artefacts, which can affect the knowledge of cultural artefacts and the ability to connect the mathematics found in the cultural artefacts with mathematics learnt at school.

Each learner was assigned a pseudonym for identification. Pseudonyms were used to adhere to the ethical issues and to protect participants' privacy. Letters of alphabet (L) and numerals in ascending order according to how they followed each other when interviewed individually. i.e Learner 1 (L1), Learner 2 (L2), Learner 3 (L3), Learner 4 (L4), Learner 5 (L5), Learner 6 (L6), Learner 7 (L7), Learner 8 (L8), Learner 9 (L9) and Learner 10 (L10). The schools are represented by S1, which refers to school one, for learner identification. RQ represents the researchers' question.

Interviews with each learner were conducted on the same day with each of their teachers, at different times, i.e., after the interviews with each of the five teachers. Data was collected during term 2 (cf. Table 4.2). Learners were interviewed at each of their respective schools, using the same venue used by teachers. Two learners from the same school were interviewed on the same day but individually or separately. Each of the ten learners was allocated 60 minutes. However, they could not stay in the interview for the allocated period because of the short responses. The longest time spent was 40 minutes. Interviews were scheduled from 14:00 to 16:00 to avoid interrupting teaching and learning or disrupting classes. Transport arrangements were made with parents of learners and teachers for learners' safety because most learners they walked with to their respective homes departed the school at 14:00.

4.2.2.1 Presentation of results from interviews with individual learners

Interviews were recorded. Learners were encouraged to elaborate when responding to questions. The presentation used Direct quotations from learners as raw information to give in-depth, detailed descriptions of learners’ viewpoints. Learners’ interviews were transcribed verbatim. Patterns were searched across the data collected. Learners’ sentences describing similar ideas were highlighted and given codes. Initial codes were generated for data collected by grouping similar items. Codes were then organized to see the relationship across the data and between learners. Several related codes were combined to make up themes and sub-themes. Themes and sub-themes that emerged are presented in Table 4.4 below.

Table 4.4: Themes and Sub-themes (learners interviews)

THEMES	SUB-THEMES
Ndebele cultural artefacts	❖ Names of cultural artefacts ❖ Learner involvement in the making of cultural artefacts ❖ Using geometry learnt at school in making cultural artefacts
Learning resources	❖ Learning geometry through using Ndebele cultural artefacts ❖ Concepts and skills developed ❖ Ndebele cultural artefacts and learners' understanding of geometry

Mathematical concepts	❖ Mathematical concepts found in Ndebele cultural artefacts ❖ How can the mathematical concepts found in the Ndebele cultural artefacts help learners learn Grade 6 geometry?

a) The interview with learner 1 (L1) from School 1 (S1)

RQ: What are the different Ndebele cultural artefacts that you know?

L1: *Umkhala and Mphothelelo (Headband and other beadwork)*

Researchers follow-up question: What is *Umkhala* [Headband] used for?

L1: *It is put on the head, usually worn by women for them to look beautiful*

Researchers' *follow-up* question: *Umkhala* and what else, can you name the others that you, or those which you can remember?

L1: Learner did not respond; she just touched her mouth.

RQ: Have you ever been involved in making Ndebele cultural artefacts?

L1: *Yes.*

RQ: Can you tell me, how were you involved?

L1*: My sister inlaw taught me how to do beadwork. I usually help her in making Umkhala* [Headband] *and others. She sells beadwork. My mother is not involved in painting and beadwork***.**

RQ: How do you help your sister?

L1: *I help her in sorting the beads according to colours, place them in different containers according to colours, put the thread inside the needle for her because she struggles in targeting the needled hole, she has poor eyesight, she can't see well. I do beadwork with her although I am not clear yet, I am still learning from her.*

RQ: Why are you helping her?

L1: *I put the thread inside the needle for her because she cannot see well and therefore takes time to do it. She is teaching me how to do beadwork. She said I have to practice in order to know it, for me* to *do it perfectly. I help her because she has many orders, sothat she can finish her orders and deliver to clients in time for clients to pay her.*

RQ: Is your sister-in-law employed?

L1: *No, she sells her beadwork to people to make living.*

RQ: Which Ndebele cultural artefacts can you make or were you involved in their making

L1: *I was involved in making Umkhala.*

RQ: How were the Ndebele cultural artefacts made?

L1: *I used a needle, beads are counted and sorted according to colour.*

RQ: Did you make use of geometry learnt at school when making the cultural artefacts?

L1: *No.*

RQ: Have you ever learnt Grade 6 geometry with using Ndebele cultural artefacts?

L1: *Yes.*

RQ: Which Ndebele cultural artefacts were used?

L1: *Picture of Ndebele painting.*

RQ: How were the cultural artefacts used to learn geometry?

L1: *We* were *asked to identify and name different 2D shapes and 3D objects, lines of symmetry from the picture***.**

RQ: Which Grade 6 geometry concepts and skills were developed using Ndebele cultural artefacts?

L1: *2D shapes and 3D objects, transformation, reflection.*

Researchers follow-up question: Are you saying you learnt the 2D shapes (Two-dimensional shapes), and transformation using the cultural artefacts?

L1: *Yes.*

RQ: Can you name an example or transformation learnt?

L1*: Reflection.*

RQ: How does using Ndebele cultural artefacts aid your understanding of Grade 6 geometry?

L1: *It does not assist me.*

RQ: What are the mathematical concepts found in Ndebele cultural artefacts?

L1*: 2D shapes.*

Researchers follow-up question: Can you name other mathematical concepts found in the Ndebele cultural artefacts, any mathematical concept you can think of?

L1: No response.

RQ: How can the mathematical concepts found in the Ndebele cultural artefacts help you in the learning of geometry?

L1: *They will help me to understand and remember what my teacher taught me In the classroom.*

Researchers Follow-up question: If I show you the Ndebele painting with (a) small and large rectangle (b) triangles that are of different sizes, how will they help you?

L1: *Will help me see shapes of different sizes.*

b) Interview with learner 2 (L2) From S1

RQ: What are the different Ndebele cultural artefacts that you know?

L2: *Ehh!* (he scratched his head) *Beadwork and painting, I actually don't know their names. I just saw them at home.*

RQ: Have you ever been involved in the making of Ndebele cultural artefacts?

L2: *No.*

Researcher follow-up question: Why are you not involved?

L2: *My grandmother is the one who is making them, she has never told me to do them.*

Researchers follow-up question: Do you have a sister, does your grandmother involve her in the making of cultural artefacts?

L2: *I have no sister, but a brother, and he is also not involved.*

RQ: Which Ndebele cultural artefacts can you make or were you involved in their making?

L2: *None, I saw my father painting a guitar and walls.*

RQ: How were the Ndebele cultural artefacts made?

L2*: I was not involved.*

RQ: Did you make use of geometry learnt at school when making the cultural artefacts?

L2: *I was never involved*

RQ: Have you ever learnt Grade 6 geometry with using Ndebele cultural artefacts?

L2: *Yes*

RQ: Which Ndebele cultural artefacts were used?

L2: *Picture of Ndebele painting from the textbook*

RQ: How were the cultural artefacts used to learn geometry

L2: *We* were *told to identify 2D shapes and 3D objects and lines of symmetry.*

RQ: Which Grade 6 geometry concepts and skills were developed using Ndebele cultural artefacts

L2: *2D shapes and 3D objects, transformation and translation.*

Researchers follow-up question: Are you saying you learnt the 2D shapes (Two-dimensional shapes), and transformation using the cultural artefacts?

L2: *Yes.*

RQ: Can you name an example or transformation learnt?

L2: *Translation.*

RQ: How does using Ndebele cultural artefacts aid your understanding of Grade 6 geometry?

L2: *I don't know.*

RQ: What are the mathematical concepts found in the Ndebele cultural artefacts?

L2: *2D shapes such as rectangles, 3D objects, lines of symmetry and length.*

RQ: How can the mathematical concepts found in the Ndebele cultural artefacts help you in the learning of geometry?

L2*: As they are part of my culture. I see them everyday and as such they will help me to remember what the teacher taught me.*

Researchers Follow-up question: If I show you the Ndebele painting with (a) small and large rectangle (b) triangles that are of different sizes, how will they help you?

L2: *Small and large rectangle will remind me of enlargement and reduction in 2D shapes.*

c) Interview with learner 3 (L3) From S2

RQ: What are the different Ndebele cultural artefacts that you know?

L3: *Ndebele paintings by Dr Esther Mahlangu, Ndebele bracelets, bangles and necklaces.*

Researchers follow-up question*:* What are the bracelets, bangles, necklaces used for, and who uses them?

L3: *Women wear them in order to look beautiful.*

RQ: Have you ever been involved in the making of Ndebele cultural artefacts

L3: *Yes*

RQ: Can you explain to me, how were you involved?

L3*: I was painting animals on their faces using Ndebele colours such as green, red, blue at the Art center for Dr Mahlangu.*

RQ: Which Ndebele cultural artefacts can you make or were you involved in their making?

L3*: I also assisted my sister-in-law to make Umkhala* [Headband] *and bracelets.*

Researchers *follow-up* question: How do you help your sister?

L3: *I sort the beads according to colours, put them in different bowls according to colours, so that she can just pick, helped her to make the headband.*

RQ: Why are you helping her?

L3: *For her to be faster, to safe her time, otherwise she would start by picking them up herself.*

RQ: Is your sister-in-law employed?

L3: *No, she is unemployed*

Researchers *follow-up* question: Then, can you tell me, why is she making the cultural artefacts. Wwhat is she doing with them?

L3*: She sells them, wear some of them such as bracelets, earrings and necklaces.*

Researcher: How were the Ndebele cultural artefacts made?

L3*: She measured the length of Umkhala using my little sisters' head. She put a wool around her head and cut I, used a needle and thread to hold the beads together, picked the beads that I have sorted one by one to make Umkhala* [Headband].

RQ: Did you make use of geometry learnt at school when making the cultural artefacts?

L3*: Yes.*

Researchers *follow-up* question: Can you mention the geometry concepts used?

L3: *2D shapes, squares, rectangles, triangles.*

RQ: Have you ever learnt Grade 6 geometry with using Ndebele cultural artefacts?

L3: *No.*

RQ: Which Ndebele cultural artefacts were used?

L3: *They* were *not used.*

RQ: How were the cultural artefacts used to learn geometry?

L3: Learner did not respond.

RQ: Which Grade 6 geometry concepts and skills were developed using Ndebele cultural artefacts

L3: *None.*

RQ: How does using Ndebele cultural artefacts aid your understanding of Grade 6 geometry?

L3*: I don't know.*

RQ: What are the mathematical concepts found in Ndebele cultural artefacts?

L3: *Counting, estimation, measuring length.*

RQ: How can the mathematical concepts found in the Ndebele cultural artefacts help you in the learning of geometry?

L3: *Counting beads can teach me how to count properly.*

RQ: What are the mathematical concepts found in Ndebele cultural artefacts?

L3: *Counting, estimation, measuring length.*

RQ: How can the mathematical concepts found in the Ndebele cultural artefacts help you in the learning of geometry?

L3: Counting beads can help you understsnd mathematics.

Reseracher's Folloup question: If I show you the Ndebele painting with (a) small and large rectangle (b) triangles that are of different sizes, how will they help you?

L3: triangles will also help me see enlargement and reduction an I will never forget them.

d) **Interview with learner 4 (L4) from S2**

RQ: What are the different Ndebele cultural artefacts that you know?

L4: Ndebele painting

RQ: Can you please give the names of the other cultural artefact, anything that you can remember?

L4: Learner did not respond

RQ: Have you ever been involved in the making of Ndebele cultural artefacts?

L4: *Yes*

RQ: How were you involved? Can you explain to me?

L4: *I painted my face in Christmas using Ndebele painting style.*

RQ: Which Ndebele cultural artefacts can you make or were you involved in their making?

L4: *Painting, I was taught by my grandmother.*

RQ: How were the Ndebele cultural artefacts made?

L4*: I don't know, my grandmother made them.*

RQ: Did you make use of geometry learnt at school when making the cultural artefacts?

L4: *Yes.*

Researchers follow-up question: Which geometric concepts did you make use of?

L4: *I used lines, triangles and rectangles.*

Researcher: Have you ever learnt Grade 6 geometry with using Ndebele cultural artefacts?

L4: *Yes.*

RQ: Which Ndebele cultural artefacts were used?

L4: *Pictures*

RQ: How were the cultural artefacts used to learn geometry

L4: Learner silent

RQ: Which Grade 6 geometry concepts and skills were developed using Ndebele cultural artefacts

L4: *Triangle, square, right angle*

RQ: How does using Ndebele cultural artefacts aid your understanding of Grade 6 geometry?

L4: *Measuring when painting, measuring paints, measuring length.*

RQ: What are the mathematical concepts found in Ndebele cultural artefacts?

L4: *Geometric patterns.*

RQ: How can the mathematical concepts found in the Ndebele cultural artefacts help you in the learning of geometry?

L4: *They can help me understand as I use and see them at home everyday.*

Researchers Folloup question: If I show you the Ndebele painting with (a) small and large rectangle (b) triangles that are of different sizes, how will they help you?

L4: *The painting will teach me that we have triangles of different sizes, triangles with sides of different length and those with sides of the same length.*

e) **Interview with learner 5 (L5) from S3**

RQ: What are the different Ndebele cultural artefacts that you know?

L5: Ndebele bangles, Ndebele tie and Ndebele belts.

Researchers follow-up question*:* What are the Ndebele bangles, Ndebele tie and belts used for, and who uses them?

L5: Ndebele bangles are worn by women as accessories, Ndebele tie and belts are worn by men as part of clothing.

RQ: Have you ever been involved in the making of Ndebele cultural artefacts

L5: *Yes.*

RQ: Can you explain how you were involved?

L5: *I observed my grandmother making them, she tried to teach me, but I found it difficult, it frustrates me*.

Researchers follow-up question: What frustrates you?

L5: *The whole process of making beadwork.*

RQ: Which Ndebele cultural artefacts can you make or were you involved in their making?

L5: *My grandmother tried to teach me Ndebele bangles, tie and belts.*

RQ: How were the Ndebele cultural artefacts made?

L5: *I used a needle and a thread, sorted beads according to colours, used a cloth, the pastic and beads, picked beads one by one with a needle to cover the cloth.*

RQ: Did you make use of geometry learnt at school when making the cultural artefacts?

L5: *Yes.*

Researchers follow-up question: Which geometric concepts did you use?

L5*: Lines, rectangles, triangles and circles.*

RQ: Have you ever learnt Grade 6 geometry with using Ndebele cultural artefacts?

L5: *Yes.*

RQ: Which Ndebele cultural artefacts were used?

L5: Learner silent.

Researchers follow-up question: Did your teacher make use of Ndebele cultural artefacts such as bangles, necklace to teach you geometry?

L5: *No.*

RQ: How were the cultural artefacts used to learn geometry?

L5: *They* were *not used.*

RQ: Which Grade 6 geometry concepts and skills were developed using Ndebele cultural artefacts?

L5: Learner silent.

RQ: How does using Ndebele cultural artefacts aid your understanding of Grade 6 geometry?

L5: Learner silent.

RQ: What are the mathematical concepts found in Ndebele cultural artefacts?

L5: *Geometric patterns, diamond, rhombus, triangle, rectangles, circles, pentagons, lines, sides of shapes.*

RQ: How can the mathematical concepts found in the Ndebele cultural artefacts help you in the learning of geometry?

L5: *They can't help me.*

Researchers Follow-up question: If I show you the Ndebele painting with (a) small and large rectangle (b) triangles that are of different sizes, how will they help you?

L5: *To know rectangles and triangles.*

f) **Interview with learner 6 (L6) from S3**

RQ: What are the different cultural artefacts that you know?

L6: *Ndebele bangles, and Ndebele tie.*

Researchers follow-up question*:* What are the bangles and Ndebele tie used for, and who uses them?

L6: *Bangles are used by women to look beautiful and Ndebele tie is worn by men to look presentable.*

RQ: Have you ever been involved in the making of Ndebele cultural artefacts

L6: *Yes.*

RQ: Can you explain how you were involved?

L6: *My grandmother was teaching me how to make bangels and ties.*

RQ: So, you ended up knowing how to make bangles and ties, which means you can now make them?

L6: *No, I can't make them.*

RQ: Which Ndebele cultural artefacts can you make or were you involved in their making?

L6: *Ndebele bangles and Ndebele tie*.

RQ: How were the Ndebele cultural artefacts made?

L6: *My grandmother took a plastic container, rapped it with a plastic and put beads around it.*

RQ: Did you make use of geometry learnt at school when making the cultural artefacts?

L6*: Yes, she used the geometry that we learn at school*

Researchers follow-up question: Which geometric concepts did you use?

L6*: She used 2D shapes Lines, rectangles, triangles and circles.*

RQ: Have you ever learnt Grade 6 geometry with using Ndebele cultural artefacts?

L6: *Yes.*

RQ: Which Ndebele cultural artefacts were used?

L6: *Picture of Ndebele painting, Ndebele tie***.**

RQ: How were the cultural artefacts used to learn geometry?

L6: *Learner silent*

RQ: Which Grade 6 geometry concepts and skills were developed using Ndebele cultural artefacts

L6: Silent.

RQ: How does using Ndebele cultural artefacts aid your understanding of Grade 6 geometry?

L6*: I don't know.*

RQ: What are the mathematical concepts found in Ndebele cultural artefacts?

L6: *Patterns, 2D shapes such as rectangle, rhombus and lines of symmetry, length of sides.*

RQ: How can the mathematical concepts found in the Ndebele cultural artefacts help you in the learning of geometry?

L6: *I am not sure.*

Researchers Follow-up question: If I show you the Ndebele painting with (a) small and large rectangle (b) triangles that are of different sizes, how will they help you

L6: *Rectangles of different sizes and triangles of different sizes.*

g) Interview with learner 7 (L7) from S4

RQ: What are the different Ndebele cultural artefacts that you know?

L7: *Ndebele dolls.*

Researchers follow-up question*:* What are the Ndebele dolls used for and who uses them?

L7*: Ndebele dolls are used for decorating the house by women*.

RQ: Have you ever been involved in the making of Ndebele cultural artefacts

L7: *No*

Researchers follow-up question: Why are you not involved?

L7: *No one does them at home. Our culture is not Isindebele.*

RQ: To which culture do you belong?

L7: *Nothern Sotho*

RQ: Ohh, it is fine my girl.

RQ: Which Ndebele cultural artefacts can you make or were you involved in their making?

L7*: None*

RQ: How were the Ndebele cultural artefacts made?

L7: Learner did not respond

RQ Did you make use of geometry learnt at school when making the cultural artefacts?

L7: Learner did not respond

RQ: Have you ever learnt Grade 6 geometry with using Ndebele cultural artefacts?

L7: *No.*

RQ: Which Ndebele cultural artefacts were used?

L7: *They* were *not used.*

RQ: How were the cultural artefacts used to learn geometry?

L7: *They* were *not used.*

RQ: Which Grade 6 geometry concepts and skills were developed using Ndebele cultural artefacts?

L7: Learner silent.

RQ: How does using Ndebele cultural artefacts aid your understanding of Grade 6 geometry?

L7: Learner silent.

RQ: What are the mathematical concepts found in Ndebele cultural artefacts?

L7: *2D shapes such as rectangles, squares, triangles and angles.*

RQ: How can the mathematical concepts found in the Ndebele cultural artefacts help you in the learning of geometry?

L7: *They will help us to understand 2 D shapes.*

Reserachers Follow-up question: If I show you the Ndebele painting with (a) small and large rectangle (b) triangles that are of different sizes, how will they help you?

L7: *I will measure the sides of the 2D shapes and compare their length.*

h) Interview with learner 8 (L8) from S4

RQ: What are the different Ndebele cultural artefacts that you know?

L8: *Ndebele dolls, Ndebele painting.*

Researchers follow-up question*:* What are the Ndebele dolls used for and who uses them?

L8: *To decorate the house and are used by women.*

RQ: Have you ever been involved in the making of Ndebele cultural artefacts?

L8: *No.*

Researchers follow-up question: Why are you not involved?

L8: *No one is making the Ndebele cultural artefacts at home.*

RQ: Which Ndebele cultural artefacts can you make or were you involved in their making?

L8: *None.*

RQ: How were the Ndebele cultural artefacts made?

L8*: I was never involved.*

RQ: Did you make use of geometry learnt at school when making the cultural artefacts?

L8*: I was never involved.*

RQ: Have you ever learnt Grade 6 geometry with using Ndebele cultural artefacts?

L8: *No.*

RQ: Which Ndebele cultural artefacts were used?

L8: *They* were *not used.*

RQ: How were the cultural artefacts used to learn geometry

L8: Learner was silent.

RQ: Which Grade 6 geometry concepts and skills were developed using Ndebele cultural artefacts

L8: Learner was silent.

RQ: How does using Ndebele cultural artefacts aid your understanding of Grade 6 geometry?

L8: Learner was silent.

RQ: What are the mathematical concepts found in Ndebele cultural artefacts?

L8: *Rectangles, squares, triangles and angles.*

RQ: How can the mathematical concepts found in the Ndebele cultural artefacts help you in the learning of geometry?

L8: No response

Researchers Follow-up question: If I show you the Ndebele painting with (a) small and large rectangle (b) triangles that are of different sizes, how will they help you?

L8: No response.

i) **Interview with learner 9 (L9) from S 5**

RQ: What are the different Ndebele cultural artefacts that you know?

L9: *Ikhaba, Isigubu, Umkhala, Segoloane, Irasi.*

Researchers follow-up question*:* Can you explain to me*,* what are the uses of each Ndebele cultural artefact mentioned and who uses them?

L9*: Ikhaba* [Calabash] *is used to store liquor, used by mothers, Isigubu* [Drum] *is used by mothers during celebrations. Umkhala* [Headband] *worn by mothers, Segoloqane* [beaded bracelets] *worn by women on legs, and Irasi* [beaded necklace] *worn by women.*

RQ: Have you ever been involved in the making of Ndebele cultural artefacts?

L9: *No.*

Researchers follow-up question: Why are you not involved?

L9: *I want to know how to make the cultural artefacts. My grandmother is the one who is making them. She is always busy, does not have time to teach me, she sells them, her focus is to make more to sell to her clients.*

RQ: Why are you interested in knowing how to make them?

L9: *Because is my culture, I also want to be able to sell them when I grow up to make money.*

RQ: Which Ndebele cultural artefacts can you make or were you involved in their making?

L9: *None.*

RQ: How were the Ndebele cultural artefacts made?

L9: *I was never involved in making the cultural artefacts.*

RQ: Did you make use of geometry leartn at school when making the cultural artefacts?

L9*: I was never involved.*

RQ: Have you ever learnt Grade 6 geometry with using Ndebele cultural artefacts?

L9: *No.*

RQ: Which Ndebele cultural artefacts were used?

L9: No response.

RQ: How were the cultural artefacts used to learn geometry?

L9: *Our teacher did not use them.*

RQ: Which Grade 6 geometry concepts and skills were developed using Ndebele cultural artefacts?

L9: *None.*

RQ: How does using Ndebele cultural artefacts aid your understanding of Grade 6 geometry?

L9: No response.

RQ: What are the mathematical concepts found in Ndebele cultural artefacts?

L9: *Triangle, rectangle, circle, hexagon, rhombus, line of symmetry.*

RQ: How can the mathematical concepts found in the Ndebele cultural artefacts help you in the learning of geometry?

L9: *I don't know*.

Researchers Follow-up question: If I show you the Ndebele painting with (a) small and large rectangle (b) triangles that are of different sizes, how will they help you?

L9: *Rectangles and triangles of different sizes.*

j) Interview with learner 10 (L10) from S5

RQ: What are the different Ndebele cultural artefacts that you know?

L10: *Ibetjhe* [apron] *and Ikhapo* [Calabash].

Researchers follow-up question: Can you explain to me, what are the uses of each Ndebele cultural artefact mentioned and who uses them?

L9*: Ibetjhe is worn by boys when dancing and Ikhapo* [Calabash] *is used by women to drink liquor.*

RQ: Have you ever been involved in the making of Ndebele cultural artefacts?

L10: *No.*

Researchers follow-up question: Why are you not involved?

L10: *There is no one to teach me*.

RQ: Is there no one at home making the cultural artefacts?

L10: *No one is making them*.

RQ: Which Ndebele cultural artefacts can you make or were you involved in their making?

L10: *None.*

RQ: How were the Ndebele cultural artefacts made?

L10: *I was never involved.*

RQ: Did you make use of geometry learnt at school when making the cultural artefacts?

L10: *I was never involved.*

RQ: Have you ever learnt Grade 6 geometry with using Ndebele cultural artefacts?

L10: *No*

RQ: Which Ndebele cultural artefacts were used?

L10: Learner silent

RQ: How were the cultural artefacts used to learn geometry

L10: Learner silent.

RQ: Which Grade 6 geometry concepts and skills were developed using Ndebele cultural artefacts?

L10: Learner silent.

RQ: How does using Ndebele cultural artefacts aid your understanding of Grade 6 geometry?

L10: No response.

RQ: What are the mathematical concepts found in Ndebele cultural artefacts?

L10: *Circle.*

RQ: Can you name the others?

L10: No response

RQ: How can the mathematical concepts found in the Ndebele cultural artefacts help you in the learning of geometry?

L10: *I don't know.*

Researchers Follow-up question: If I show you the Ndebele painting with (a) small and large rectangle (b) triangles that are of different sizes, how will they help you?

L10: *I don't know*

4.2.2.2 Ndebele cultural artefacts

This theme captures learners' knowledge of different Ndebele cultural artefacts. Learners were asked to name the different cultural artefacts. To explore learners' knowledge further, the researcher asked them to explain their involvement in making cultural artefacts and indicate what they could make. Further investigation was done to check whether learners used geometry learnt at school to create cultural artefacts.

4.2.2.3 Learners' knowledge of Ndebele cultural artefacts

The theme explored learners' knowledge of different Ndebele cultural artefacts. Learners were asked to name different Ndebele cultural artefacts. Some learners from the same school mentioned similar artefacts, while others created various artefacts. Findings revealed that learners lack knowledge of the names of different cultural artefacts compared to their teachers. One learner said he does not know their names (L2), one mentioned Ndebele paintings only (L4), three learners mentioned only one cultural artefact, L1 said *Umkhala* and the two from the same school said Ndebele dolls (L7 and L8), they could not mention the other Ndebele cultural artefacts even after asking them to think or remember the others. It also emerged that girls had more knowledge of the names of Ndebele cultural artefacts than boys, and L3, L5, and L9 were girls. L3 mentioned 2, L5 mentioned mentioned 3, L9 mentioned 4.

Cultural artefacts mentioned by learners were *Umkhala* [Headband] *Segoloane* thick beaded bracelet, Ndebele necklaces, Ndebele tie, Ndebele belts, Ndebele dolls, *Isigubu* [Drum], *Irasi* [beaded necklace], *Ibetjhe* (boys' apron) and *Ikhapo* [Calabash]. A *follow-up* question was raised based on the uses of cultural artefacts, and learners could mention their uses and the people who use them. L5 and L6 said men wear Ndebele ties and belts as part of their clothing. Women use *Ikhapo* to drink liquor or water, and *Isigubu* [Drum] is used by both males and females during traditional celebrations. L7 and L8 said Ndebele dolls are used for decoration.

4.2.2.4 Examples and explanations of pictures of Ndebele cultural artefacts referred to by learners

The following section presents examples of Ndebele cultural artefacts mentioned by learners during the interview, along with concise explanations to provide context and insight into their creation and techniques, cultural significance, functional use and location. The aim is to give the readers rich visual information, making the content more engaging, accessible, and easier to understand.

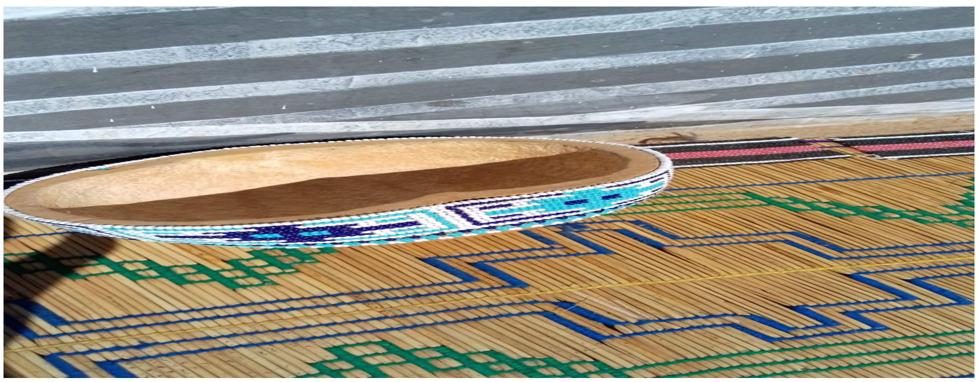


Figure 4.12: ***Ikapho*** **[Half Calabash]**

A suitable calabash is selected from the garden, cut into two halves and cooked. It will then be cleaned thoroughly. Seeds are removed from its inside. A sharp knife or sharp object removes the outer green layer, creating a smooth yellowish surface. The calabash is now shaped to the desired shape and allowed to dry. Beads were used to cover the calabash for decoration. Half Calabash is used to drink water, like a jug. According to W3, the bride traditionally makes the calabash to give to the father-in-law as a present. It is used at home and during traditional celebrations. Found in W3 Art Gallery. The calabash has mathematical concepts embedded in it such as counting, numeric and geometric patterns.

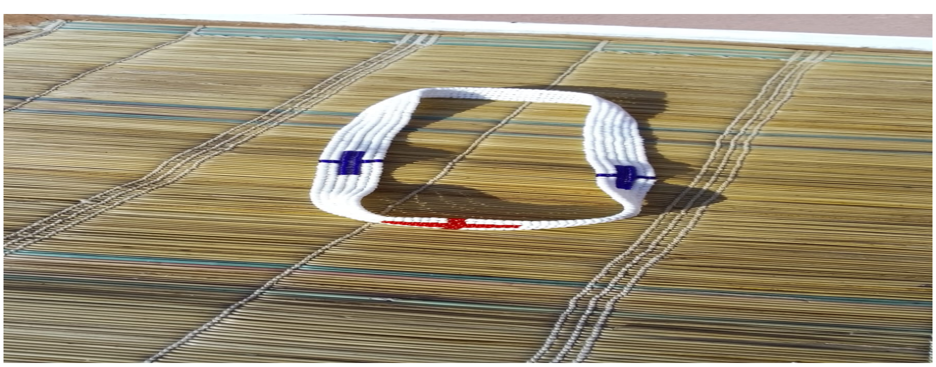


Figure 4.13: ***Umkhala*** **[Head bracelet]**

Umkhala is the head bracelet or headband made of beads, worn by women and graduates' initiates during the initiation process. The head bracelet above is for Manala style and has three crosses. When worn, the red cross must be at the front and the blue one on the side. Crosses symbolize Jesus' crucifixion on the cross. W3 made the cultural artefact. It is available in her art gallery at Troya (GaMatempule). The mathematics in umkhala include concepts such as counting, properties of 2D shapes and measurement.

Figure 4.14: ***Irasi*** **[flat beaded necklace]**

Irasi is a flat beaded necklace worn on the neck. It is made of beads of different bright colours and geometric designs that reflect Ndebele culture. Women wear it to enhance their style and overall look; it is decorative. It symbolizes Ndebele's cultural identity and heritage. It is worn during traditional ceremonies, weddings and so on. Available in W2, W3 art galleries, and Kghodwana Cultural Village. Several mathematical concepts are embedded in the design and construction of the necklace such as Geometry: the necklace feature geometric patterns including triangles, squares, circles, arranged to create a visually appealing and balanced compositions.

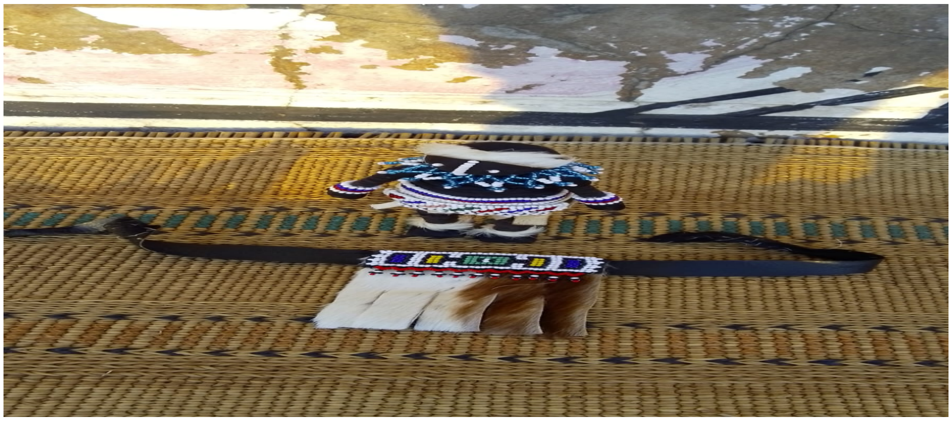


Figure 4.15: ***Ibhetjha*** **[apron]**

Ibhetjha is worn by young men to cover the front part, just like an apron. It is made of animal skin, decorated with beads, and a cloth to tie it at the back. It is one of the traditional attire for Ndebele men. W3 made it. It is available in her art gallery, W2 Art Gallery, and Kghodwana Cultural Village.

Picture 4.16: ***Ithayi*** **[NdebeleTie]**

The *Ithayi* [Ndebele Tie0 was made by W2 using upholstery thread, needle and beads of different bright colours, creating beautiful geometric patterns. The tie is worn around the neck, sitting comfortably at the base of the throat, usually centred with the pattern facing forward for display. It is also known as a beaded rope of honour. It is worn during ceremonies and special celebrations like weddings and cultural festivals. The Ndebele tie was found in the W2 Art Gallery.

Figure 4.17: ***Ibhande*** **[Ndebele Belt] (Sourced: Pinterest)**

Ibhande, known as the Ndebele Belt, is made of beads. Ladies typically wear it around the waist during celebrations or as a decorative piece.

Despite being created by women without formal schooling, the cultural artefacts have rich geometric patterns and mathematical concepts inherent in Ndebele culture, demonstrating a deep connection between culture, art and mathematics, innate mathematical abilities and artistic talents of the WKH.

4.2.2.5 Learner involvement in the making of Ndebele cultural artefacts

The interview excerpts below reflect on learner involvement in making Ndebele cultural artefacts. Six learners do not make cultural artefacts (L2, L6, L7, L8, L9, and L10). L7 is a Nothern Sotho girl. The reason given by learners was that no one made the Ndebele cultural artefacts at home**.** L6 is a boy who said that his grandmother tried to teach him, but he could not grasp the process, which was surprising as the literature said beadwork is the responsibility of females. L6: *My grandmother was teaching me how to make bangles and ties.*

One learner (L5) said her grandmother taught her, but she found it difficult and frustrating. Their sister-in-laws taught two learners (L1 and L3) and indicated that their mothers are not involved in making Ndebele cultural artefacts. The learners, L1 and L3, help their sister inlaws to save time for orders to be completed and delivered to clients. L1 and L3 are still learning from their sisters-in-law, who sell cultural artefacts to generate income as they are unemployed. L1: *I also learn more things and extend the knowledge every time*. L1 is assisting her sister because she can't see clearly and struggles with inserting cotton into the needle. Learners 3 and 4 indicated that they were involved in painting. L3*: I was painting animals on their faces using Ndebele colours such as green, red, and blue at the Art Center for Dr Mahlangu.* L4: *I Painted my face at Christmas using the Ndebele painting style.*

a) RQ: How were the Ndebele cultural artefacts made?

The interview excerpt reflects the learner's knowledge of making the Ndebele cultural artefacts. This question aimed to look into learners' real-life applications with the hope that they are actively involved in making Ndebele cultural artefacts taught by their parents at an early age, as in the literature review.

Data collected revealed that Ndebele cultural artefacts are made by WKH, which shares its knowledge with other women or women of different age groups. Ms Sophy Mahlangu has a group of women, youth, and young girls who are currently taught how to make cultural artefacts. According to her, girls come to the art gallery to practice beadwork after school at least once a week, aligning with what is practised within their culture by transferring the IK as part of cultural practice, Ndebele women pass their knowledge of cultural expression to the younger generation hence learners in families consisting of women with knowledge of making the cultural artefacts are participating actively in a form of learning.

Learners were asked to explain the process of making the Ndebele cultural artefacts. L1 said she sorted beads according to colours. Both learners (L1 and L3) mentioned sorting the beads according to colours. Sorting as a skill is emphasized. Estimation is also used. L3*: She measured the length of Umkhala using my little sister's head. She put a wool around her head and cut it.* She picked up beads one by one to make headbands, which included counting.

L6 was not involved in making Ndebele cultural artefacts; however, he said he watched his grandmother making beadwork. L6: *My grandmother took a plastic container, wrapped it with a plastic and put beads around*. Five learners were never involved and never observed anyone making the Ndebele cultural artefacts (L2, L7, L8, L9 and L10) and therefore could not respond to the question.

4.2.2.6 Using geometry learnt at school in making cultural artefacts

The sub-theme explored learners' use of geometry learnt at school in making the Ndebele cultural artefacts. The researcher asked learners if they used geometry concepts learnt at school when making Ndebele cultural artefacts.

Learners responded as follows: L1: No, L3*, said yes including L4 and L5*

A probing question was directed to L1: *In other words, are you saying you did not make use of any 2D shapes like triangles when making the cultural artefacts?* L1 earlier said she was involved during interviews with her, and she responded, *"Yes"*.

Individual learners were asked to mention the geometry concepts used when making the cultural artefacts, and they responded as follows:

L3, L4 and L5 mentioned *2D shapes, squares, rectangles, triangles*, *lines, and circles.*

L6 said he observed his grandmother, who used 2D shapes, lines, rectangles, triangles and circles.

L2, L7, L8, L9, L10 said they were never involved in the making of Ndebele cultural artefacts.

4.2.2.7 Learning geometry using Ndebele cultural artefacts

The interview excerpt reflects on using ethnomathematical approaches to teach Grade 6 geometry. Learners were asked whether they had been taught or learnt geometry using the Ndebele cultural artefacts. The aim was to determine teachers' use of ethnomathematical approaches. In responding to classroom activities that learners were engaged in using Ndebele cultural artefacts, five said yes and five said No. L1 and L2 said yes. Learners from school 2 gave different responses; L3 said *'No',* and L4 said *'Yes'*. Their teacher said yes after the concept of ethnomathematics and ethnomathematical approaches were explained to him (cf. 4.2.1.1.2.2). The other four learners, L7, L8, L9 and L10 said *'No'*, they were from the TD and TE classes. Their responses correlate with their teachers' responses.

4.2.2.7.1 Ndebele cultural artefacts used to learn Grade 6 Geometry

The interview excerpt below reflects on the cultural artefacts that learners used to learn Grade 6 geometry. L4: said Pictures. L1, L2, L6: Ndebele painting from the textbook, L6: Ndebele tie.

L5: Silent. **Researchers' follow-up question: Did your teacher make use of Ndebele cultural artefacts such as bangles, necklace to teach you geometry?**

The response from L5 was *'No'*.

L3, L7, L8, L9 and L10: Cultural artefacts were not used because L3 said no and the other learners did not respond.

Researchers' question: How were the cultural artefacts used to learn Grade 6 geometry?

Two learners from S1 responded. L1: *We* were *asked to identify and name different 2D shapes and 3D objects with lines of symmetry from the picture*. L2: *We* were *told to identify 2D shapes and 3D objects and lines of symmetry.*

No response from L3, L4, L6, L8 and L10.

> L5: *They* were *not used*. L7: *Not used.* L9: *Our teacher did not use them.*

4.2.2.7.2 Grade 6 geometry concepts developed using Ndebele cultural artefacts?

Researcher: Which Grade 6 geometry concepts and skills were developed using Ndebele cultural artefacts?

L1, L2 and L4 responded as follows: L1: 2D shapes and 3D objects, transformation, reflection.

> L2: *2D shapes and 3D objects, transformation and translation,* L4: *Triangle, square, right angle.*
>
> L3: *None, L9: None, L5, L6, L7, L8, L10* did not respond.

Researchers probing: Are you saying you learnt the 2D shapes (Two-dimensional shapes) and transformation using the cultural artefacts?

This probing question was directed to L1 and L2, who mentioned transformation as a concept different from the responses given by other learners.

> L1, L2*: Yes*

To understand learners' views and, most importantly, explore their knowledge of mathematical concepts, the researcher probed learners on transformation. She further asked learners to name the example of transformation learnt through the Ndebele painting used.

L1 mentioned reflection and L2 translation.

4.2.2.7.3 Ndebele cultural artefacts and learners' understanding

Researcher: How can using Ndebele cultural artefacts aid your understanding of Grade 6 geometry?

Learners demonstrated a lack of knowledge in this theme. Only one learner responded, L4: *Measuring when painting, measuring paints, measuring length.* L1 said it does not assist her, three learners, L2, L3, L6, said they don't know, and five learners, L5, L7, L8, L9, L10, did not respond.

4.2.2.8 Mathematical concepts identified by learners in Ndebele cultural artefacts

The theme explored learners' knowledge of mathematical concepts in the Ndebele cultural artefacts. Interviews with learners revealed several mathematical concepts found in Ndebele cultural artefacts. All ten learners who participated in the study could respond to the question. Similar views were shared during the interview with learners, for example:

L1 said 2D shapes, whereas other learners (L2, L5, L6, L7, L8, L9) gave examples of 2D shapes such as rectangles, rhombus, triangles, pentagons, hexagons, and octagons. L2 mentioned 3D objects, L2 and L6 mentioned lines of symmetry, and L7 and L8 included angles.

Examples of mathematical concepts beyond geometric concepts are L3-mentioned counting, estimation, and L4 and L5 geometric patterns. L2, L3 and L6 are the most commonly mentioned lengths.

4.2.2.9 Learners' views on how the mathematical concepts can be found in the Ndebele cultural artefacts help them in the learning of Grade 6 Geometry

The sub-theme explored learners' understanding of how mathematical concepts found in Ndebele cultural artefacts can help them learn geometry. Halve of the learners could respond positively to the question. L1 and L2 said mathematical concepts will help them understand and remember the content learnt. L2 could further indicate that the cultural artefacts are part of his culture and will help him remember them as he sees them daily. L3, L4, and L7 shared the same understanding.

On the other hand, half of the learners could not respond to the question. One learner said L5 said they couldn't help her, L6 said he was unsure, L8 was silent, and L9 and L10 said they didn't know.

The researcher probed learner responses further and asked them if I show you the Ndebele painting with (a) small and large rectangles and (b) triangles that are different, how will it assist you? And they responded, for example:

Only two learners mentioned enlargement and reduction (L2 and L3); L3 further indicated that she would never forget them because she sees them daily at home and around the surroundings, within the community, on wall painted and cultural artefacts. L4 indicated that it would teach him triangles of different sizes, triangles with sides of equal length, and those with lengths of sides different, whilst L1 mentioned that she would see shapes of various sizes. One learner, L7, noted that she will measure the sides and compare the length, which is the most critical step in identifying triangles. L8 did not respond to L9, and L10 said they didn't know.

4.2.3 Results from lesson observations

This section presents results from teachers' practices captured through lesson observations. One lesson observation was conducted for each of the five teachers participating. Lesson observations were conducted during August. The table below shows the teacher's observations, the number of learners in a class, and the date and time of lesson observation. According to CAPS (2011:6), Mathematics is allocated 6 hours per week. One of the five weekdays has two periods utilized to observe lessons.

Table 4.5: Schedule for lesson observations

Teachers	Grade observed	Number of learners	Date	Day and time scheduled
Teacher A	Grade 6	36	22/08/2022	Monday 08:00 – 10:00
Teacher B	Grade 6	40	23/08/2022	Tuesday 11:00 – 13:00
Teacher C	Grade 6	46	25/08/2024	Thursday 10:00 – 12:00
Teacher D	Grade 6	41	25/08/2022	Thursday 12:30 – 14:30
Teacher E	Grade 6	36	23/08/2022	Tuesday 08:00 – 10:00

Teachers and learners were assigned pseudonyms for identification during participation in lesson observations. Learners were numbered as they responded, such as Learner 1 (L1) and Learner 2 (L2). Teacher from school A is referred to as teacher A (TA), teacher from school B (TB), teacher from school C (TC), teacher from school D (TD) and teacher from school E (TE). When learners responded simultaneously, they were referred to as AL (all learners). The data from lesson observations were organized mainly into Learning content, using Ndebele cultural artefacts, Learner participation, interactions and communication, and learner assessment.

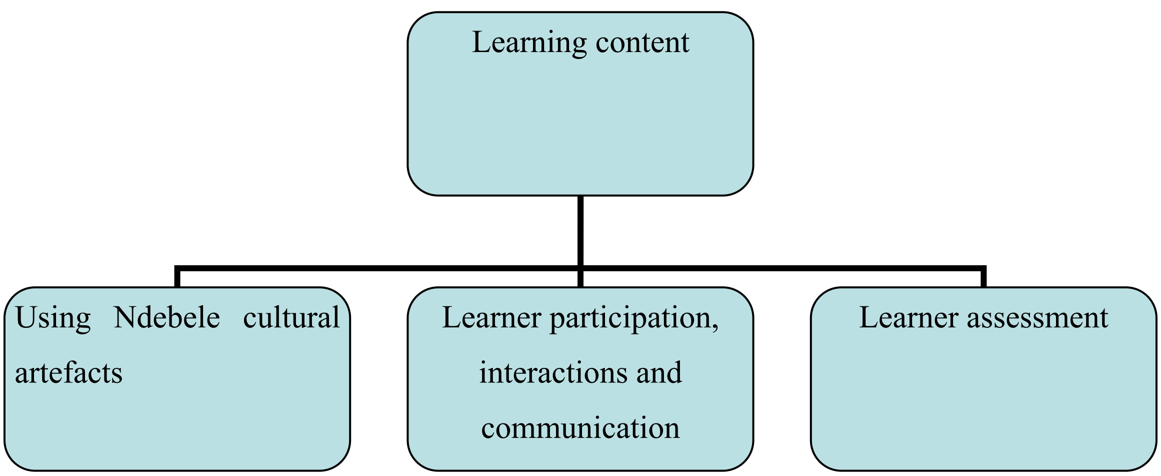


Figure 4.18: Summary of lesson presentation aspects

The observation schedule used has a rating scale of 1, which is not at all, 2 very little, 3 a little, 4 a lot to 5, which is great. The observation schedule was completed whilst conducting lesson observation in each of the five schools. Field notes were captured. I observed the lessons and noted new information in italics on the designed observation tool using designated spaces (cf

Appendices K, L, M, N, O). The focus of the observation was on the naming of cultural artefacts, identification of geometric shapes, using cultural artefacts, teaching and assessment activities, analysis of cultural artefacts, learners' participation, interest and excitement in learning geometry, learners' interaction, communication, using mathematical language and linking mathematics in the classroom to mathematics used at home when making cultural artefacts.

4.2.3.1 Learning content

The lessons demonstrated followed the RATP (2022) and CAPS (2011:212), which indicated that the focus was on the properties of two-dimensional shapes and transformation. Learners were taught the different types of 2D shapes, their names, number of sides, angles in 2D shapes and transformations.

4.2.3.2 Using Ndebele cultural artefacts in learning Grade 6 Geometry

Teachers, TA, TB, TD and TE, did not use Ndebele cultural artefacts when teaching learners properties of 2D shapes. No other concrete objects or teaching and learning resources, such as manipulatives, were utilized. TC learners brought along the cultural artefacts to the classroom. The educator used the Ndebele cultural artefacts as teaching and learning resources to teach the properties of 2D shapes. Learners were instructed to name the cultural artefacts, analyse them and identify 2D shapes in them, describe and sort 2D shapes in terms of their characteristics, analyse mathematical and geometric concepts in the cultural artefacts, and identify transformations used when decorating them.

4.2.3.3 Learner participation, interactions and communication

Teacher C used the question-and-answer method and discussion and investigation in teaching properties of 2D shapes. He asked his learners questions and encouraged them to discuss in groups of four while analyzing the cultural artefacts. A great deal of participation and interactions occurred in the TC classroom.

Learners from TA, TB, TD and TE classrooms were passive listeners. Their teachers told them the names of 2D shapes, explained the properties of 2D shapes and gave them a classwork to write. No questions were asked to test learners' understanding of the concept.

Below is an excerpt of how TC introduced his lesson to learners. The responses captured are from learners the teacher chose, among others, to respond to his question. They were labelled according to the order the teacher selected them to respond to.

> TC explained to learners: *We are going to learn about the 2D shapes from the objects that you are having. We are calling those objects Ndebele cultural artefacts.*

TC asked learners: *Can you tell us the names of the cultural artefacts you are having in your groups?* Most learners responded by showing their objects to the class, but the teacher selected only five to answer. Each of the five learners was given a chance to react whilst others were listening and observing the cultural artefact shown.

> L1: *Ibetje and Umkhala.*
>
> L2: *Ndebele necklace and Ndebele bangle.*
>
> L3: *Earrings.*
>
> L4: *Waist hoops and leg hoops.*
>
> L5: *Ndebele tie.*

TC: Do you like the cultural artefacts?

> AL: *Yes, teacher* (all learners).
>
> TC: Why do you like them?
>
> L6: *They are beautiful.*
>
> L7: *They portray our culture.*

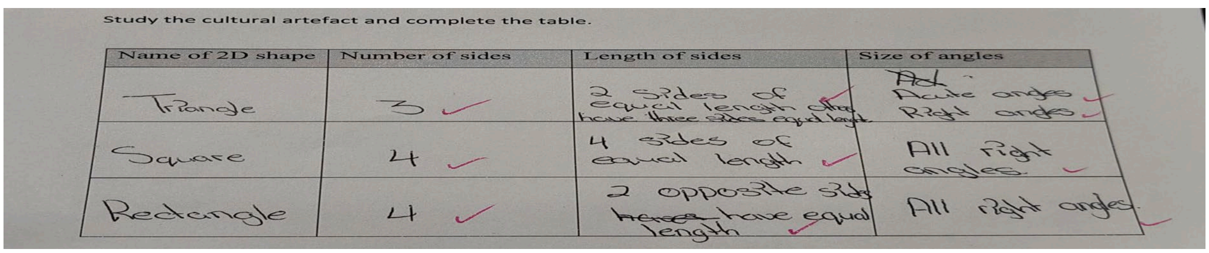
After the responses from the seven learners, TC continued with her lesson.

I found learners in the TC classroom seated in pairs. Their teacher instructed them to work in groups of four to allow for cooperative learning. Two learners from the front desk turned around to work with two learners behind their desks to form a group of four.

Learners brought cultural artefacts to the classroom, such as pictures of painted walls, headbands, necklaces, earrings, bangles, aprons (*ibetje*), and Ndebele ties. The learners' desks were arranged into four rows. Each of the four rows was allocated an activity (Four groups)

Group or row 1: To identify the 2D shapes on their cultural artefacts. The group had bangles, necklaces, and headbands (*Umkhala*) (the responses included squares, triangles, rectangles, hexagons, pentagons, and rhombuses. TC noted their responses on the chalkboard.

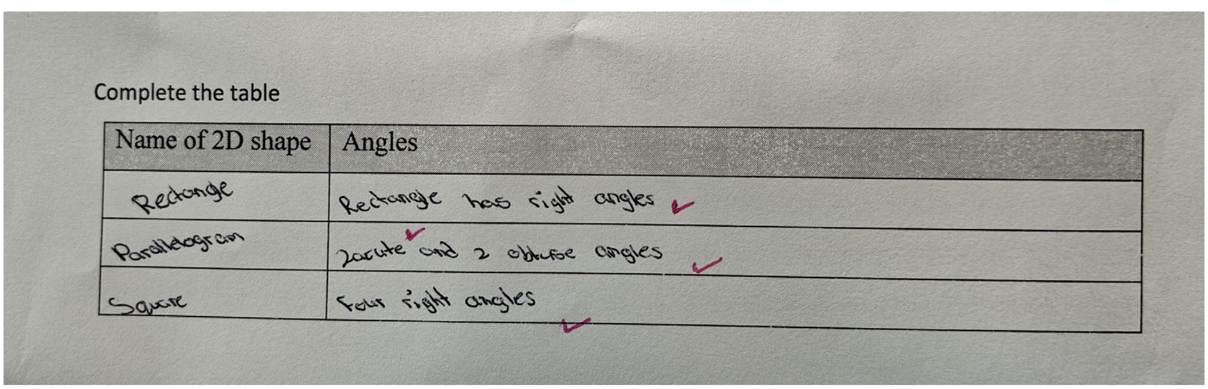
Group or row 2: Choose any three different types of 2D shapes on the cultural artefacts and complete the table. The team analysed the cultural artefacts and completed the table. Learners were given rulers to measure the length of the sides of 2D shapes (Table 4.19 below has answers showing learners' chosen shapes and completed information).


Study the cultural artefact and complete the table.

Name of 2D shape	Number of sides	Length of sides	Size of angles
Triangle	3	2 sides of equal length other have three sides equal length	Acute angles Right angles
Square	4	4 sides of equal length	All right angles.
Rectangle	4	2 opposite sides have equal length	All right angles

Figure 4.19: Example of learner responses from row 2

Group or row 3: Choose three different 2D shapes from the cultural artefact and recognize and name their angles.


Complete the table

Name of 2D shape	Angles
Rectange	Rectange has right angles
Parallelogram	2 acute and 2 obtuse angles
Square	four right angles

Figure 4.20: Example of learner responses from row 3

Group or row 4: To describe patterns by looking at lines of symmetry, rotations, reflections, and translations. The learners identified lines of symmetry, rotations, reflections and translations in bangles. TC wrote their responses on the chalkboard.

Probing was used when learners were busy with activities such as: What is happening in this mathematical activity? What resources are being used, what mathematical concepts are found, and what geometric concepts are found?

TC noted learners' responses on the chalkboard and gave all his groups 30 minutes to do their activity.

Figure 4.21: Learners' responses written on the chalkboard

4.2.3.4 Learner assessment activities

TA, TB and TE's assessment activities were irrelevant to ethnomathematical approaches. An activity from DBE Book 1, pages 54-55, was administered.

TD did not use cultural artefacts in his concept development; however, the assessment activity given was on the Ndebele wall picture, whereby learners were instructed to identify and name the 2D shapes and transformations. TC instructed learners to identify 2Ds and transformation on Ndebele cultural artefacts and reported back.

TC Learners analyzing Ndebele cultural artefacts during the Mathematics period.

TC teaching, using his hat decorated with Ndebele shapes

TD learners writing Informal assessment

Figure 4.22: TC and TD learners in the classroom

4.2.3.5 Learner performance in formative assessment

TC Learners demonstrated a lot of improvement when responding to geometry concepts, the informal assessment activity is written, and their response to questions; TA, TB, TD and TE showed minimal improvement in learner performance.

4.2.4 Presentation of results generated from interviews with Women Knowledge Holders'

This section presents the study results generated from semi-structured interviews with WKH. Individual interviews were conducted with each of the five WKH separately. Each woman was given a pseudonym followed by a numeral for identification to adhere to the ethical guidelines and ensure that participants' privacy rights are respected, i.e. W1, W2, W3, W4 and W5. The letter 'W' stands for Woman in this context. Based on the background information provided, numbering was assigned to women, which shows that W1, W2, and W3 have successfully established and grown their own thriving businesses.

On the other hand, W4 works with W2 and W5 with W3. WKH provided verbal consent to participate in the research study, acknowledging that their names and contributions may be featured and understanding that this could lead to opportunities for economic growth. A non-disclosure agreement was explained, and women opted for verbal consent, indicating their trust and willingness to share their expertise and cultural knowledge to benefit the research and their communities. In this study, the research question is denoted by 'RQ'. Questions were initially recorded in Isindebele and followed by the English translation in brackets for broader understanding.

The section starts by presenting the background information of each participant. Interview results will be presented for each of the WKH separately. The themes and sub-themes identified will be discussed. This section also features a map of Persia (modern-day Iran), a country personally visited by the four WKH (W2, W3, W4, and W5) to share beadwork and mural art techniques. The inclusion of the map aims to provide the reader with a visual understanding of the geographical context of the specific area said to be visited by WKH. The section also showcases a selection of Ndebele cultural artefacts, which women highlighted as significant examples of their products. These artefacts are also complemented by images of pieces found in the art galleries and at Kghodwana Cultural Village.

The Ndebele people have a rich history, with two main tribes which are the Ndzundza and Manala (also known as Kwamanala), having distinct cultural identities and artistic traditions, as evident in their unique mural art styles, which are showcased in this section highlighting the diverse and heritage of these creative communities.

4.2.4.1 Women Knowledge Holders' background information

This part presents the background information of WKH. The participants' background information was captured through a checklist completed with individual WKH separately to gain a deeper understanding of each team member's strengths and weaknesses and to maintain confidentiality and privacy (cf. Appendix R).

Table 4.6: Summary of Background Information for Women Knowledge Holders

ITEMS	W1	W2	W3	W4	W5
Level of education	Standard 10/Grade 12	Never attended formal schooling	Never attended formal schooling	Std 1/Grade 3	Standard 10/Grade 12
Age in years	41 – 50	>71	>71	61 – 70	51 - 60
No years/	18	>31	>31	25	26

experience in making cultural artefacts					
Mural art experience	None	>31	>31	25	26
Beadwork experience	18	>31	>31	25	26
Speciality/Area of focus	Ndebele Hats, T-shirts,	Ndebele Mural Art and Beadwork	Ndebele Mural Art and Beadwork	Ndebele Mural Art and Beadwork	Ndebele Mural Art and Beadwork
Own art gallery	No	Yes	Yes	No	No
Residential area	GaMabhoko	GaMabhoko	GaMatempule	Ga-Mabhoko	Ga-Matempule

4.2.4.1.1 Background information for Woman 1 (W1)

W1 stays at Ga-Mabhoko village in Mpumalanga Province under Dr JS Moroka municipality. The ga-Mabhoko community consists of people who speak both Sepedi and Isindebele. While both languages are spoken, most of the community predominantly speaks isiNdebele. As a custodian of Ndebele culture, she is a practitioner, an entrepreneur, and a knowledge keeper dedicated to preserving and promoting the rich cultural heritage of the Ndebele people. She is between 41 and 50 years old, has Standard 10 (Grade 12) and has learnt mathematics up to Standard 8 (Grade 10). She has a different particular focus for her business. She makes hats and shirts, which are worn at initiation ceremonies. She sells them to make a living as she is currently unemployed.

4.2.4.1.2 Background information for Woman 2 (W2)

The participants included a prominent lady known as Ms Sophy Mahlangu. She is referred to as W2 in the study. W2 is the custodian of Ndebele art and has an outstanding knowledge of Ndebele cultural artefacts. She is also a resident of Ga-Mabhoko, a woman between the ages of 71 and 80 who has never attended formal schooling. She is a multifaceted talent who excels as a practitioner, educator, and mentor, utilizing her innate intellectual abilities to train and empower unemployed youth, and she holds a Grade 12 certificate. Her primary objective is to use her knowledge to uplift the community, focusing on poverty alleviation and job creation by empowering young people to turn their passion for beadwork and mural art into sustainable livelihoods. It was interesting to find that besides Dr Esther Mahlangu, other prominent ladies know Ndebele cultural artefacts, W2 being one of them. She had the privilege of working alongside the legendary Dr Esther Mahlangu, learning from and contributing to creating stunning beadwork and mural art pieces that showcase the beauty of Ndebele culture and heritage.

She highlighted Ngaya eJapan, Persia ukuyo gwala nokuyophothela umncamo [she said she went to Persia and Japan to paint and beadwork].

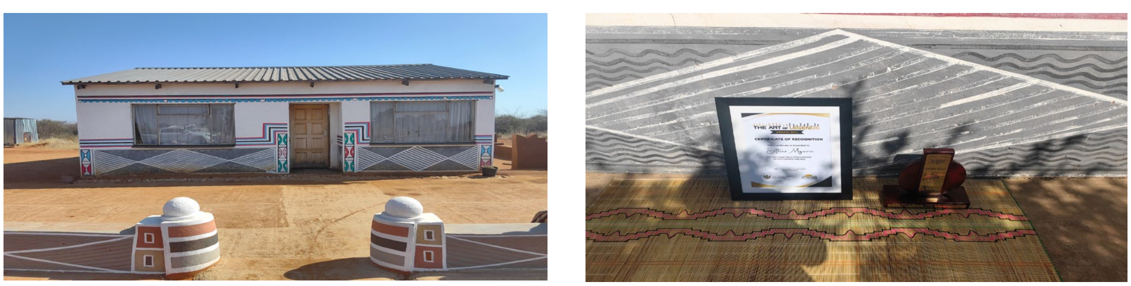
W2 mentioned that she is the founder of Kghodwana Cultural Village in the Nkangala region in the western part of Mpumalanga Province. She said that she painted the houses and walls of Kghodwana Cultural Village using the Manala and Ndzundza painting style and made the beadwork displayed for tourists at Kghodwana Cultural Village. She currently has her art gallery exhibiting and selling Ndebele cultural artefacts. I visited Kghodwana Cultural Village to see the houses and walls she painted and her beadwork displayed for tourists (cf. Chapter 2)

According to SA News (2024), President Ramaphosa bestowed National Orders at Sefako M. Makgatho Presidential Guesthouse in Tshwane on the 30th of April 2024. W2 is one of the awardees of the Order of Ikhamanga 2024 Silver recipients. Order of Ikhamanga symbolises the unique beauty of the achievements of South Africans in different categories such as creative arts, culture, literature, music, journalism and sports. The order can be awarded in three categories, i.e. Category 1: Gold, Category 2: Silver and Category 3: Bronze. Sophy Msoziwa Mahlangu was awarded Silver (category 2) for her excellent contribution to Indigenous Ndebele arts and dedication to transferring knowledge of Ndebele culture to younger generations (SA News, 2024).

Figure 4.23: W2 awarded by President (SA News, 2024)

4.2.4.1.3 Background information for Woman 3 (W3)

WKH 3 is also a custodian of Ndebele culture, a practitioner, and an entrepreneur in Ndebele mural art and beadwork, with more experience and broad information about the Ndebele cultural artefacts. W3 stays at the Matempule village, which is between Loding and Marapyane under Dr JS Moroka Municipality. Matempule has a mixture of people speaking Isindebele and Sepedi. W3 is a woman between the ages of 71 and 80 who has never attended formal schooling. Esther Mguni founded Sibunjwa Fine Art, Pottery and Beadwork in Troya, also known as (Matempule). She is one of the Women who painted the Kgodwana Cultural Village. She has a daily register of visitors to her art gallery, which is kept as evidence of safety and control measures and monitored by her daughter. She also offers training to other women who are interested in Matempule village. W3 indicated that she worked with Doctor Esther Mahlangu. She also mentioned that she went to Persia (Iran) and Japan to do beadwork and mural art, and she was accompanied by her daughter, who works collaboratively and cooperatively with her.



W3 Art Gallery walls feature murals in the traditional Manala art style, distinguished by flowing curved and straight lines, which she refers to as the 'waves of the sea.'

Legendary awards obtained: 2024 (from Department of Culture, sports & recreation Mpumalanga)

Figure 4.24: W3 Art Gallery and Legendary Award obtained in 2024

The work above exhibits advanced mathematical ideas and geometric shapes, demonstrating the natural knowledge, talent and expertise of W3 despite having no formal schooling.

4.2.4.1.4 Background information for Woman 4 (W4)

Woman number 4 mentioned that she was trained by Ms Sophy Mahlangu (W2). She is also an entrepreneur in mural art, and she is knowledgeable and experienced. She is a woman between the ages of 61 and 70 years. She has Standard 1 (currently known as Grade 3) and has studied mathematics up to Standard 1. According to W4, Ms Sophy Mahlangu (W2) was supposed to go to Persia, but unfortunately, due to other commitments, she could not make it on her trip. She then called her for training on Ndebele mural art and beadwork so she could go on her behalf. W4 indicated that she started by painting a small area like a rigid board the same size as a box of tomatoes and later proceeded to the wall used for practising Ndebele mural art using feathers. She then went to Persia on behalf of W2. She is a colleague at the art gallery and a neighbour to W2, making their relationship a dual one.

4.2.4.1.5 Background information for Woman 5 (W5)

Woman number 5 is a daughter of W3. She is also a practitioner entrepreneur in Ndebele mural art and beadwork and has experience and more information about the Ndebele cultural artefacts learnt from her mother. She is a woman between the ages of 51 and 60 years. W5 has a Standard 10 certificate (currently known as Grade 12) and has studied mathematics up to Grade 9. She indicated that W3 taught her mural art and beadworks, that she started learning to paint using a rigid box, and then proceeded to walls using feathers. She also indicated that she accompanied her mother (W3) to Persia and Japan to do beadwork and painting. W5 works with her mother at the art gallery on their additional plot, immediately outside the yard. She also assists her mother in training other women interested in Matempule village.

4.2.4.2 Presentation of results from individual Women Knowledge Holders

The responses from each woman were captured and included in the findings to avoid generalizing and provide a more comprehensive understanding of ethnomathematics, IK and WKH. The aim was to highlight their individual experiences and perspectives, which were found to be different, to showcase the diversity of their background and viewpoints and to emphasize their unique contributions. This demonstrated that each woman's experience is relevant and valuable. The five women were interviewed for 50 to 60 minutes following the attached interview programme below. The time and venue for the interview were suggested by w based on their availability for interviews.

Table 4.7: Programme of Interviews for Women Knowledge Holders

PARTICIPANT	DATE	VENUE	TIME
WKH 1	24/06/2022	Empty Classroom (TE) School	08:00 - 09:00
WKH 2	29/06/2022	W2 Art Gallery at Ga-Mabhoko	16:00 - 17:00
WKH 3	07/07/2022	W3 Art Gallery at Ga-Matempule	15:00 - 14:00
WKH 4	29/06/2022	W2 Art Gallery at Ga-Mabhoko	11:00 - 12:00
WKH 5	07/07/2022	W3 Art Gallery at Ga-Matempule	12:00 - 13:00

The concept of geometry and geometric shapes was explained to WKH before commencing with the interviews and FGDs so they could clearly understand the question on geometric shapes and respond appropriately. It was explained to Women that geometry is the branch of mathematics concerned with the shape of individual objects. It is the study of flat surfaces and three-dimensional objects (Encyclopedia Britannica, 2024). In geometry, we study the sizes, shapes, Positions, angles, and dimensions of shapes. Examples of two-dimensional shapes in geometry are squares, rectangles, and triangles (SplashLearn), called geometric shapes. Explanation was given while pointing at the wall painted so that participants could clearly understand using pictorial representation.

WKH was allowed to use the language with which they were comfortable. The interview was conducted with four women (1, 2, 3 and 5) using their home language, Isindebele. Women 4, whose native language is Setswana, revealed that although she is proficient in both Setswana and

Isindebele, she prefers speaking Isindebele, as it has become her language of daily life at home with her Ndebele husband, children, inlaws and neighbours since she was married 30 years ago. She feels more comfortable communicating in it. I have the basic knowledge and understanding of the isiNdebele language, which made the interaction possible and interesting. In addition, I was accompanied by one of the educators whose home language was Isindebele to ensure clear pronunciation of words and that data presented by knowledge holders was captured accurately for translation. Transcripts were translated into English.

Probing questions encouraged women to share more detailed and thoughtful responses, fostering a deeper understanding of their experiences. The presentation used Direct quotations from participants as raw information to give in-depth, detailed descriptions of women's viewpoints. Women's interviews were transcribed verbatim. The researcher familiarized herself with the data collected by reading and re-reading transcripts and presenting transcriptions of verbal data from interviews in written form. Patterns were searched across the entire data set. Sentences describing similar ideas were highlighted and given codes. Several related codes across the data set were combined to make up themes and sub-themes. Themes and sub-themes are presented in the Table below:

Table 4.8: Themes and Sub-themes

THEMES	SUB-THEMES
Making cultural artefacts	❖ Names of different Ndebele cultural artefacts ❖ Ndebele cultural artefacts *that woman can make* ❖ The process of making the cultural artefact ❖ Shapes used in making the cultural artefact ❖ Significance of shapes used
Knowledge of cultural artefacts	❖ Process of acquiring knowledge and skills ❖ Transfer of knowledge
Mathematical concepts	❖ Mathematical concepts found in Ndebele cultural artefacts ❖ The use and mastery of mathematical concepts at home to help learners learn geometry at school ❖ The support to schools on using mathematical concepts to help learners learn geometry

	❖ Importance of using mathematical concepts in Ndebele cultural artefacts in the learning of geometry

a) Interview with Woman 1 (W1)

The excerpt reported below is on the interview that was conducted with Woman 1 (W1)

Names of different Ndebele cultural artefacts

RQ: *Yiziphi izinhlobo ezahlukene zobuciko zamasiko zamaNdebele ozaziko?*

[What are the different Ndebele cultural artefacts that you know?]

W1: *Inaka lenziwe ngeskhumba senyamazane, Iphephethu, Isthimba, Isiviko***.**

[*Inaka* made of animal skin worn by men, *iphephethu* is a rectangular beaded apron for matured Ndebele women, *Isithimba* – a piece of cowhide used to cover the lower back of a maiden and a shield].

Ndebele cultural artefacts *that woman can make*:

RQ: *Ngiziphi izinto zamasiko wamaNdebele ongakwazi ukuzenza*?

[Which Ndebele cultural artefacts are you able to make?]

W1: *Isikipa nengwani njenge skotaiki esimbathwa bomma nabobaba ngeskhathi seminyanya wamaNdebele emphakathini.*

[T-shirts and hats worn by mothers and fathers during celebrations for Amandebele community.]

The process of making cultural artefact:

W1 uses modern tools such as wool and needles to make Ndebele hats. W1 indicated that she was also using a sewing machine, which is currently not in good condition. She explained that she could not fix it due to a lack of funds and that she had tried to look for a second-hand machine with no success.

RQ: *Uwenza njani amasiko wakho wesiNdebele? (How do you make your Ndebele cultural artefacts?)*

W1: *Ngiberegisa manalidi amabili newulu. Nginomtjhini kodwa awukho ebujameni obuhle futhi awutholakali lula, ngiqale ezitolo kodwa angiwutholi. Ngiyabala, ngisebenzisa 2s, kubili ikhona* *elinye nelinye ngisebenzisa imida eyisithupha (6) ukwenza i-rhombus ngobukhulu / ngesayizi efanako, hlela ngokukhambisana kwemibala eluhlaza okwesibhakabhaka, onzima nobukhobe okumibala wamaNdebele, ukulinganisa kuyasetjhenziswa godi.*

[I use two needles, and a wool. I have a knitting machine but it is not in good condition and not easily obtained, I count, I used 2s, 2 on each corner and 6 on the lines to make rhombus of the same size, arrange according colours that is blue black and pink, which are the Ndebele colours, Estimation is also used.]

Shapes used in making the cultural artefact:

RQ: *Ngimaphi amajamo aberegiswako lapho kwenziwa ubukghwari / ubuciko bamasiko wesiNdebele?*

[Which shapes are you using when making Ndebele cultural artefacts?]

W1: *Isiyingilizi, idayisi, iqatjhazi, oncantathu, imida, i-rhombus.*

[Circle, dice, dots, triangles, lines, rhombus.]

Significance of shapes used :

RQ: *Kubaluleke kangangani ukuberegisa lawo majamo kumasiko wesiNdebele?*

[What is the significance of using those shapes in your Ndebele cultural artefacts?]

W1: *Abadala abwasebenzisi amagama esiwafunde esikolweni, bavele bawabize ngobujamo, mhlambe abadala banezizathu kodwa bawabiza ngokuthi umhlobiso wamagwalo.*

[The elders don't use the names that we learned at school. They just call them shapes. Maybe elders have reasons, but they call them decorations.]

W1 mentioned that the concepts elders use are different from those used at school when learning mathematics.

Knowledge of the cultural artefacts and the process of acquiring knowledge and skills:

RQ: *Wathola njani begodi wathola nini ilwazi nekghono lokwenza izinto zobukghwari / zobuciko zamasiko?*

[How and when did you acquire knowledge and skills of making the cultural artefacts?]

W1: *Ngathola ilwazi lokuthunga esikolweni (imisebenzi/imiberego yenalidi) la pha eskolweni samabanga aphasi.*

[I acquired knowledge of knitting from school Needlework in primary school as it was compulsory.]

RQ**:** *Wathoma nini ukwenza izinto zamasiko wakho wesiNdebele?*

[When did you start making your own Ndebele cultural artefacts?]

W1: *Esikhathini sakade. Ngithengisa iingwani neenkipa zesiNdebele, okwanje iingwani ngizo ezithengisa khulu ngombana abantu balungiselela iminyanya yengoma.*

[Long time ago. I can't remember the year clearly. I sell Ndebele hats, shirts and T-shirts to make a living. Currently, hats are fast selling because people are preparing for celebrations to welcome initiates.]

Transfer of knowledge:

RQ: *Ulidlulisela njani ilwazi nekghonolakho ebantwaneni bakho, abomakhelwana noma ebantwini abanetjhisakalo?*

[How do you transfer your knowledge and skills to your children, neighbours or people with interest?]

W1*: Ngazama ukufundisa abentwana besikolo ukuthunga, babaleka namawula wami namanalidi wokuthunga, bengibafundisa mahala, eqinisweni angifuni ukutjhiya umhlaba lo ngikhambe nelwazi enginalo ngingakalabeli abanye abantu.*

[I tried to teach learners knitting, they went away with my wools and cross needles, I was teaching them free of charge. My aim is not to leave this world with my knowledge without sharing it with other people.]

RQ: *U zamile ukuthola abentwana besikolo ababalekile ukuthi isizathu yini?*

[Did you try to look for those learners to get their reasons?]

W1*: Iye, kwazile bangitjela ngemiberego eminingi nakuphuma isikolo begodu bafuna isikhati sakudlala nabangani babo.*

[Yes, I did. They told me that is because they have lots of homeworks to do after school and they also need some time to play with friends.]

Mathematical concepts found in Ndebele cultural artefacts:

The excerpt below explores W1's knowledge of mathematical concepts in the Ndebele cultural artefacts. W1 could mention the concepts in CAPS that our Grade 6 learners currently use.

> RQ: *Ucabanga ukuthi zikhona izibalo zesikolo hlangana kwamasiko wesiNdebele?*
>
> [Do you think that there is school mathematics within the Ndebele cultural artefacts?]
>
> W1: *Iye, nakanjani kukhona.*
>
> [Yes, absolutely there is.]
>
> RQ: *Ngimiphi imiqondo yezibalo etholakala hlangana nobukghwari / nobuciko bamasiko wesiNdebele?*
>
> [What are the mathematical concepts found in Ndebele cultural artefacts?]
>
> W1: *Ama-engeli, oncantathu, isiyingilizi, imida.*
>
> [Angles, triangles, circles, lines.]

W1 explained, looking at the wall painted, and said that their decoration is made of triangles, circles, diamonds, chevrons and zigzags.

The geometric concepts were mentioned by W1 and translated into English for the reader using the Isindebele/English dictionary. Given her background in mathematics, she could draw upon her knowledge of mathematics concepts up to Grade 10 to support her argument. She also indicated that elders are not using the concepts used at school, which reveals her ability to interpret and translate shapes elders use into the language of mathematics.

The use and mastery of mathematical concepts at home to help learners learn geometry at school:

The report below is from the interview conducted with W1.

> RQ: *Singaqinisekisa njani ukuthi ubuhlakani bemiqondo yezibalo ezintweni zobukghwari/zobuciko bamasiko ekhaya ukuze sirhelebhe abafundi ukuthi bafunde i-geometry esikolweni?*
>
> [How can you ensure the use and mastery of mathematical concepts in cultural artefacts at home to help learners learn geometry at school?]

W1: *Ngingasebenzisa umncamo ukufundisa abafundi ukubala, ukuhlanganisa, ukukhipha nokuhlukanisa.*

[I can use beads to teach learners counting, addition, subtraction, multiplication and division.]

The support to schools on using mathematical concepts to help learners learn geometry:

The interview excerpt below reflects on the views from W1 on the support that she can provide to schools on using mathematical concepts found in the cultural artefacts.

RQ*: Singazirhelebha njani iinkolo ukuthi kuberegiswe imiqondo yezibalo kubukghwari/kubuciko bamasiko, ukuze sirhelebhe abafundi bafunde i-geometry?*

[How can you support schools to use of mathematical concepts in cultural artefacts to help learners learn geometry?]

W1: *Ngicabanga ukuthi ngingasiza abafundisi ukuthi zihlobaba njami izibalo ezenziwe eklasini nezibalo ezenziwa emakhaya.*

[I think I can help teachers to relate mathematics done in the classroom with the mathematics done at home.]

The researcher probed W1 to explain her thinking.

Researcher*: ungakwazi ukusitjela ukuthi ugenza njani?*

[Can you tell us how you will do it?]

W1: *Ngingasiza abafundi ngezibonelo zemisebenzi okufanele bayisebenzise ekufundiseni kwabo. Imisebenzi okufanele uyihlole eklasini.*

[I can help teachers with examples of activities to be used in their instruction, activities to explore in the classroom.]

Importance of using mathematical concepts in Ndebele cultural artefacts in the learning of geometry:

RQ*: Kubaluleke ngani ukusebenzisa imiqondo yezibalo emgwaleni yamasiko esiNebele ekufundweni kwe-Geometry?*

[What is the importance of using mathematical concepts in Ndebele cultural artefacts in the learning of geometry.]

W1: *Imiqondo yezibalo kobuciko besiko izosiza abafundisi nabafundi ukuthi bamukele ubujamo bamasiko wesikolo.*

[Mathematical concepts in cultural artefacts will help teachers and learners to embrace the school's cultural context.]

b) Interview with Woman 2 (W2)

Names of different Ndebele cultural artefacts:

RQ: *Yiziphi izinhlobo ezahlukene zobuciko zamasiko zamaNdebele ozaziko?*

[What are the different Ndebele cultural artefacts that you know?]

W2: *Ukuphothela, ukugwala, isirholwani. Umkhala umbathwa ngengoma ukutjhengisa bona ikosi ithabile nathi sithabile. NgesiNdebele nawumbethe Umkhala njengomma kulungile noma ungakathwali litho ehloko.*

[Beadwork and painting, *isirholwani* is a thick beaded necklace, and *Umkhala* is worn during initiation to show we are happy. According to isiNdebele, if you have *Umkhala* on it's fine even if you have nothing on the head as a woman.]

Ndebele cultural artefacts *that woman can make*:

The interview excerpt below reflects on Ndebele cultural artefacts that W2 can make. She is actively involved in both mural art and Beadwork. W2 Art Gallery showcases different cultural artefacts. She indicated that she has several orders to prepare for her clients. Pictures were taken with her permission.

RQ: *Ngiziphi izinto zamasiko wamaNdebele ongakwazi ukuzenza?*

[Which Ndebele cultural artefacts are you able to make?]

W2: *Yoke imikhiqizo yomncamo Kanye nokugwala, ukuluka umseme. Nangabe uyakwazi ukuphothela nokugwala, noma bangakunikela into etjha ukuyenza, uzokwazi ukukwenza*

[All beadwork products and painting, making pillows, If you know beadwork and painting, even if they can give you a new thing to do, you will be able to do it.]

The process of making cultural artefact:

RQ: *Uwenza njani amasiko wakho wesiNdebele?*

[How do you make your Ndebele cultural artefacts?]

W2*: Emandulo besisebenzisa ihlabathi nasigwalako. Slongwe semlanjeni, ubumba lezi zeskhathi sanje bezingekho. Ibloisela yayiberegiswa /yayisetjhenziswa ukuba mbala ohlaza kwesibhakabhaka. Abathengi bethu bafuna imibala egcwele ekhanyako. Ukugwala: sisebenzisa iinsiba. Njalo vasa isiba emuva kokulisebenzisa kumbala omunye.*

[We were using clay soil to paint, but these current ones were unavailable. Blousel was used for blue colour. Our clients need bright full colours, painting we use feathers. Always wash the feather after using a certain colour.]

W2, when asked why she uses feathers to paint, she reasoned that there were no paintbrushes in the past, and that she was taught how to paint by her mother using a chicken feather.

Ngi beregisa amasiba ukupenda ngoba ngeskathi esidlulileko bowangekho amabhrhratjhi, wa fundiswa ukupenda ngunina. Simeda ngokulinganisangamehlo. Sisebenzisa isandla, imino imino eyikhomba nothubhakghuru oluliweko, njengobude ofuna ukugwala ubujamo ngakho. iRobho ibuye isetjhenziswe ukumeda ubude beboda, bhinca irobho phakathi (uyibophe) ukuze uyijamise phakathi, khona-ke uzokwazi ubujamo efanele ubugwale / ubudwebe. Imida elinganiseneko isebenza njenge-dermacation, nebhosolo yokudweba/ yokugwala, ukuze umgwalo wakho unembeke, ukulinganisa kuyasetjhenziswa, kusetjhenziswa ngamehlo ukuqiniseka ukuthi imida inqophile. Abentazana bayavunyelwa bona basebenzise irula, isiba, ibhosolo nentambo/irobho. Intambo ifakwa phakathi kwepende bayisebenzisa njengomzila wokuyikghama, imida kufanele ibe nobukhulu obufanayo (ubudege) futhi inqophe.

[We measure through estimation. I use my eyes to estimate. Uses a hand span, seven fingers and a thumb stretched according to the length you want to draw a shape. Rope is also used to measure the length of the wall; fold the rope in the middle, tie it to determine the centre, and then you will know the shapes to draw. The parallel lines serve as demarcation; water passes; for your painting to be accurate, estimation is used, using eyes to ensure straight lines. The young ladies are currently allowed to use rulers, feathers, paintbrushes and a rope. A rope is placed into the paint and used like a choke lane. The lines must be of the same thickness (breadth) and be straight.]

W2 explained that she permits young ladies in her mural art training to utilize paintbrushes and rulers. When questioned about her new approach, she mentioned that it is a time-saving measure, and the ladies advised her that it works faster with modern tools.

W2 (with focus on beadwork):

Umncamo: uyawukhetha umncamo hlela ngokombala, dobha ngayinye ngayinye, hlukanisa umncamo ngokuya ngemibala. Umkhala: meda ihloko ngentambo/ngerobho, ibhince ujamisa phakathi. Kubala kusebtjhenziswa u1, 2,3,4,5 okubusako. Esinye siyafika kwikhulu linye (100) kuyango mfanekiso ofuna ukuwenza, usebenzisa ukuhlanganisa nokukhipha, uthatha oyisithupha (6) uhlanganise nomunye oyisithupha (6) iyokunikela itjhumi nambili (12), itjhumi nesithupha (16) uhlanganise netjhumi nesithupha (16) iyokunikela amatjhumi amathathu nambili (32), kumfanekiso noma ekutlanyweni kwakhe 8,6,4, 2, ukubala ubuyele emuva ngambili (2).

[Beadwork: you sort your beads according to colours, pick up 1 by 1, sort the beads according to colours. *Umkhala*: measure the head with a rope, fold it to determine the centre. Counting is used,1 2,3,4, 5 are numbers that are dominantly used. From one to hundred depending on the pattern you want to make, you use addition and subtraction, you say 6 plus another 6 it gives you 12. The next pattern is 16 plus 16 gives you 32, in her pattern or design 8;6;4 2; counting backwards in twos or each time subtract 2.]

RQ *Ngenye indlela ungakwazi ukubalana?*

[In other words, are you saying you know how to count?]

W2*: Iye. Ngingakwazi ukubala ukubala kufika ekhulwini (100).*

[Yes. I can count up to 100.]

Shapes used in making the cultural artefacts:

RQ: *Ngimaphi amajamo aberegiswako lapho kwenziwa ubukghwari / ubuciko bamasiko wesiNdebele?*

[Which shapes are you using when making Ndebele cultural artefacts.]

W2: *Ipewulani, drie hook, Umkhonto, ehlaba, Isirayithoni, elihlo, ufilisi, Isirayithoni esine pewulani (ilihlo ukudosa ukunaka kwabantu, ukubona, kumele kuvaleke, ilihlo lingaba namahugu amane, ukukhanyisa, Isirayithoni esinamastepisi, itjhefana, ngaphakathi kwelihlo elinamahugu amane, iketani, uberegisa wakho umtlami ngaphambi kokuthi ugwale ngaphasi, ufaka istimela ngaphezulu, uthoma ngokufaka iketani, kuya ngokuthi ufuna muphi umfanekiso, ungasebenzisa iputumende igama elithethwe kubhoduluko, izinto ongazisebenzisa usekhaya, isuthikhesi or makasana, Ufilisi, Ipewulani bujamo obuvelele, ukufaka phakathi, uzig zag, mbatanga.*

[Shape with three corners and a sharp arrow, eye to attract people's attention, it must be closed, an eye it can have four corners to make it bright or attractive. *Isirayithoni* with steps resembles a raisor blade. You think of your own design before you paint. You start with a chain, it depends on your own design, you can use things that we use at home (*isuthikeisi* or *makasana*) suitcase or kists. W2 said *Filis*i is the name taken from cards, that dominant shapes used are (*drie hook*) shape with three corners including zig zags and lines].

Ungafaka okunye ukubunjwa kokudala futhi uy thiye wakho amagama akutjho ukuthi ajamele isiNdebele, ubujamo obunamahugu abukhali.

[You can include other creative shapes and give them your names, not that they represent isiNdebele, shapes with sharp corners.]

Significance of shapes used:

RQ: *Kubaluleke kangangani ukuberegisa lawo majamo kumasiko wesiNdebele?*

[What is the significance of using those shapes in your Ndebele cultural artefacts?]

W2: *Ukuze uqiniseke ukuthi isko lesiNdebele, liyakhambisana, uzoqaphela ukuthi lomuntu uyakwazi ukugwala. Kumatshwayo wesiko lesiNdebele, umgwalo wakho wesiNdebele kumele ube nepewulani, drie hook, makasana, Umkhonto, ufilisi, itjhefana, Isirayithoni ukukhomba/ ukuveza ukuthi ngeyesiNdebele***.**

[To show that it is Ndebele culture. You will realize that this person knows how to paint. Your Ndebele mural art must have three corner shapes, kists, arrows, *ufilis*, and *israeton* with an arrow to show that it is for Isindebele.].

I could not find the English word for some of the words such as *ufilis*, *itjhefana* and *Isirayithoni*; however, *ufilis* looks like a rhombus, *drie hook* looks like a triangle, and kists look like a rectangle.

Process of acquiring knowledge and skills:

The excerpt below explores how W2 acquired her knowledge and skills in making the cultural artefacts. It also reveals a time when knowledge was acquired. W2 is highly experienced because she acquired knowledge from her mother at the age of 10 years. She has been in practice from the approximated age of 10 years to date. She started practising by painting at the back of the house and now has her own art gallery in the yard.

RQ: *Wathola njani begodi wathola nini ilwazi nekghono lokwenza izinto zobukghwari / zobuciko zamasiko?*

[How and when did you acquire knowledge and skills of making the cultural artefacts?]

W2: *Ekhaya, ngikhule ngibona umma aphothela, nalokha nakagwalako, bengimsiza ngokuphothela, ngathoma ukugwala ngemva kwendlu wathi nakabona bona sengyakwazi ukugwala wafuna bona ngigwale ngaphambili. Idizayini/umtlamo awuwuplani sekuziqabangela wena ngokuya kwekghono lakho. Uyawatjhentjha amadizayini uziqabangele ngokwekghono lakho. Kumnandi ukuzicabangela umgwalo. Ngathoma ukufunda ukuphothela nokugwala nangisathoma ukufunda ukupheka. Ngicabanga bona benginesumi leminyaka.*

[At home, I grew up observing my mother doing beadwork and painting; I also assisted her with beadwork. I started painting at the back, and when she realised I could paint, she wanted me to paint at the front. You don't plan the design. It is all about being creative. You keep on changing the design spontaneously through creativity. It is nice to create and paint. I started to learn beadwork and painting whilst I started learning to cook. I think I was 10 years old.]

RQ: *Ngubane ofundise umamakho?*

[Who taught your mother?]

W2*: Umma wami naye ufunde kummakhe. Azange khengiye eskolwani eseza namakhuwa. Abentwana bethu abakuthandi ukuvunula iskhethu. Kade thina besihlala sivunulile. Nayidabukileko bekumele uzilungisele wena. Beku ngandeleka ukuthi ube nelwazi loku phothela.*

[My mother learned it from her mother. I never attended any schooling. Our kids don't like wearing traditional clothes. In the past, we were to wear them every time. If worn out, you were supposed to fix it yourself.]

W2 said the reason for the transfer of knowledge was for them to be able to fix their clothes or make new ones if worn out.

RQ: *Wathoma nini ukwenza izinto zamasiko wakho wesiNdebele?*

[When did you start making your Ndebele cultural artefacts?]

W2: *Khengaberega eKghodwana cultural village. Ngimi uwayithoma phasi, sisandla sami. Ngimi owakha bewagwala izindlu leza zeskhethu ezihluke ngokuya kweminyaka (Ngodwana) nale yanje, lapho sithome khona sisebenzisa ihlabathi ngombana bekungakabi neempende. Ngenza nezinye izinto zeskhethu ebazibeke lapho zizokubukelwa babantu abavakatjhileko. Ngithethe umhlala phasi. Ngathoma indowo yokukhangisa imisebenzi yam ingo-2003.*

[I worked at Kghodwana Cultural Village. I am the one who started it from scratch, my own creativity. I am the one who built and painted those cultural houses that are different according to different years/ages, including the current one, from where we started using soil, as there were no paints. I also made the cultural artefacts that are on display for tourists. I am on a pension. I started my own art gallery in 2003.]

Transfer of knowledge:

RQ**:** *Ulidlulisela njani ilwazi nekghonolakho ebantwaneni bakho, abomakhelwana noma ebantwini abanetjhisakalo?*

[How do you transfer your knowledge and skills to your children, neighbours or people with interest?]

W2 explained displaying confidence:

*Ngibamba izifundobandulo zokuphothela nokugwala, ipende mahala. Ngifundise abomma emphakathini wangekhethu. Begodu ngifundise nabantwana beskolo eenkolweni ezahlukahlukeneko. Kuthi laba abanekareko beze ngizobafundisa ngokuzeleko. Bazokuthoma ngokugwala amatekisana. Ngimi wokuthoma owakwazi ukuphothela nokugwala endaweni le. Ngifundisa nabantazinyana, ngombana sesibadala begodu zizokudlula emhlabeni, kufuze sabele abanye ilwazi ukuze isiko lethu lingatjhabalali. Ngathatha abomma ebengibafundisa ngabasa e-Kgodwana ukuyokugwala izindlu, besiyokuvuselela imigwalo. Laba abasebatjha ekugwaleni bathoma ngokuvuselela imigwalo, ngemva kwalapho kufuze baziqabangele, bazizele nemigwalo emitjha nentayela zabo. Laba esele banelwazi lokugwala bazokugwala izindlu kusukela phasi. Kufuze basebenze ukuze bathole imali. Nginesiqhema sabomma abanamakghono, sesibuya ne France ne- Embasy of the United States of America nasePitori. Onyakeni lo ngo-March ngathatha abantwana ngabasa eKgodwana bayokugwala ngombana bengibona bona bayathuthuka***.**

[I conduct workshops on beadwork and mural art and offer free paints. I trained women around my community and learners at various schools; those interested will come and obtain full training. They will start by painting sneakers. I was the first one to learn about beadwork and mural art here. I also train little girls because we are old, and one will be gone. We have to share knowledge so that our culture is not extinct. I took ladies I trained to Kghodwana Cultural Village to paint houses and renew painting. New ones start by copying renew. After that, they must be creative, come up with new things, and develop their own styles. Those with knowledge will paint houses from the start. They must work so that they can get money. I have a team of ladies

> with skills. We are already from France, and the Embassy is in Pretoria. During this year, in March, I took learners to the Kghodoana Cultural Village for painting and realised there was progress.]

In her response to the question, W2 demonstrated extreme confidence, showing a profound understanding and experience sharing her skills, expertise and knowledge in working with people of all ages. She is passionate about empowering others and confident in her knowledge of cultural artefacts.

Mathematical concepts found in Ndebele cultural artefacts:

> RQ: *Ucabanga ukuthi zikhona izibalo zesikolo hlangana kwamasiko wesiNdebele? (Do you think that there is school mathematics within the Ndebele cultural artefacts).*

W2: *Iye***.**

[Yes.]

RQ: *Ngimiphi imiqondo yezibalo etholakala hlangana nobukghwari / nobuciko bamasiko wesiNdebele?*

[What are the mathematical concepts found in Ndebele cultural artefacts?]

W2*: Kukhona ukungezelela nokukhipha, ukuphindaphinda nokuhlukanisa, ukubala.*

[There is addition and subtraction, counting.]

The mastery of mathematical concepts at home to help learners learn geometry at school:

RQ*: Singaqinisekisa njani ukuthi ubuhlakani bemiqondo yezibalo ezintweni zobukghwari/zobuciko bamasiko ekhaya ukuze sirhelebhe abafundi ukuthi bafunde i-geometry esikolweni?*

[How can you ensure mastery of mathematical concepts in cultural artefacts at home to help learners learn geometry at school?]

W2*: Njengogogo nomkhulu kumele sifundise abentazana bethu, ukuze bakwazi ukufundisa abentwana, kufanele futhi sifundise abesana ubuciko/ubukghwari bokugwala umgwalo ukuze kuthuthukiswe isiko lethu lapho boke babandakanywa ekhaya bazophumelela izibalo kwezobuciko/kwezobukghwari basemabodeni Kanye nomncamo.*

[As grandparents, we must teach our granddaughters so that they can teach their children. We must also teach boys mural art to sustain our culture. When all are involved at home, they will master the mathematics of mural art and beadwork.]

The support to schools on using mathematical concepts to help learners learn geometry:

RQ: *Singazirhelebha njani iinkolo ukuthi kuberegiswe imiqondo yezibalo kubukghwari/kubuciko bamasiko, ukuze sirhelebhe abafundi bafunde i-geometry?*

[How can you support schools using mathematical concepts in cultural artefacts to help learners learn geometry?]

W2*: Ngingaba nohlelo nomfundisi futhi nginikele amanye amalanga ngokwenza izinto zamasiko, abafundi kuzofanele bakhombe izibalo emigwaleni yamasiko bese bayihlobansie nezibalo ezenziwa esikolweni.*

[I can have a programme with teachers and dedicate some days to making cultural artefacts. Learners will have to identify mathematics in the cultural artefacts and relate it to the mathematics done at school.]

Importance of using mathematical concepts in Ndebele cultural artefacts in the learning of geometry:

RQ: *Kubaluleke ngani ukusebenzisa imiqondo yezibalo emgwaleni yamasiko esiNebele ekufundweni kwe-Geometry?*

[What is the importance of using mathematical concepts in Ndebele cultural artefacts in the learning of geometry.]

W2: *Imiqondo yezibalo izoba nokuqonda nokusiza abafundi ukuthi bakhumbule.*

[Mathematical concepts in the cultural artefact will aid understanding and help learners remember.]

c) Interview with Woman 3 (W3)

Woman 3 indicated that there are two kinds of Amandebele tribes known as Manala and Ndzundza, who are siblings, both belonging to the royal family *(AmaNdebele simihlobo emibili, Manala namaNdzundza, bentwana bomuntu begodu boke ngebebukhosini)*. She explained the difference between the two styles of paintings: the one with grey and white stripes forming *ufilis*, with waves of the sea creating a *drie hook* (three corners), is for Manala, and the other one with razors is for Ndzundza. She emphasized that the painting style showcases the Ndebele culture and incorporates both styles to satisfy all the clients in her mural art.

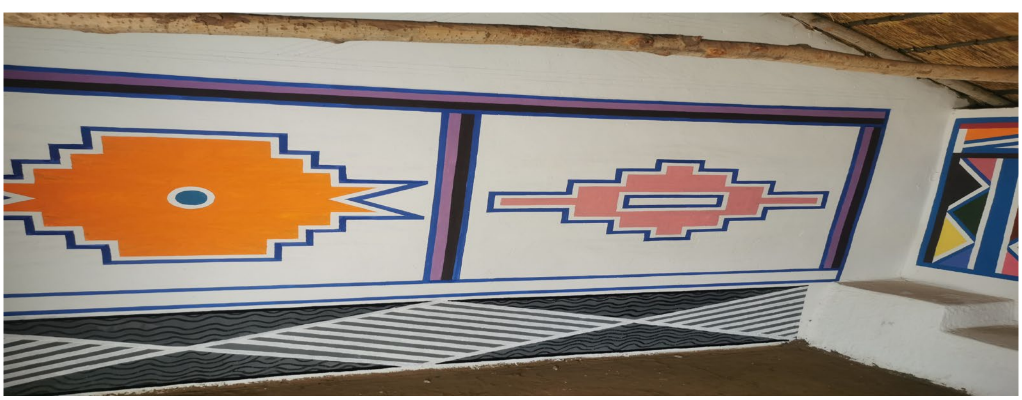


Figure 4.25: Kwamanala and Ndundza mural art (Kghodwana Cultural Village)

Making of Ndebele cultural artefacts:

RQ: *Yiziphi izinhlobo ezahlukene zobuciko, zamasiko zamaNdebele ozaziko?*

[What are the different Ndebele cultural artefacts that you know?]

W3: *Mina ngazi ukuphothela: Umlingakobe, Umkhala, isirholwani, abonompopi besiNdebele ababentazana nababesana, umngudwana (indlu yeskhethu), intonga nofana isitjhinghwana, mfayere, ispanere, izipha imincamo emihlophe ehlobiswe ngemincamo yombala obovu namkha onzima, imbathwa masokana nakabuya engomeni*.

[I know beadwork, *Umlingakobe* worn by women during the period of son initiation, *Umkhala* worn on the head, *isirholwani* (thick beaded necklaces), Ndebele dolls, Ndebele Boy, *mgudwana* (Ndebele house), spanner, *izipha* (white beads with either red or black colour for decoration worn by boys from initiation.]

Ndebele cultural artefacts *that woman can make*:

The interview excerpt below reflects on Ndebele cultural artefacts that W3 can make.

RQ: *Ngiziphi izinto zamasiko wamaNdebele ongakwazi ukuzenza?*

[Which Ndebele cultural artefacts are you able to make?]

W3: *Koke okuphothelwako nakhokoke okugwalwako. Ngingenza koke okufunako. Nginendawo yami langibeka khona lokhu engikwenzileko engikuthengisako. Mina ngiphila ngakho ukuthengisa insetjhenziswa zesikhethu. Ngaphothela Umntazana wesiNdebele ojamele mina ngisesemncani, ngamenza kuthoma phasi. Nangisakhulako, bengembatha so. Ngaphothela nomntazana wakwaManala. Ngisebenzisa / ngiberegisa itjhila, imincamo nesgodo, ngihlukanisa imincamo ngokuya ngokombala bese ngiyabala ukwenza amaphetheni/ imfanekiso.*

[I can make anything you want, including all beadwork products and Ndebele painting. I have my own art gallery. I sell cultural artefacts to make a living. I made the Ndzundza girl represent me while still a girl. I made her from scratch. While I was growing up, I wore things like this. (pointing at Ndebele girl she did) I also did a KwaManala girl. I use cloth, beads and wood; I sort beads into colours and count them to make a pattern.]

The *Ndzundza and KwaManala* dolls are beautiful handcrafts used for interior decoration and carry a significant cultural value. Each doll tells a story about the respective communities' culture, traditions, cultural identity, and clothing. The craft-making process preserves traditional techniques and patterns passed down by women's knowledge Hoders from generation to generation. They are decorated with colourful beads and other materials. The dolls can serve as educational resources for teachers to teach learners about the kind of girl envisaged by the Ndzundza and KwaManala tribes.

> W3: *Ngingumma wokuthoma owaphothela umsana weNdebele bengathola nonongorwana wakhona ngombana abantu abanengi bebaqalelelele ekuphotheleni Umntazana weNdebele. Ngaya eJapan, Persia ukuyo gwala nokuyophothela umncamo***.**
>
> [I am the first lady who made the Ndebele boy. I even got an award for my creativity, as many people focused on the Ndebele girl. I went to Japan and Persia to do painting and beadwork.]

Ndebele Boy is a traditional handicraft made to represent the Ndebele boy's relevant expectations or requirements regarding cultural values, beliefs, attire, and traditions. The Ndebele boy helps to remind Ndebele boys of their cultural roots, preserves cultural heritage and develops a sense of identity and pride in boys**.**

The process of making cultural artefact:

> RQ: *Uwenza njani amasiko wakho wesiNdebele?*
>
> [How do you make your Ndebele cultural artefacts.]
>
> W3: *Ngenza zombili izinto zobuciko / zobukghwari zamasiko. Ahlukene ngesizathu sokufanisa. Ngingu Ndzundza ngatjhada kwa-Manala, emandulo beyingekho ibhosolo, ngangisebenzisa iinsiba. Ngiphinde ngisebenzise uthubhakghuru wami ukugwala kwa-Manala kanye nentende yesandla ukwenza umrhabiso waphasi ngobulongwe bekomo. Ubukhulu balemida bulingana nothubhakghuru wami. Ngisebenzisa isilinganiso sobude. Ngenza ingcenye eyodwa kuqala kanti ezinye kamuva. Amathulusi wokulinganisa afana nerula azisetjhenziswa.*
>
> [I make both KwaManala and Ndzundza cultural artefacts. They are different for the sake of identification. I am Ndzundza, and I was married to a man from the Manala tribe. In the olden days, there were no brushes, and we used feathers. I also use my thumb to do kwaManala painting and the palm of my hand to decorate the floor with cow dung. The thickness of this line is the size of my thumb. I use estimation for length. I do one part first and the others later. Measuring instruments like a ruler are not used.]

RQ: *Ungitjele ukuthi uberegisa isithupasakho ukumeda ubunono bemida, ubunono buyalingana ngakoke gemida?*

[Are you saying you use your thumb to measure the thickness of your lines so the thickness is the same in all the lines?]

W3: *Iyana, ngiberegisa isithupa begodu yoke imida iyalingana ngokufana ngomnono nomakanjani mangenzeka ngiphenduleke emntazaneni wami ngokuhlobisa enhlangothini lami ngobunono bemida kunge umehluko kimi.*

[Yes, I am using my thumb, and all the lines are the same thickness. However, if I request my daughter to decorate on my behalf, the thickness of her lines will be different to mines.]

W3*: Uma ngiphothela umncamo, ngisebenzisa ukubala, ngidobha umncamo ngamunye ngamunye. Uma udobha okubili kumele wazi ukuti izibalo zingu2, 2, 2. Lapho wakha umfanekiso ngibala ngezinye izikhathi kabili, kabili, lapho umncamo obuyi-3 isikhathi ngasinye 3,3,3, nagu 4,4 lapha 5,5. Uma ngingabali njalo ngekhe ngikwazi ukwakha umfanekiso. Akukho ongakwenza ngaphandle kokubala. Uma wenze iphutha ekubaleni nawuqedileko umfanekiso wakho uzobhajwa. I-Kwamanala ayiberegisi okunzima okunengi, ngakho- ke kufanele ulinganise futhi ubale kuhle.*

[When doing beadwork, I use counting; I pick up beads one by one. If you pick up two, you must know that your maths is 2, 2, 2. When creating a pattern, I sometimes count two, two, here, and three beads each time. 3,3,3 here is 4,4, here 5; 5. If I don’t count like this, I cannot create a pattern. There is nothing that you can do without counting. You will get stuck once you make a mistake in counting when you have to complete your pattern. Kwamanala does not use a lot of black, so you have to estimate and count properly.]

RQ*: Ngenye indlela ungakwazi ukubalana?*

[In other words, are you saying you know how to count?]

W3*: Iye. Ngingakwazi ukubala ukubala kufika ekhulwini (100), kodwa umfanekiso ufaka izinombolo ezincane njengokubala kufikela kumatjhumi amabili (20).*

[Yes. I can count up to 100, but the patterns involve small numbers like counting up to 20.]

When asked how she learnt to count up to 100 because she mentioned that she never had the opportunity to attend formal schooling, W3 attributed her ability to count up to 100 to informal learning, her daily routine activities, social interactions, and counting money obtained from her social grant and business. She confidently counted up to 100 to demonstrate her numeracy skills, switching between Afrikaans, isiNdebele and English. She also alluded that she is still struggling with writing number names.

Shapes used in making the cultural artefact:

RQ: *Ngimaphi amajamo aberegiswako lapho kwenziwa ubukghwari / ubuciko bamasiko wesiNdebele?*

[Which shapes are you using when making Ndebele cultural artefacts?]

W3: *Ngakha ubujamo enqondweni yami. Kuwumrhabiso nje. Sinomgwalo wakwaManala nomgwalo wakwaNdzundza ngokulandelana. Umgwalo wami ujamele amagagasi wolwandle (Umgwalo wakwaManala). Kuwubuhlakani okuvela ehloko yami. Sina-bo K, njengalabo Ks, simane sizinikele amagama. Afana nabo ketlela, ispanera esisetjhenziswa ukubamba isikepe, ifremu, imida, ufilisi ongakapheleli*.

Isirayithoni sokukhanya, amehlo ayakhanyisa. Ipewulani, ilihlo, yigama nje elidaliweko elinganancazelo. Iketani (oncazine otjhelelako) sizinikele amagama.

[I create shapes from my mind. It is just decoration. We have a painting for Kwamanala and a painting for Ndzundza, respectively. My painting represents the waves of the sea. (Kwa manala painting). It is just creativity in my head. We have K, such as those two Ks, we just give ourselves names, such as kettle, spanner used to hold a boat, frame, lines, *ufilis*, *Isirayithoni*, eyes to make the painting bright, chains we give ourselves names.]

Significance of shapes used:

RQ*: Kubaluleke kangangani ukusebenzisa / ukuberegisa lawo majamo kumasiko wesiNdebele?* [What is the significance of using those shapes in your Ndebele cultural artefacts.]

W3***:*** *Ihloso ekulu ukurhabisa kanye nokuhlukanisa umgwalo wakwaManala nowakwa Ndzundza. Akunancazelo ethileko yesiko. Umgwalo wami ujamele amagagasi wolwandle.*

[The main aim is to decorate and differentiate KwaManala and Ndundza paintings. There is no specific meaning. My painting represents waves of the sea (Kwa manala painting).]

Process of acquiring knowledge and skills:

The excerpt below explores how W3 acquired knowledge and skills in making cultural artefacts. W3 is also highly experienced because she acquired knowledge from her mother by the age of 14 years.

RQ: *Wathola njani begodi wathola nini ilwazi nekghono lokwenza izinto zobukghwari / zobuciko zamasiko?*

[How and when did you acquire knowledge and skills of making the cultural artefacts?]

W3: *Ngafundiswa ngumma nangine-14 yeminyaka.*

[I was taught by my mother when I was 14 years old.]

RQ**:** *ngubane ofundise umamakho?*

[Who taught your mother?]

W3*: Umma wafundiswa ngumma wakhe. Ilwazi lidluliselwa enzukulwaneni neenzukulwaneni. Bengirhelebha umma ngokuphothela, ukugwala nokusinda ngehlabathi nobulongwe. Imihlobiso yenziwa ngemino. Ngikhule ngimbatha imincamo ngokuya kwesiko lethu. Azange ngiye esikolweni. Umma nguye ebekangifundisa imisebenzi yekhaya ekufakahlangana ukuphothela nokugwala.*

[My mother was taught by her mother. Knowledge is transferred from one generation to the other. I was helping my mother with beadwork, painting and floor maintenance with soil and cow dung. Decoration is done through fingers. I grew up wearing beads as required by our culture. I did not attend any schooling. My mother was responsible for teaching me household chores, including beadwork and painting.]

RQ***:** Wathoma nini ukwenza izinto zamasiko wakho wesiNdebele?*

[When did you start making your own Ndebele cultural artefacts?]

W3*: Ngathoma ngokusiza abanye abantu. Bese ngemva kwesikhathi ngo-1986 ngombana besele amabhunu angsalimi., ngimi wokuthoma owazisa abantu ngokuphothela. Ngarhelebha ikhuwa elinye eJohannesburg obekane oda elisuka ePersia lezinto eziphothelwako. Ngathoma ngahlanganisa isqhema sabomma ngabafundisa ukuphothela samrhelebha. Ukusikela lapho ngakhetha ukuzithomela lami irhwebo ngemva kweminyaka eyi-30. Ngaphambi kobana ngivule yami indawo bengenza izinto eziphothelwako nezigwaliweko ngizithengise begodu lokho* *kungirhelebhile ekondleni umndeni wami ngombana ubaba wakwami bekakhubazekile begodu angasebenzi / angaberegi.*

[I started by helping other people. Later 1986, I started beadwork because whites practised no more farming. I am the first one to introduce beadwork. I assisted a white person from Johannesburg who ordered beadwork from Persia. I organized a team of ladies, taught them beadwork and assisted him with his order. I then decided to do my own business after 30 years. Before the art gallery, I used to make and sell cultural artefacts, which assisted me in caring for my family because my husband was disabled and unemployed.]

Transfer of knowledge:

RQ: *Ulidlulisela njani ilwazi nekghonolakho ebantwaneni bakho, abomakhelwana noma ebantwini abanetjhisakalo.*

[How do you transfer your knowledge and skills to your children, neighbours or people with interest?]

W3: *Nginabomma abayisishiyagalombili (8) engiberega nabo. Ngabona kutlhogeka bona ngabele abanye abomma amakghono wami kunokuthi ngihlale ekhaya ngingenzi ulutho. Ngabafundisa ukuggwala nokuphothela. Bayeza la Phakathi kweveke bazokuphothela. Nginabantwana besikolo abangalinganiselwa kematjhumi amabili (20) nabo engabafundisako kade, okwanje anginabo abentwana besikolo engiba bandulako kodwana ngirhelebha laba abeza ngokungibuza imibuzo ngesiko lesiNdebele njenge ngcenye yemisebenzi yabo yesikolo. Bngibuza imibuzo njengoba usenza namhlanje bese ngibapha iimpendulo.*

[I have a team of 8 ladies that I work with. I saw it necessary to share my skills with other ladies rather than stay home and do nothing. I taught them how to paint and do beadwork. They are coming here during the week to do beadwork. I have about 20 learners that I also taught in the past. Currently, I don't have school learners I am training; however, I help those who come and ask me questions on Ndebele culture as part of their schoolwork. They interviewed me like you are today, and I gave them answers.]

W3*: Ngidlulisele ilwazi nemntwaneni wami omntazana lo ohlala nami, othengisa izinto eziphothelwako nezigwaliweko ukuziphilisa. Ngaya naye e-Japan siyokuphothela nokugwala. Sabekelwa indawo ehotela ehle. Ngonyaka ka-2011 ngaya ngeKosini ukuyokufundisa abafundisi/abotitjhere, kuneenkolo ezakhethwako. Besibandula abafundisi eEsther Mahlangu ekaba yobuciko / yobukhgwari besaya neskolweni ukuyokufundisa abantwana besikolo. Benginomma uEsther Mahlangu no Sophy Mahlangu, besibathathu. Ihloso bekukufundisa* *ubukghwari namasiko eenkolweni, sabhadalwa ngu-Hellet Smart njengoba bekumsebenzi wakhe. Abobaba abagwali, umsebenzi wabo kufulela imizi yabo. Eskhathini sanje bakhona abagwalako ngombana bayakuthanda.*

[I transferred knowledge to my daughter, who is currently staying with me and selling the artefacts to make a living. I went with her to Japan to do beadwork and painting. We were booked together in a beautiful hotel. 2011 I went to Ga-Mabhoko to train teachers, and some schools were selected. We trained teachers at Esther Mahlangus Art Centre and went to school to train learners. I was with Umama Esther Mahlangu and Sophy Mahlangu, and there were three of us. The aim was to teach art and culture to schools. Hellet Smart paid us as it was her project. Men don't do painting; they are responsible for roofing for the house. Nowadays, we have some men painting because they like it.]

Mathematical concepts found in Ndebele cultural artefacts:

RQ: *Ucabanga ukuthi zikhona izibalo zesikolo hlangana kwamasiko wesiNdebele?*

[Do you think that there is school mathematics within the Ndebele cultural artefacts?]

W3*: Ngangingazi kwaze kwaba kulapho ngatjhelwa ngomunye umma omhlophe ekabeni yamasiko eKghodwana eyafika ikhamba nomfundisi bebazofuundisa ngezinto esizenzako zobukghwari / zobuciko zamasiko. Wangibuza ukuthi ngiyazi na ukuthi ngenza iimbalo, ngathi awa ngiyarhabisa kuphela nje, wangichazela ngezibalo engizenzako. Angizange ngilibhade esikolweni, bengirhabisa nje ngingazi ukuthi kunezibalo kumrhabiso wami.*

[I did not know until I was told by one white lady at Kghodwana Cultural Village who came with teachers to teach them about our cultural artefacts. She asked me whether I was aware that I was doing Maths. I said no, I am just decorating. She explained to me the maths that I am doing. I did not attend schooling; I was just decorating without knowing that Maths is in my decorations.]

RQ*: Ngimiphi imiqondo yezibalo etholakala hlangana nobukghwari/ nobuciko bamasiko wesiNdebele?*

[What are the mathematical concepts found in Ndebele cultural artefacts?]

W3*: Ukubala, ukwenza umfanekiso ngiyabala kwesinye isikhathi kube kabili, lapha kunomncamo omthathu (3) iskhathi ngasinye, la kuna 5,5,6,7,8,9,10, uma kusetjhenziswa umbala owodwa kuphela akukho ukubala. Ngiyahlanganisa futhi ngikhuphe umncamo ukwenza umfanekiso.*

[Counting, creating a pattern I sometimes count two, here three beads each time, here is 5; 5, 6, 7,8, 9, 10, if only one colour is used, there is no counting. I add and subtract beads to create a pattern.]

W3: *Isilinganiso esingakahleleki somlingakobe, silinganisa nje ubude esibufunako bunobude obuhlukene kuya ngesilinganiso osikhethileko angisebenzisi ithulusi lesimedo kukhona ezide kunalena. Azange ngiye eskolweni kodwana ngafunda ukubhala igama lami okomtlikitlo. Abazali bebangafuni umntwana womntazana ukuya eskolweni noma emva kobana isikolo sathulwa ngokomthetho.*

[Informal measurement of *Umlingakobe*: we just estimate the length we want; they have different lengths depending on your chosen estimation. I don't use measuring instruments; there are those longer than this one (pointing at her *umingakobe*). I did not go to school; however, I learnt how to write my name for the sake of the signature. Our parents did not want the girl child to attend school even after the formal school was introduced.]

The use and mastery of mathematical concepts at home to help learners learn geometry at school:

RQ: *Singaqinisekisa njani ukuthi ubuhlakani bemiqondo yezibalo ezintweni zobukghwari/zobuciko bamasiko ekhaya ukuze sirhelebhe abafundi ukuthi bafunde i-geometry esikolweni?*

[How can you ensure mastery of mathematical concepts in cultural artefacts at home to help learners learn geometry at school?]

W3: *Ngizofundisa abantwaana emphakathini ukuze kuthi uma baya esikolweni babenelwazi ebalithole eminonweni yamasiko, uma ngibafundisa ngiqinisekisa ukuthi bayaqaphela izibalo futhi benze imiqondo yangaphakathi.*

[I will teach children within the community so that they have grasped concepts acquired from the cultural artefacts when they go to school. When I teach them, I will ensure that they take note of math and internalise concepts.]

The support to schools on using mathematical concepts to help learners learn geometry

RQ: *Singazirhelebha njani iinkolo ukuthi kuberegiswe imiqondo yezibalo kubukghwari/kubuciko bamasiko, ukuze sirhelebhe abafundi bafunde i-geometry?*

[How can you support schools using mathematical concepts in cultural artefacts to help learners learn geometry?]

W3*: I can assist teachers with the cultural artefacts so learners can investigate mathematics and relate the mathematics found to the school mathematics.*

RQ: *ungenza njani?*

[How will you do it?]

W3*: They can be given an activity to compare mathematics at home and at school.*

Importance of using mathematical concepts in Ndebele cultural artefacts in the learning of geometry:

RQ*: Kubaluleke ngani ukusebenzisa imiqondo yezibalo emgwaleni yamasiko esiNebele ekufundweni kwe-Geometry?*

[What is the importance of using mathematical concepts in Ndebele cultural artefacts in the learning of geometry.]

W3: *Ukuthi abafundi bakhumbule.*

[To help learners remember.]

d) Interview with Woman 4 (W4)

The excerpt reported below is from the interview that was conducted with W4. She works with W2 at her art gallery.

Names of Ndebele cultural artefacts:

RQ: *Yiziphi izinhlobo ezahlukene zobuciko zamasiko zamaNdebele ozaziko?*

[What are the different Ndebele cultural artefacts that you know?]

W4: *Ukuphothela: Umkhala, iphephethu, ukugwala.*

[Beadwork, headband, *iphephethu* is a rectangular beaded apron for matured Ndebele women, painting.]

Ndebele cultural artefacts *that woman can make*:

RQ: *Ngiziphi izinto zamasiko wamaNdebele ongakwazi ukuzenza?*

[Which Ndebele cultural artefacts are you able to make?]

W4: *Ubuciko /ubukghwari basebodeni*.

[Mural art]

The process of making cultural artefact:

RQ**:** *Uwenza njani amasiko wakho wesiNdebele?*

[How do you make your Ndebele cultural artefacts?]

W4: *Ngenza ubuciko / ubukghwaru basemabodeni. Emgwaleni, okwanje sivunyelwe ukusebenzisa irula / ilithi lokulinganisa ukulinganisa. Siphinde sisebenzise ibhosolo, ipotilodi neraba. Amapende siwameda kusetjhenziswa amalitha, nasigwalako iboda silinganisa ubukhulu bobujamo siqala ubukhulubeboda, sigwala imida bese simeda ngemithara yelithi.*

[I do mural art. In painting, we are currently allowed to use a ruler and a measuring stick for measurement. We also use brushes, a pencil and a rubber. Paints are measured using litres. When we paint the wall, we estimate the size of a shape by looking at the size of the wall. We draw lines and measure them with a metre stick.]

RQ*: Uyangitjela ukuthi uyazi ukumeda kuhle basebenzisa izinto zakumeda?*

[Are you telling me that you know how to measure accurately using the measuring instruments?]

W4: *Iye. Nginga kwazi ukufunda imizuzu ngama gadango ngingakhona ukuwafunda begodu ngingawa meda kuhle.*

[Yes, I can read the units on the metre stick, cm, and metres. I can read and take measurements well.]

Despite completing Standard 1, W4 surprisingly mentioned that she can read cm and m can use a ruler and the metre stick. She attributed this ability to her co-workers at the art gallery belonging to W2

Shapes used in making the cultural artefact:

RQ: Ngimaphi amajamo aberegiswako lapho kwenziwa ubukghwari bamasiko wesiNdebele? [Which shapes are you using when making Ndebele cultural artefacts?]

W4: *Abo K, simane sizinikele amagama. Afana nabo ufilisi, iketani, ifremu, ketlela, ispanera esisetjhenziswa ukubamba isikepe, imida, Isirayithoni sokukhanya, amehlo ayakhanyisa, Ipewulani.*

[The Ks, we just give ourselves names, such as *filis*, chain, frame, kettle, spanner used to hold a boat, lines, Isiraithoni that is bright, eyes to brighten the shape.]

Significance of shapes used:

RQ: *Kubaluleke kangangani ukuberegisa lawo majamo kumasiko wesiNdebele?*

[What is the significance of using those shapes in your Ndebele cultural artefacts?]

W4*: Kumatshwayo wesiko lesiNdebele, umgwalo wakho wesiNdebele kumele ube nepewulani, ifilisi, itjhefana, amakasana, amabanda Isirayithoni ukukhomba ukuthi ngeyesiNdebele.*

[Symbolises Ndebele culture. Your Ndebele painting must have *ifilis*i, *itjhefana* [apron], a*makasana* (kists), lines, *Isirayithoni* with arrows to show that it is for isiNdebele.]

Process of acquiring knowledge and skills:

RQ: Wathola njani begodi wathola nini ilwazi nekghono lokwenza izinto zobukghwari / zobuciko zamasiko?

[How and when did you acquire knowledge and skills of making the cultural artefacts?]

W4: *Ngibandulwe ngumma (referring to W2). Bengingazi lutho. Wangithoma phasi. Ngimndebele ngokwamasiko, ngimuMotswana. Kwakufanele aye ePersia, kodwa ngenxa yezinye izibopho, akakwazanga. Wangibiza wangibandula ukugwala nokuphothela umncamo ukuze ngikwazi ukumjamela. Ngathoma ngokugwala indawo encani njenge planka eliqinileko elilingana nebhokisis lamatamati ngase ngiqhubekela ebodeni. Ngineminyaka engaba matjhumi amabili (20). Ngokubandulwa kwakhe, nagesekelo eliqhubekako nangokungitjheja, ngaya ePersia. Bengithoma thomi ukukhwela isphaphamtjhini sobujamo obuphezulu. Njenganje ngigwala / ngidweba izambatho ezizokutjhugululwa zibe yisithombe esine rhalasi nefremu*.

[I was trained by my mother (referring to W2). I knew nothing at all. She started me from scratch. I am not Ndebele by culture, I am Motswana. She was supposed to go to Persia, but due to other commitments, she could not. She then called me and trained me to paint and do beadwork so I could go on her behalf. I started by painting a small area like a rigid board the same size as a box of tomatoes, then proceeded to the wall. It was about 20 years ago. With her training, ongoing support and monitoring, I went to Persia. It was for the first time that I climbed an aeroplane of high status. Currently, I am painting cloths that will be turned into a picture with a glass and a frame.]

RQ: *Wathoma nini ukwenza izinto zamasiko wakho wesiNdebele?*

[When did you start making your own Ndebele cultural artefacts?]

W4: *Ngathoma ngonyaka ka-2012*.

[I started in 2012.]

Transfer of knowledge:

RQ: *Ulidlulisela njani ilwazi nekghonolakho ebantwaneni bakho, abomakhelwana noma ebantwini abanetjhisakalo?*

[How do you transfer your knowledge and skills to your children, neighbours or people with interest?]

W4: *Njenganje ngisiza umma ukubandula itjha ezobandukwa ngengoba ingasebenzi.*

[I currently assist my mother in training youth who come in for training as they are unemployed.]

Mathematical concepts found in Ndebele cultural artefacts:

RQ: *Ucabanga ukuthi zikhona izibalo zesikolo hlangana kwamasiko wesiNdebele?*

[Do you think that there is school mathematics within the Ndebele cultural artefacts?]

W4: *Iye.*

[Yes.]

RQ: *Ngimiphi imiqondo yezibalo etholakala hlangana nobukghwari / nobuciko bamasiko wesiNdebele?*

[What are the mathematical concepts found in Ndebele cultural artefacts?]

W4*: ifilisi, isiyingilizi.*

[*Filis* and a circle.]

The use and mastery of mathematical concepts at home to help learners learn geometry at school:

RQ: *Singaqinisekisa njani ukuthi ubuhlakani bemiqondo yezibalo ezintweni zobukghwari/zobuciko bamasiko ekhaya ukuze sirhelebhe abafundi ukuthi bafunde i-geometry esikolweni?*

[How can we ensure the use and mastery of mathematical concepts in cultural artefacts at home to help learners learn geometry at school?]

W4*: Ngizofundisa abafundi ubuciko/ ubukghwari basebodeni Kanye nomncamo ngigcizelela imida enqophileko ukuqinisekisa ukunemba, imida yokulinganisa kusetjhenziswa iinsimbi zokumeda, nokuqinisekisa ukuthi abafundisi bayawaqonda amayunithi okulinganisa ukuze noma bawasebenzise ngendlel efaneleko, okungukuthi mm Kanye no-cm.*

[I will teach learners mural art and beadwork with emphasis on straight lines, ensuring accuracy, measuring lines using measuring instruments and ensuring that learners understand the units of measurement so that they can use them correctly, that is, mm and cm.]

RQ: *ungakwazi ukusitjela thina ukuthi uwenza njani?*

[Can you tell us how you will do it?]

W4*: ngingathoma gokubafundisa ama metre stick, ngiba fundise ngama mm, cm begodu m, bakhone ukuzwisa ngaphambi kobana nithome ngoku.*

[I will start by teaching them the metre stick, mm, cm, and m so they can understand before we start drawing.]

The support to schools on using mathematical concepts to help learners learn geometry:

RQ: *Singazirhelebha njani iinkolo ukuthi kuberegiswe imiqondo yezibalo kubukghwari/kubuciko bamasiko, ukuze sirhelebhe abafundi bafunde i-geometry?*

[How can you support schools using mathematical concepts in cultural artefacts to help learners learn geometry.]

W4***:** *Lokhu kuzosiza abafundisi nabafundi kwezobuciko basemabodeni Kanye nomncamo ukuze baqinisekise ukuthi banolwazi ngamasiko wethu.*

[I can train teachers and learners on mural art and beadwork just to ensure that they have knowledge of our culture.]

Importance of using mathematical concepts in Ndebele cultural artefacts in the learning of geometry

RQ*: Kubaluleke ngani ukusebenzisa imiqondo yezibalo emgwaleni yamasiko esiNebele ekufundweni kwe-Geometry?*

[What is the importance of using mathematical concepts in Ndebele cultural artefacts in the learning of geometry.]

W4: *Umfundi uzobona ukuthi izibalo yinto edalwe mumuntu noma umsebenzi womuntu.*

[Learner will realize that mathematics is a human creation or human activity.]

e) Interview with Woman 5 (W5)

The excerpt below is from the interview conducted with W5, the daughter of W3.

Names of different Ndebele cultural artefacts

RQ: *Yiziphi izinhlobo ezahlukene zobuciko zamasiko zamaNdebele ozaziko?*

[What are the different Ndebele cultural artefacts that you know?]

W5*: Ukuphothela, ukugwala, Umlingakobe, Iraso, Isiphokgho.*

[Beadwork and painting, *umlingagobe* is worn by women who took their sons to initiation school, *irasu* is a beaded necklace, *isiphokgho* is a beaded rectangular apron worn by adult married women.]

Ndebele cultural artefacts *that woman can make*:

RQ: *Ngiziphi izinto zamasiko wamaNdebele ongakwazi ukuzenza?*

[Which Ndebele cultural artefacts are you able to make?]

W5: *Umlingakobe (iinyembezi), Iraso, Isiphokgho ye-engeli yomfanekiso oyindilinga enomncamo, Umkhala, inyoga, Ibhetjha, ubukghwari basebodeni.*

[*Umlingakobe* -tear *Irasu* is a beaded necklace, *Isiphokgho* refers to beaded angle hoops, *umcala* made of beads worn on the head, *inyoga* –veil, *ibhetji* – beaded apron, mural art.]

The process of making cultural artefact:

RQ: *Uwenza njani amasiko wakho wesiNdebele?*

[How do you make your Ndebele cultural artefacts?]

W5: *Ukugwala: sisebenzisa iinsiba. omunye. Simeda ngokulinganisa. Sisebenzisa isandla, imino imino eyikhomba nothubhakghuru oluliweko, njengobude ofuna ukugwala ubujamo ngakho. iRobho ibuye isetjhenziswe ukumeda ubude beboda, bhinca irobho phakathi (uyibophe) ukuze uyijamise phakathi, khona-ke uzokwazi ubujamo efanele ubugwale, asisebenzisi amathulusi wokulinganisa.*

[Painting: We use feathers and measure them through estimation. Uses a hand span, seven *fingers* and a thumb stretched according to the length you want to draw a shape. Rope is also used to measure the length of the wall; fold the rope in the middle (tie it) to determine the centre, and then you will know the shapes to draw. We don't use measuring instruments.]

When asked why they use feathers in their mural art*,* W5 responded.

Isiba liberegiswa emgwaleni wamaNdebele, laliberigiswa ngabadala kithi manje thina sillandela isiko leskhathi semandulo. Amasiba abamba ukubaluleka kwamasiko, atholakala kalula, amakwasi wokupenda bowangatholakali eskhathini semandulo, sinenkukhu zethu esithola kizo amasiba, futhi okhunye okubaluleke khulu, amasiba angaberegiswa ukugwala imida egobeneko okungabanzima okukwenza ngamakwasi wokupenda.

[A feather is a traditional material used in Ndebele mural art; our elders used it, so we follow a long-standing cultural practice. Feathers hold a cultural significance and are easily accessible; paint brushes were not available in the past, we have our own chickens which we get feathers from, and more importantly, feathers can be used to draw curved lines, which may be difficult to achieve with paint brushes.]

W5 indicated that they are not using measuring instruments, and when asked why, she responded:

Umma wami wangifundisa ukuthi ukulinganisa ngiberegise amehlo wami, ukulinganisa ngokngakahleleki ngisebenzisa izandla zami, begodi ngizigedlile ngalokho.

[My mother taught me how to estimate using my eyes to measure informally using my hands, and I am comfortable with it.]

W5 has learned about Ndebele mural art, which, according to WKH, does not rely on measuring instruments and paintbrushes but on informal measurement or estimation and using a feather. Knowledge is passed down from one generation to the other. She learned from a skilled and experienced mother, an artist with a natural sense of proportion and scale, without the need or use of modern measuring instruments. She is, therefore, following her mother's and elders' footsteps.

W5*: Lapho nasiphothelako noma nasenza umsebenzi womncamo, silinganisa inani lomncamo ondingekako, sihlele umncamo ngombala nangobukhulu.*

[When doing beadwork, we estimate the number of beads needed and sort the beads according to colour and size.]

Shapes used in making the cultural artefact:

RQ: *Ngimaphi amajamo aberegiswako lapho kwenziwa ubukghwari / ubuciko bamasiko wesiNdebele?*

[Which shapes are you using when making Ndebele cultural artefacts?]

W5*: Ipewulani drie hook, Uncantathu, Umkhonto, Isirayithoni, ifilisi, isiyingilizi, ilihlo, ilihlo lingaba namahugu amane ukukhanyisa,*

[Three corners, triangle, arrow, *Israeton*, *filis*, circle, eye can have four corners to brighten. *Uncantathu* is a triangle, and *Isiyingilisi* refers to a circle according to Isindebele in the English dictionary.]

The Womans's mention of geometric shapes like triangles and circles demonstrated an understanding of mathematics gained through her completion of Grade 9 (Standard 7) mathematics. It also showcased her ability to integrate mathematical concepts into Ndebele mural art and beadwork, making meaningful connections.

Significance of shapes used:

RQ**:** *Kubaluleke kangangani ukuberegisa lawo majamo kumasiko wesiNdebele?*

[What is the significance of using those shapes in your Ndebele cultural artefacts?]

W5: *Ihloso ekulu ukurhabisa kanye nokuhlukanisa umgwalo wakwaManala nowakwa Ndzundza.*

[The main aim is to decorate and differentiate Kwamanala and Ndzundza paintings.]

Knowledge of Ndebele cultural artefacts

RQ: *Wathola njani begodi wathola nini ilwazi nekghono lokwenza izinto zobukghwari / zobuciko zamasiko?*

[How and when did you acquire knowledge and skills of making the cultural artefacts?]

W5*: Ngifundiswe ngumma uEsther Mnguni. Wangifundisa ukugwala. Ngathoma ngebhokisi eliqinileko, ngase ngiqhubeka emabodeni. Umma wangifundisa ukugwala nokuphothela umncamo. Ngakhamba naye ePersia njengomrhelebhi wakhe. Njenganje ngisebenza naye ekabnei yezobukghwari, ngisiza/ ngirhelebha ukubandula abomma abatjha abathanda ukufunda, ngihlathululela izivakatjhi ngezinto zobukghwari zamasiko, ngigcina imininingwana ezivakatjhi malanga woke encwadini yezivakatjhi.*

[I was trained by my mother, referring to W3. She taught me how to paint. I started with a rigid box, then proceeded to walls. My mother taught me how to paint and do beadwork. I went with her to Persia as her assistant. I am currently working with her at the art centre; I assist her in training young women interested in learning, explaining cultural artefacts to tourists, and recording visitors daily in the visitor's notebook.]

RQ: *Wathoma nini ukwenza izinto zamasiko wakho wesiNdebele?*

[When did you start making your own Ndebele cultural artefacts?]

W5: *Anginazo zami izinto zobuciko / zobukghwari zamasiko. Ngiberega nomma. Noma lapho kukhona ihlelo/ irhemo noma umtlamo siwenza ndawonye.*

[I don't have my own cultural artefacts. I work with my mother. Whenever there are orders or projects, we do them together.]

Transfer of knowledge:

RQ: *Ulidlulisela njani ilwazi nekghonolakho ebantwaneni bakho, abomakhelwana noma ebantwini abanetjhisakalo?*

[How do you transfer your knowledge and skills to your children, neighbours or people with interest?]

W5*: Njenganje ngisiza umma ukubandula itjha no bomma.*

[I currently assist Umama to train youth and women.]

Mathematical concepts found in Ndebele cultural artefacts

RQ: *Ucabanga ukuthi zikhona izibalo zesikolo hlangana kwamasiko wesiNdebele?*

[Do you think that there is school mathematics within the Ndebele cultural artefacts?]

W5: *Iye.*

[Yes.]

RQ: *Ngimiphi imiqondo yezibalo etholakala hlangana nobukghwari / nobuciko bamasiko wesiNdebele?*

[What are the mathematical concepts found in Ndebele cultural artefacts?]

W5*: Kukhona ukungezelela nokukhipha, ukuphindaphinda nokuhlukanisa, ukubala, imida, ubujamo,*

[There is addition and subtraction, multiplication, division, counting, lines, shapes.]

The use and mastery of mathematical concepts at home to help learners learn geometry at school

RQ: *Singaqinisekisa njani ukuthi ubuhlakani bemiqondo yezibalo ezintweni zobukghwari/zobuciko bamasiko ekhaya ukuze sirhelebhe abafundi ukuthi bafunde i-geometry esikolweni?*

[How can we ensure the use and mastery of mathematical concepts in cultural artefacts at home to help learners learn geometry at school?]

W5: *Ngingabafundisa abafundi ngomm no-cm.*

[I can teach learners mm and cm.]

RQ*: ungenza njani?*

[How will you do it?]

W5: *Ngibakhombise ukthi u-mm ulingana no-10mm. Banikeze ithuba lokugwala futhi bazijayeze imida bzsebenzisa isilinganiso sabo, sizabe sesikala ndawonye ukuze sihlole ukunemba*

[Will show them that 1cm equals 10mm.]

W5 pointed at the line on the wall:

Give them a chance to draw and practice lines using their own measurements. Then, we will measure them together to check accuracy.

The support to schools on using mathematical concepts to help learners learn geometry:

RQ*: Singazirhelebha njani iinkolo ukuthi kuberegiswe imiqondo yezibalo kubukghwari/kubuciko bamasiko, ukuze sirhelebhe abafundi bafunde i-geometry?*

[How can you support schools using mathematical concepts in cultural artefacts to help learners learn geometry.]

W5: *Ngicabanga ukuthi kufanele sibandule abafundisi ukuze bakwazi ukusebenzisa izinto zobuciko ngendlela efaneleko ukuze kurhatjhwe ukufunda kwemiqondo Kanye nezinto zobuciko zamasiko esikolweni, kusetjhenziswa amagama adingekako ezibalweni zesikolo.*

[I think we should train teachers to use artefacts correctly to accelerate learning the concepts found in the cultural artefacts at school using terminology required for school mathematics.]

Importance of using mathematical concepts in Ndebele cultural artefacts in the learning of geometry:

RQ: *Kubaluleke ngani ukusebenzisa imiqondo yezibalo emgwaleni yamasiko esiNebele ekufundweni kwe-Geometry?*

[What is the importance of using mathematical concepts in Ndebele cultural artefacts in the learning of geometry.]

W5: *Imiqondo yezibalo kubuciko bamasiko izokwenza ukufunda kubambezeleke*

[Mathematical concepts in the cultural artefacts will make learning concrete.]

4.2.4.2.1 Making of Ndebele cultural artefacts

The theme reports on how WKH make the different Ndebele cultural artefacts. It is organized into five sub-themes, which are: (1) Names of different Ndebele cultural artefacts, (2) Ndebele cultural artefacts *that woman can make*, (3) the process of making cultural artefacts, (4) shapes used in making the cultural artefact and their significance of shapes used. Some cultural artefacts have no specific English names and were captured in the isiNdebele language; however, some names were translated or described in English so the reader could understand their use and significance. Examples and explanations of pictures of Ndebele cultural artefacts referred to by WKHs are included.

4.2.4.2.2 Names of Ndebele cultural artefacts

WKHs shared their insights into different Ndebele cultural artefacts, commonly citing *Umkhala* (beaded headband), *isirholwani* (beaded circular hoops), *Umlingakobe* (train), *iraso* [beaded necklace]. *Iphephethu* rectangular apron for mature women. For example:

W2*: Umkhala umbathwa ngengoma ukutjhengisa bona ikosi ithabile nathi sithabile.*

[It is a beaded necklace, and *Umkhala* is worn on the head during initiation to show we are happy.]

W4: *Umkhala, iphephethu, [Beadwork, headband], iphephethu is a rectangular beaded apron for matured Ndebele women, painting),* With W1 including *Inaka animal skin worn by men*, *Isiviko* (shield), *Isithimba– a piece of cowhide used to cover the lower back of a maiden*

W1: *Inaka lenziwe ngeskhumba senyamazane, Iphephethu, Isthimba, Isiviko***.**

W5*: Umlingakobe, Iraso, Isiphokgho.*

[*Umlingagobe* is worn by women who took their sons to initiation school, *irasu* is a beaded necklace, and *isiphokgho* is a beaded rectangular apron worn by adult married women.]

4.2.4.2.3 Ndebele Cultural artefacts that woman can make

W1 indicated that she has her own particular focus that is different from others. W1 makes Ndebele hats, Ndebele T-shirts and others. The other four women confidently stated they possess the skills and knowledge to create all the Ndebele cultural artefacts, demonstrating their comprehensive knowledge. For example,

W2: *Yoke imikhiqizo yomncamo Kanye nokugwala, ukuluka umseme. Nangabe uyakwazi ukuphothela nokugwala, noma bangakunikela into etjha ukuyenza, uzokwazi ukukwenza.*

[All beadwork products and painting, making pillows, If you know beadwork and painting, even if they can give you a new thing to do, you will be able to do it.]

The two WKH, W2 and W3, have their own art galleries that showcase different cultural artefacts.

W3: *Ngingumma wokuthoma owaphothela umsana weNdebele bengathola nonongorwana wakhona ngombana abantu abanengi bebaqalelelele ekuphotheleni Umntazana weNdebele. Ngaya eJapan, Persia ukuyo gwala nokuyophothela umncamo***.**

[I am the first lady who made the Ndebele boy.]

W3 further indicated that her painting incorporates both Manala and Ndzundza styles. Comprehensive information on the two tribes is presented in the next chapter (cf. Chapter 5).

4.2.4.2.4 Explanations of pictures of Ndebele cultural artefacts referred to by WKHs

Examples of Ndebele cultural artefacts that WKH referred to are illustrated in pictures to provide a visual representation and enhance understanding and appreciation of the Ndebele cultural artefacts. An explanation is also given for the name of the cultural artefact, how it is crafted, the material used, its significance, the people who wear it, the reasons behind wearing it, and where it can be located.

Figure 4.26: Ndebele hat

The Ndebele hat above was made by WKH 1 using wool and knitting needles. It is decorated with lines, *filis* and a dot inside it. It is worn during Ndebele traditional ceremonies and rituals, special occasions like weddings, and as a cultural expression during heritage events. It is a symbol of Ndebele's cultural identity. It was made at GaMabhoko village, Dr Js Moroka municipality in Mpumalanga.

Figure 4.27: Flowerpots and their crafting stages

According to W3, her flowerpots are made of paper mash. Newspapers are mixed with water and pieces of bath soap to make the flowerpot strong so that it lasts for a long time. The paper paste is then applied to a bowl surface and allowed to dry; when it is dry, it is then removed from the bowl, shaped to your choice of design, use a bottle of glycerine to make it smooth, allow it to dry again, apply the first coat and then painted or decorated with Ndebele traditional designs. They are used for decorative purposes, can be given as gifts, and symbolise Ndebele's cultural heritage. Artefacts were found at W3 and W2 art galleries in Mpumalanga.

Figure 4.28: W3 showcasing the length of *Umlingakobe*

This long *Umlingagobe* was made by W3 using an upholstery thread, a needle and beads of different colours. It has two narrow strips of woven beading hanging on each side of the head. It portrays a mother wearing the *linga kobe* at the ceremonies marking the end of his sons' initiation ceremony. A pair of narrow bands reaching onto the ground are a representation of tears of sorrow at losing her son to the adult world and the joy a mother has because her son has reached manhood. *Umlingagobe* can have different lengths depending on the individual choice, but it should be long enough; the WKH estimates the size or length. They are placed on the mat like W3 has demonstrated when displayed. The artefact is similar to what the *linga kobe* doll portrayed. They differ in length but have the same cultural significance. Artefacts were found in W2 and W3 art galleries and at Kgodwana Cultural Village, Mpumalanga.

Figure 4.29: KwaManala Woman

The artefact was made by W3 using wood, covered with cloth, and feet made of wood covered with black cloth. She has a head bangle known as *Umphaere*, which is made of grass and decorated with beads. She is wearing a necklace (*Ispani)* made of grass covered with white, blue and red beads, with 11 leg bangles worn on each leg leading to 22 bangles. The apron worn in front is called *Iphotho.* It is made from hard plastic and covered with beads, and it is said to be worn by married women only. At her back, she is wearing an *Isithimba* decorated with beads; she has a blanket decorated with beads. It is said that when she dances during cultural celebrations, she has to remove the blanket to showcase that she is a wholly married Kwamanala woman, who is cared for by her husband. The artefact illustrates the attire of a married KwaManala Woman.

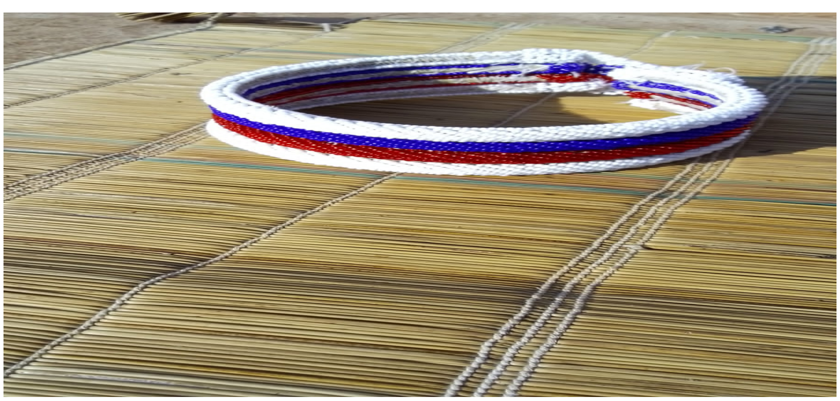


Figure 4.30: ***Ispani*** **[Manala Necklace]**

An *Ispani* Manala necklace is made of soft grass and is covered with white, blue, and red beads. It is worn by a married woman during traditional celebrations or heritage days and crafted by W3.

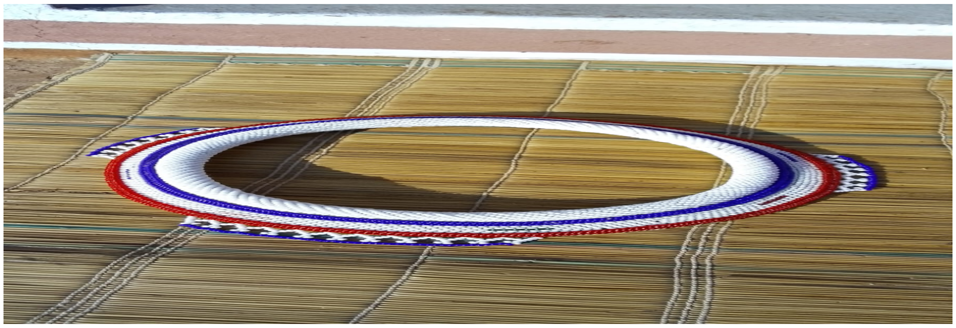


Figure 4.31: ***Umphayiri*** **[head bangle]**

Umphayiri is a head bangle for Manala style. It is crafted from grass, skillfully shaped to form a circle and decorated with white, blue and red beads. Manala women wear it. The cultural artefact was found in the W3 Art Gallery.

Figure 4.32: KwaManala Man

W3 made the cultural artefacts. It is an artefact of a KwaManala man sitting on a wooden chair. He is at the celebration enjoying himself, wearing *Inaka*, which is made of skin animal, *Ibhetjha [a traditional trouser];* his legs are covered with black cloth. He is holding a dancing stick and a knobkerrie, which he uses as a weapon to protect himself and as a tool to dance with, showcasing the traditional dance style. According to W3, in the past, there were no clothes; therefore, the artefact portrays the traditional attire of the KwaManala man. It can be used for decoration, as a gift, or as an educational tool for the history of KwaManala. It was found in W3 Art Gallery at Troya (GaMatempule), Mpumalanga Province.

Figure 4.33: Widow

It was fascinating to find how culture is respected concerning Women who lost their husbands. The cultural artefact was crafted by W3, using old cloths and wood covered with black fabric. The significant difference noticed is that the Widow is not decorated with beads as she is mourning for her beloved one. She is also covered with a grey blanket and has a rope around her figure to show that she has lost her husband. She is expected to carry a traditional broom made of grass to keep away children, protecting them from illness associated with her situation. The number of sticks/grasses to make a broom is determined through estimation, and it is enough for the hand of the widow to hold. The broom is also used with a traditional herb to perform a kraal ritual for cattle's safety. The artefact showcases the attire and way a woman whose spouse has died should behave.

a) Ndebele dolls

Ndebele dolls are part of Ndebele culture and have meanings linked to Ndebele rituals. WKH makes the dolls. They are sold to people who buy them as gifts and decorations. The examples created by WKH include the Nzdundza girl, KwaManala girl, Ndebele *Linga Koba* doll and African Ndebele Rasta doll.

Figure 4.34: The Nzdundza girl/doll

The Ndzundza girl was made by W3 using wood and covered with old clothes. She is wearing a top called *ichemisi*, which covers the breasts, a beaded head belt called *icubi* on her head, three neck bangles on her neck, her legs are made of natural wood (*isgodo)* and her feet made of wood (*lepolanka*) for balancing and covered with cloths. She is wearing beaded bangles on her legs called *inghrolwane* with different colours and *inghrolwane zezandla* (hand bangles) on both hands. The girl is wearing *an iphephethu [apron], and the isthimba at the back is* made of leather and decorated with beaded strings called *Iyeghrana.* She is carrying a suitcase for cosmetics (said w3). The cultural artefact illustrates the traditional ideal of an unmarried Ndzundza girl. The artefact is used for decoration, showcasing Ndebele's cultural heritage, and as an educational resource for teaching cultural values and traditions. It was found in the art gallery of W3 at Troya (Matempule), Mpumalanga Province.

Figure 4.35: KwaManala girls/dolls

W3 created the KwaManala girls using old clothes, wrapping them with a black cloth and covering their bodies and legs in beads. According to their tradition, the woman explained that in the past, there were no clothes; people wore beads and animal skins instead. This cultural heritage led to a challenge when schools were introduced, as parents wanted their daughters to wear traditional attire. In contrast, schools introduced black gym dresses, which led to a clash of ideas, which was eventually resolved. The KwaManala girls demonstrate that during celebrations, they have to sit down on the mat or floor and not on the chair, as a tradition. They were crafted to showcase the traditional attire, cultural beauty and heritage. They can be shared as gifts and used for interior house decoration. The cultural artefacts were found in the W3 Art Gallery.

Figure 4.36: Ndebele *Linga Koba* Doll

The *Linga Koba* doll was made by W2. The doll is wearing a blanket decorated with beads forming geometric shapes and lines. The doll has *Umlingakobe* on her head, illustrating the same cultural significance as the one created by W3; however, the difference lies with the length. The *Linga Koba* doll was found in the W2 Art Gallery at GaMabhoko Village in Mpumalanga.

Figure 4.37: African Ndebele Rasta Doll

W2 made the African Ndebele Rasta Doll. She covered cloths with tiny colourful beads around the circumference, made two eyes on the face with a line dividing the head into two equal parts, and had long dreadlocks and gold rings around her neck. She used a black hairpiece to decorate the dreadlocks and put beads on the hair. The artefact represents an authentic African doll. It serves as a toy for young girls and can be given to girls as a gift to help them learn about the African Ndebele Rasta Doll. The cultural artefact was found at the art gallery for W2, GaMabhoko, Mpumalanga Province.

According to W3, she made history by crafting the first ever Ndebele boy, demonstrating her remarkable gift and was honoured with an award for preserving the Ndebele traditions.

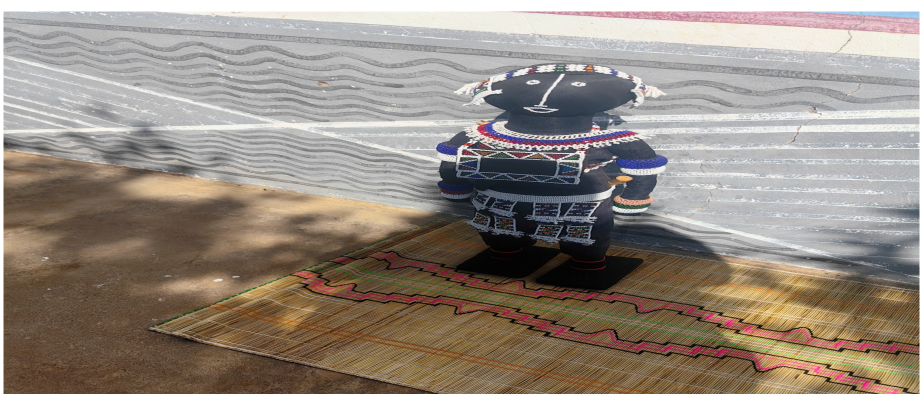


Figure 4.38: Ndebele boy

The Ndebele boy was crafted by W3 using wood and old clothes. He is wearing a necklace and other beadwork made by his two girlfriends. The two girls gave him gifts made of beads to wear, hoping that upon his return from initiation, he would choose the one who created the most beautiful pieces as a preference for a potential bride. It was found in the W3 Art Gallery and at Kghodwana Cultural Village, Mpumalanga Province.

Figure 4.39: ***Izipha*** **(White beads)**

The *izipha* (white beads) were crafted by W2, using an upholstery thread, a needle, white beads and blue beads for decoration. According to W2, the number of beads to be used is estimated depending on the body size of the boy who placed an order. They are worn by men across their bare bodies from initiation school. Cultural artefacts were found in the W2 Art Gallery. Below is a picture showing how *Izipha* is worn.

Figure 4.40: A man wearing ***Izipha*** **(Sourced: Ridge Times, 27/07/2024)**

4.2.4.2.5 The process of making the Ndebele cultural artefacts

W1 uses modern tools such as wool and needles to make Ndebele hats. Counting is used in her process of making hats *(I use two needles and a wool. I counted and used 2s, two on each corner and six on the lines, to make rhombuses of the same size, arranged according to blue, black and pink colours (the Ndebele colours).* The other women involved in the study, W2 to W5, also stressed the importance and use of counting in doing beadwork, highlighting that there is nothing you can do without counting.

> W3: *Uma ngiphothelela umncamo ngisebenzisa ukubala, ngidobha umncamo ngamunye ngamunye.*
>
> [When doing beadwork, I use counting; I pick up beads one by one.]

Women stressed the importance of estimation in the creation of Ndebele cultural artefacts.

> W2: *Simeda ngokulinganisa. We measure through estimation; I use my eyes to estimate. Uses a hand span, seven fingers and a thumb stretched according to the length you want to draw a shape. Rope is also used to measure the length of the wall; fold the rope in the middle, tie it to determine the centre, and then you will know the shapes to draw.*
>
> W3*: I use estimation for length.*

W2 and W3 indicated that they use bright colours to satisfy their clients.

> W2*: Emandulo besisebenzisa ihlabathi nasigwalako. Slongwe semlanjeni, ubumba lezi zeskhathi sanje bezingekho. Ibloisela yayiberegiswa / yayisetjhenziswa ukuba mbala ohlaza kwesibhakabhaka. Abathengi bethu bafuna imibala egcwele ekhanyako.*
>
> [We were using clay soil to paint, but these current ones were unavailable. Blousel was used for blue colour. Our clients need bright, entire colours.]

Women pointed out using feathers in their traditional painting *W2: Ukugwala: sisebenzisa iinsiba,* with W3 stating that in the olden days, there were no brushes.

W2 explained that she permits young ladies in her mural art training to utilize paintbrushes and rulers, and when questioned about her new approach, she mentioned that it is a time-saving measure; the ladies advised her that it works faster with modern tools.

A little difference emerged regarding the process of Ndebele mural art; all the women who participated mentioned that older women traditionally used estimation and feathers to paint, no measuring instruments and paint brushes were used, and three women said they are still adhering to cultural practices where one woman (W4) deviated from this traditional approach, revealing that she learnt Ndebele mural art the traditional way, using feathers and without a ruler but currently she uses feathers and modern tools like rulers and paint brushes to safe time. This minor difference highlights the gradual change of cultural practices and individual innovations in mural art over time.

4.2.4.2.6 Names of shapes and their significance

W1: *Isiyingilizi, idayisi, iqatjhazi, oncantathu, imida, i-rhombus.*

[Circle, dice, dots, triangles, lines, rhombus.]

W3*: Sina-bo K, njengalabo Ks, simane sizinikele amagama. Afana nabo ketlela, ispanera esisetjhenziswa ukubamba isikepe, ifremu, imida, ufilisi ongakapheleli*.

Isirayithoni sokukhanya, amehlo ayakhanyisa. Ipewulani, ilihlo, yigama nje elidaliweko elinganancazelo. Iketani (oncazine otjhelelako) sizinikele amagama.

[I create shapes from my mind. It is just decoration.]

Some of the responses given by knowledge holders concerning the shapes used were similar, and this was observed where women provided similar responses, indicating a shared perspective or experience. For instance, W2, W3 and W5 commonly mentioned:

Ipewulani, drie hook, Umkhonto, ehlaba, Isirayithoni, elihlo, ufilisi,

[*Ipewulani*, Shape with three corners and an arrow, *Isirayithoni* eye, *ufilis*.]

W2: *You think of your own design before you paint. Depending on your design, you start with a chain; you can use things we use at home (isuthikeisi or makasana), a suitcase or kists.*

W2 said *Filis*i is the name taken from cards,

WKH showed a striking consensus in their responses, particularly when asked to name the shapes used in making the cultural artefact, with many mentioning similar shapes such as "*Ipewulani* (three-sided shape), *utjhefana* (razor), *Umkhonto* (arrow), *Isirayithoni*, *ufilis*i (four-sided shape), *ilihlo* (round shape), *iketani* (chain), *imida* (lines), *makasana* (kists/four-sided shapes) and so on.

a) Significance of shapes used

Women stated that elders used shapes to decorate. They are part of Ndebele culture; to ensure that a design is genuinely Ndebele, it must feature all the shapes mentioned by WKH.

W4*: Kumatshwayo wesiko lesiNdebele, umgwalo wakho wesiNdebele kumele ube nepewulani, ifilisi, itjhefana, amakasana, amabanda Isirayithoni ukukhomba ukuthi ngeyesiNdebele.*

[Symbolises Ndebele culture. Your Ndebele painting must have i*filis*i, *itjhefana* [apron], a*makasana* (kists), lines, *Isirayithoni* with arrows to show that it is for Isindebele.]

W2: *Ukuze uqiniseke ukuthi isko lesiNdebele.*

[To show that it is Ndebele culture.]

W3***:*** *Ihloso ekulu ukurhabisa kanye nokuhlukanisa umgwalo wakwaManala nowakwa Ndzundza. Akunancazelo ethileko yesiko. Umgwalo wami ujamele amagagasi wolwandle.*

[The main aim is to decorate and differentiate KwaManala and Ndundza paintings.]

W3 stated that the main aim is to decorate and differentiate the two tribes, Manala and Ndzundza. W3 further described her painting as a demonstration of the waves of the sea.

4.2.4.2.7 Process of acquiring and transferring Indigenous knowledge

The women in the study uniformly expressed a keen interest in disseminating their knowledge to other women, fostering a sense of creating a network of shared knowledge and collaboration.

> W1*: Ngazama ukufundisa abentwana besikolo ukuthunga, babaleka namawula wami namanalidi wokuthunga, bengibafundisa mahala, eqinisweni angifuni ukutjhiya umhlaba lo ngikhambe nelwazi enginalo ngingakalabeli abanye abantu.*
>
> [I tried to teach learners knitting, but they went away with my wools and cross needles; I was teaching them free of charge; my aim is not to leave this world with my knowledge without sharing it with other people.]

W2 acquired knowledge from her mother at the age of 10 years; her mother was taught by her grandmother.

> W3: *Ngafundiswa ngumma nangine-14 yeminyaka.*
>
> [I was taught by my mother when I was 14 years old.]
>
> W3*: Umma wafundiswa ngumma wakhe.*

The WKH responses revealed a consistent pattern in transmitting knowledge related to Ndebele cultural artefacts, with participants citing mother-to-daughter transfer as the primary means of learning the Ndebele cultural tradition. This demonstrates the significance of intergenerational learning and mothers' vital role in passing down cultural knowledge and skills to their daughters, ensuring the continuation of Ndebele's cultural heritage. The similarities in responses highlighted the commonalities that exist among WKHs.

4.2.4.2.8 Mathematical concepts found by Women Knowledge Holders

> W1: *Ama-engeli, oncantathu, isiyingilizi, imida.*
>
> [Angles, triangles, circles, lines.]

W1 explained by looking at the painted wall and said that their decoration is made of triangles, circles, diamonds, chevrons, and zigzags. The mathematical concepts presented by W1 indicated a strong foundation in mathematics acquired through formal education.

W2*: Kukhona ukungezelela nokukhipha, ukuphindaphinda nokuhlukanisa, ukubala.*

[There is addition and subtraction, counting.]

W5*: Kukhona ukungezelela nokukhipha, ukuphindaphinda nokuhlukanisa, ukubala, imida, ubujamo,*

[There is addition and subtraction, multiplication, division, counting, lines, shapes.]

W4*: ifilisi, isiyingilizi.*

[*filis* and a circle.]

W3: *Ukubala, uma kusetjhenziswa umbala owodwa kuphela akukho ukubala.*

[Counting: if only one colour is used, there is no counting.]

Women interviewed commonly mentioned that the Ndebele Cultural artefacts have embedded mathematical concepts and consistently pointed out the four basic operations and counting. W5 included lines and shapes, while W4 noted i*filis* and a circle.

4.2.4.2.9 Using mathematics in culture to learn mathematics at school

According to WKH, learning mathematics in the context of culture will aid understanding and help learners to remember. Women pointed out that culturally relevant mathematics will make learning concrete and enhance retention. For example:

W2: *Imiqondo yezibalo izoba nokuqonda nokusiza abafundi ukuthi bakhumbule.*

[Mathematical concepts in the cultural artefact will aid understanding and help learners remember.]

W1 said she can use beads to teach learners counting, addition, subtraction, multiplication and division.

W4: *Umfundi uzobona ukuthi izibalo yinto edalwe mumuntu noma umsebenzi womuntu.*

[Learner will realize that mathematics is a human creation or human activity.]

WKH support to schools

W2*: Ngingaba nohlelo nomfundisi futhi nginikele amanye amalanga ngokwenza izinto zamasiko, abafundi kuzofanele bakhombe izibalo emigwaleni yamasiko bese bayihlobansie nezibalo ezenziwa esikolweni.*

[I can have a programme with teachers and dedicate some days to making cultural artefacts.]

W4***:** Lokhu kuzosiza abafundisi nabafundi kwezobuciko basemabodeni Kanye nomncamo ukuze baqinisekise ukuthi banolwazi ngamasiko wethu.*

[I can train teachers and learners on mural art and beadwork just to ensure that they have knowledge of our culture.]

W5: *Ngicabanga ukuthi kufanele sibandule abafundisi ukuze bakwazi ukusebenzisa izinto zobuciko ngendlela efaneleko ukuze kurhatjhwe ukufunda kwemiqondo Kanye nezinto zobuciko zamasiko esikolweni, kusetjhenziswa amagama adingekako ezibalweni zesikolo.*

[I think we should train teachers to use artefacts correctly to accelerate learning the concepts found in the cultural artefacts at school using terminology required for school mathematics.]

W2 and W4 suggested a training initiative for teachers and learners on creating cultural artefacts to enhance their cultural competence. At the same time, W5 advocated for teacher training sessions on using Ndebele cultural artefacts to teach mathematics concepts embedded in them using the mathematical language.

W1 said she can help teachers relate mathematics in the classroom with mathematics at home.

W2: *Learners will have to identify mathematics in the cultural artefacts and relate it to the mathematics done at school.*

W3*: They can be given an activity to compare mathematics at home and school*.

It was a common theme among Women that learners would participate in activities connecting mathematical concepts in cultural artefacts and the mathematics they learn in school.

W3*: I can assist teachers with the cultural artefacts so learners can investigate mathematics and relate the mathematics found to the school mathematics.*

W3 indicated that she can help the teachers by ensuring access to Ndebele cultural artefacts for teaching and learning resources.

4.2.4.2.10 The importance of using mathematical concepts in Ndebele cultural artefacts in learning Geometry

W3: *Ukuthi abafundi bakhumbule*

[To help learners remember.]

W5: *Imiqondo yezibalo kubuciko bamasiko izokwenza ukufunda kubambezeleke.*

[Mathematical concepts in the cultural artefacts will make learning concrete.]

W4: *Umfundi uzobona ukuthi izibalo yinto edalwe mumuntu noma umsebenzi womuntu.*

[Learner will realize that mathematics is a human creation or human activity.]

W1 and W5 based their arguments on helping learners to remember and making learning concrete. Concrete experiences of Ndebele Cultural artefacts will help learners remember mathematical concepts better.

4.2.5 Presentation of results generated from Focus Group Discussions with Women Knowledge Holders

This section presents the results of the study generated from FGDs with WKH. The FGDs were conducted with six WKHs at the art gallery belonging to W2. The art gallery is an enormous double-door garage with open space. It has a place to display cultural artefacts, a place to store paints, a working space with tables for painting and a space for beadworkers.

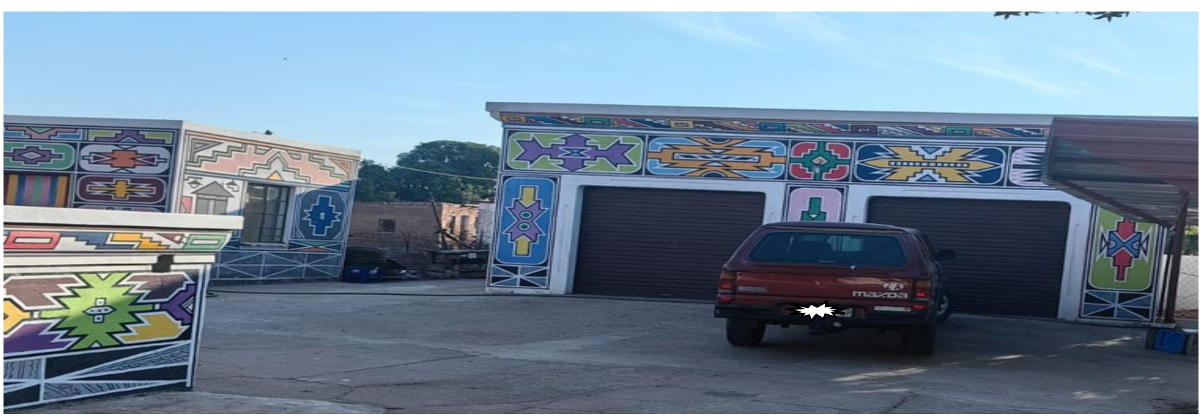


Figure 4.41: W2 Art Gallery, situated at GaMabhoko

Each woman was given a pseudonym for identification. Pseudonyms were allocated to adhere to the ethical issues and to protect participants' privacy. Women were assigned pseudonyms based on their involvement either in beadwork or painting and numerals according to their number in the work assigned to them. Three women were painting clothes that would be put into frames to make pictures, and the other two were busy with beadwork. Women busy with painting were called Woman Painters Number 1, 2 and 3 (WP1, WP2 and WP3). Women busy with beadwork were called Woman Beadwork Number 1 and 2 (WB1 and WB2). Their leader was called Woman Painter and Beadworker (WPB) because she has expertise in both and supports both teams. The women stated they had no problem with the names used in the research study. No written agreement was secured. WPB assisted the researcher in selecting the knowledge holders based on their experience, interest and knowledge of making cultural artefacts. It was her pre-existing group; hence, they enjoyed comfort and familiarity with each other. RQ will represent the researcher's question in the research.

FGDs were recorded to avoid missing comments or opinions by the participants during the discussion. Data was transcribed from voice recording and translated from Isindebele to English. The researcher acknowledged the presence of the audio recording equipment picture taking and assured participants confidentiality. All were requested to complete and sign the Consent forms.

Five women indicated that they can speak Isindebele, English and Setswana. Isindebele was used as a language of communication to accommodate WPB, who stated that she struggles to understand Setswana and does not know English. The discussion was guided and monitored. Notes were written in a notebook. Triangulation was done with field notes and recordings.

The section starts by presenting background information for each participant. Themes and sub-themes identified will discussed.

4.2.5.1 Women Knowledge Holders' information

This part presents the background information of WKH. The participant's data was captured through a questionnaire read to all six women (c.f Appendix S) and completed individually with support. The focus group consisted of two WKHs, W2 and W4, and four women not part of the individual interviews. Therefore, the background information for W2 (WPB) in the FGD and W4 (WP1) will not be detailed as it was given during the presentation of interviews with WKH.

4.2.5.1.1 Background information for Woman Painter and Beadworker (WPB)

WPB was interviewed as (W2). Her background has already been captured. WPB indicated that she has also trained some unemployed men and boys in the skill of mural art, and the community members currently hire them to paint their walls and houses. A gentleman was found painting dishes, and WPB mentioned that he had trained him.

4.2.5.1.2 Background information for Woman Painter Number 1 (WP1)

Her background has already been outlined, and she was referred to W4 in the interviews.

4.2.5.1.3 Background information for Woman Painter Number 2 (WP2)

WP2 indicated that she is good at mural art; however, she is still learning beadwork and wants to explore it further. She is a woman between the ages of 40 and 50 years. She obtained Grade 12 and has studied mathematics. Unfortunately, she could not secure tertiary-level funding and meet bursary admission requirements.

4.2.5.1.4 Background information for Woman Painter Number 3 (WP3)

WP3 is an entrepreneur in mural art only. She is a woman between the ages of 40 and 50 years. She is in Grade 12 and has studied mathematics up to Grade 12. WP3 said that WPB trained her, but she could not get employment or further her studies.

4.2.5.1.5 Background information for Woman Beadwork 1 (WB1)

WB1 is an entrepreneur in beadwork only. She is a woman between the ages of 30 and 40 years. She is in Grade 12 and has studied mathematics up to Grade 12. WB1 said that Ms Sophy Mahlangu trained her.

4.2.5.1.6 Background information for Woman Beadwork 2 (WB2)

WB2 knows beadwork. She is still studying painting under the supervision and support of Ms Sophy Mahlangu. She is a woman between the ages of 30 and 40 years. She is in Grade 11 and has studied mathematics up to Grade 11.

4.2.5.2 Presentation of results from Focus Group Discussions

Probing techniques facilitated in-depth responses, inviting WKH to share detailed accounts of their experiences. To preserve the authenticity of the information collected, direct quotations from participants were incorporated into the presentation, providing rich, in-depth, and detailed descriptions of women's views. The researcher familiarized herself with the data collected by reading and re-reading transcripts and presenting transcriptions of verbal data from interviews in written form. Patterns were searched across the entire data set. Sentences describing similar ideas were highlighted and given codes. Several related codes across the data set were combined to make up themes and sub-themes. Themes and sub-themes are presented in the table below:

Table 4.9: Themes and sub-themes

THEMES	SUB-THEMES
Geometric shapes	❖ Reasons for using geometric shapes ❖ How knowledge of shapes was acquired ❖ The meaning conveyed by Geometric shapes
Process of making Ndebele cultural artefacts	❖ Steps to be followed in making the cultural artefacts ❖ Using Mathematics learnt at school in making cultural artefacts
Active role players	❖ The role played by women and girls ❖ The role played by men and boys ❖ Equitable cultural artefacts knowledge to all genders
Partnership with schools	❖ Sharing knowledge and skills with teachers and learners ❖ Benefits of sharing knowledge and skills with teachers and learners

4.2.5.2.1 Geometric shapes

This theme captures the geometric shapes found in the Ndebele cultural artefacts. It also explores reasons for using geometric shapes, how knowledge of creating shapes was acquired by WKH and the meaning conveyed by geometric shapes. It appeared that WPB trained all the WKH in the FGD.

a) Reasons for using geometric shapes in making Ndebele cultural artefacts

The concept of geometry and geometric shapes was explained to WKH before commencing with the FGDs.

> RQ: *Kubayini usebenzisa ihlobo lamadizayini namkha amabumbeko we jiyomethri la wena owasebenzisako ukwenza iinsetjenziswa zobukghwari beskhethu?*
>
> [Why are you using geometric shapes in making your cultural artefacts?]
>
> WPB*: Izimo zadalwa babantu abadala bekhethu. Sibathole zisetjhenziswe bomma bethu. Abadala bethu batlhama baqala izinto ezizombe ibhoduluko, izinto ababezisebenzisa malanga woke, bazigwala njengoba kungezo kurhabisa.*

[Shapes were created by our elders. We found them being used by our mothers. Our elders created them by looking at the things around the environment that they were interacting with daily and drawing them as they are for decoration.]

The researcher probed WPB to get more information on what elders interacted with. Researcher: *Ngizingi izinto lezo? Sibawa usitjhele?* [What are those things? Can you please tell us?]

WPB: *Izinto ezifana namathulusi ebesiwasebenzisa njenge spanera, tjhefana, iketlela, amapotimonde, derefude, ikasi lokubeka izambatho, yindlela uyenziwa ngayo kusukela yasungulwa ngabadala bethu.*

[Things like the tools that we were using, such as spanner, raisor blade (pointing at the shape on the wall), kettle, suitcases, *drie hook*, Kist for storing clothes, it is how it is done since our elders invented it.]

WP1: *amaketana, izitimela, amasungulo.*

[Chains, trains, arrows.]

WP2*: Amafasidere, iminyano, nezindlu, izinto zasemabodeni zifakwe njengezindlu, manje sisebenzisa isitayella sanje ngehlosos yokwanelisa itjhisakalo yabathengi bethu.*

[Windows, doors, houses, and modern things are currently included. We are now using a contemporary style intended to satisfy interests.]

WP3: Amajamo afanako aphindaphindiwe emudeni ofanako, amanye aphendulwa ukuze alethe ukuhluka okuthileko ekurhabiseni.

[Similar shapes are repeated on the same row; some are turned around to bring some variation in decoration.]

WPB: *Umgwalo wesiNdebele kuyizibalo nokho ababelethi betthu abadala lokho bebangazi bona benza izizbalo njgnoba bangazange baya eskolweni, mara bebazi ukuthi amajamo kumele agwalwe ngendlela efaneleko ukuthi iganukeje. Ihloso yabo ekulu kwakukurhabisa.*

[Isindebele painting is Mathematics; however, our parents who created this did not know that they were doing mathematics as they did not attend schooling, but they knew that shapes must be drawn accurately for them to be attractive. Their main intention was to decorate.]

RQ: *Lithini igama lobujamo lobo?*

[What is the name of that shape? (pointing at a shape on the cultural artefact that WB1 was busy making)].

WB1: *Yifilisi*

[It is Fillis]

WB1: *Asiwasebenzisi amagama njengezibalo ezisetjhenziswa njengeskolweni. Ifilisi iyisik*were *esincani, isiyingilizi noma uncazine ngaphakathi kobujamo obukhulu. Ngokutjho kwabadala yaziwa ngeihlo, esetjhenziswa ukwenza ubujamo bubuhle ukuze kukhanukejeke abathengi.*

[We do not use the names as in Mathematics used at school. Fillis is a small square, a circle or a rectangle inside the more oversized shape. According to elders, it is known as *ilihlo*, which makes the shape beautiful to attract clients.]

WB2*: kutjhengisweko ukuthi kuyisiko lesiNdebele isebenzisa ubujamo bakhe ekurhabiseni kwakho ukugwala kanye nomncamo kodwa amagama asetjhenziswako awafani nalawo asetjhenziswa kujiyomethri yesikolo.*

[Ndebele culture uses these shapes in its decorations for paintings and beadwork, but the terminology used is different to the one used in geometry at school.]

Women painting the clothes indicated that if they do not use squares and rectangles, the picture will not fit properly and that the shapes must be of equal size on the cloth. The same thing applies to measurement. If they don't measure appropriately, the lines will not be the same length.

4.2.5.2.2 How knowledge of shapes was acquired

RQ: *Uwafunde bunjani amabumbeko namkha amadizayini ahlukahlukeneko la owasebenzisako?*

[How did you learn the different shapes you are using?]

Women taking part in the FGD indicated that WPB taught them. Knowledge holders explained that they started by observing WPB for some time and later learned how to paint using small boards for practice. Their first product is the board. There is also a wall for them to paint as a progression from boards when there is improvement.

WP1: *Ongazuza khulu kunabanye. Ngaya e-Italy ngiyokwenza umgwalo egameni likagogo Sophy Mahlangu. Ngafundiswa ngumma uSophy Mahlangu ngesikhathi ngifika la kwaNdebele. NginguMsotho ngokwesiko, mara angikae ngabandlululwa. Ngivela e-Italy ngenxa yakhe. Ngaya lapho ngeziphaphamtjhini zangeNingizimu Afrika egameni lakhe. Bekumele aye lapho kodwana* *wangakwazi ngenxa yezibopho zomndeni. Wabe esengibawa ukuthi ngidwebe umuda onqophileko ngaphandle kokusebenzisa irula. Isikhathi sasinganele njengoba kwadingeka bona ngiye e-Italy. Besisebenzisa amehlo wethu ukwenza isilinganiso. Ngemuva kwesikhatjhana lapho abona ukuthi ngingakwenza, wabesethi ngingasebenzisa irula ukuze ngibemsinyana, Ngikhulele kumaNdebele, ngazi yoke into ehlanganisa isiNdebele ubukghwari / ubuciko bemabodeni kanye nomncamo.*

[I benefited more than others. I went to Italy to do painting on behalf of WPB. I was taught by WPB when I arrived here at Ndebele. I am Mosotho by culture, but I was never discriminated against. I am from Italy because of her. I went there through South African Airways on her behalf. She was supposed to go there but then she couldn't due to family commitments. She then requested me to go on her behalf. She started by teaching me how to draw lines on her wall. She instructed me to draw a straight line without using a ruler. Time was insufficient as I had to go to Italy. We were just using our eyes to do estimation. After a while, when realizing that I could do it, she said I could use a ruler to be faster. I Grew up with Amandebele, and I know everything that involves Isindebele mural art and beadwork.]

WP2*: ngathoma ngebhodi elincai ne yege, ngase ngiragela phambili ebodeni elisetjhenziselwa ukuzijwayeza.*

[I started with the small board and the gate, then moved to a wall that is used for practice.]

She pointed at the small boards below displayed for tourists.

Figure 4.42: Small boards used to practice painting

WP3: *Ngathoma ngebhodi elincani, Wasihlelela isifundobandulo. Amajamo asetjhenziselwa umrhabiso ukuze umgwalo wethu ube muhle. Ngisebenzisa ithulusi lokulinganisa ukugwala. Angikwazi ukusebenzisa isiba.*

[I also started with the small board. She arranged a workshop for us. The shapes are used for decorations for our painting to be beautiful. I use measuring instruments to paint. I cannot paint through estimation. I can't use a feather.]

WB1: *Ugogo Sophy Mahlangu wathoma ukusifundisa esebenzisa into encani. Wasikhombisa indlela yokukhetha umncamo, ukuhlukanisa ngokwemibala, ukuthi iphathwa njani inalidi, indlela yokujhintjhana ukwenza ubujamo ngomncamo.*

[Ugogo Sophy Mahlangu started to teach us using a small item. She showed us how to pick beads, sort them according to colours, handle a needle, and take a turn to make a shape with beads.]

WB2: *Iye, sathoma ngokumqala, sambukela ephothela umncamo, sabe sasebenzisa into encani ukuzifundisa ngaphasi komhlahlo wakhe. Ngazama ngaze ngakwazi ukuwenza. Manje sengiyakwazi ukwenza izinto ezihlukahlukeneko zamasiko*

[Yes, we started by observing her, watching her make beadwork, and then using a small item to practice under her guidance. I tried until I could make it. I am now able to create a variety of cultural artefacts.]

The researcher further probed women to check on the duration they took to learn how to make the cultural artefact.

Researcher: *Kukuthathe isikhathi esingangani ukuthi uzwisise futhi ukwazi ukugwala?*

[How long did you understand and know how to paint?]

WP2: *Kwamambala kuyangomuntu ngamunye. Ngazinikela isikhathi sokwasi ukuthi ngizokwenza njani ukuthi kunembeke futhi ngobuthakgha.*

[It depends on the individual. I took time to know how to do it accurately and neatly.]

WP3: *Abantu abafani, manje iye, isikhathi sizohluka. Azange ngizabalaze ngalelozinga.*

[People are different, so yes, time will be different. I did not struggle to that extent.]

WP1: *Eqinisweni ngangijabulile, ngigqugquzelwa ukuthi ngizokhamba ngesiphaphamtjhini ngiye kwenye inarha. Azange kungithathe isikhathi ukwazi ukugwala, ngemuva nje kwesikhatjhana, ngangilinelekile ngoba ngangizinikele futhi nginesithakazelo kulokho engangikufunda.*

[I was excited and motivated by the fact that I would travel by aeroplane to a foreign land. It did not take me time to know how to paint within a short time. I was an expert because I was dedicated and interested in what I was learning.]

WB2: *isikhathi sokufunda indlela yokuphothela umncamo siyahluka kuyangomuntu njengoba kuhluka emadleni omuntu ngamunye, abanye bamsinyana abanye babuthaka.*

[The time frame to learn how to make beadwork differs from one individual to the other as it depends on an individual's capability; some are faster while some are slow.]

WB1: *Iye, kuyiqniso, abanye babona kulula kanti abanye babona kubudisi kudingeka ukuzibophelela noku zimisela kumuntu ngamunye.*

[Yes, it's true; some find it easy, some find it difficult. It needs commitment and determination from an individual.]

4.2.5.2.3 Meaning conveyed by geometric shapes

W2, W3 and W4 said that the kwamanala painting represents the waves of the sea. Shapes are about things they used in the past, such as arrows, and they portray Ndebele culture.

RQ: *Inga rhani amabumbeko we-jiyomethri namkha amadizayini la anomlayezo namkha kunento ayitjhoko na?*

[Do geometric shapes convey meaning or message?]

Nangebi uyavuma, anamuphi umlayezo namkha atjho ukuthini?

[If yes, what meaning do they convey?]

WPB: *Awa, ubujamo obusetjhenzisiwe abunancazelo angazi ukuth butjho ukuthini.*

[No. The shapes used do not have meaning. I don't know what they mean.]

The researcher asked a follow-up question:

Nangabe uyala, kubayini unekareko kiwo?

[If no, why are they of much interest to you?]

WPB: *Zisetjhenziselwa ukurhabisa, eqinisweni zisetjhenziselwa ukujamela ubuciko besiko lamaNDebele. Invelaphi yobuciko base mabodeni wesiNdebele kanye nomncamo kutholakala kumajamo esiwasebenzisako.*

[They are used for decoration to represent the art of Ndebele culture. The originality of Ndebele mural art and beadwork lies in the shapes we are using.]

WPB: *Njenganje sivanga amajamo wokuthoma ngesikhathi sanje ngoba siyathengisa, senza irhwebo ukuze singenise imali ihlosos kukudosa nokwanelisa abathengi. Manje sesihlanganisa imibala ehlukahlukeneko kanye nokubunjwa okungasiko kwesiko lamaNdebele ngehloso yokwamukela boke abamnyama nabamhlophe. Sifaka imibala yamaXhosa ngokunjalo asisacabangeli esikweni lama Ndebele kuphela. Eskhathini sanje abantu sebathanda ukuvanga imibala.*

[Currently, we are mixing original shapes with modern things to meet the demands of the modern era because we are selling and doing business to generate income. The aim is to attract and satisfy the clients. We are now including various colours and shapes, which are not for Ndebele culture, and we aim to accommodate all blacks and whites. We include colours for the Xhosas as well and no longer concentrate on Ndebele culture only. Nowadays, people like colour blocking.]

Researchers' follow-up question:

Awucabangi ukuthi lokho kuzoba nomthelela omumbi ngokwemvelo lwesiko lamaNdebele.

[Don't you think that that will negatively impact the originality of Ndebele culture?]

WPB: *Iye, ngakho-ke kuphazamisa umlayezo kanye nemvelaphi yesiko lamaNdebele. Esikhathini esidlulileko uzoqaphela ngobujamo nemibala ukuthi ubuciko bassemabodeni nokupothela umncamo wesiNdebele obumsulwa, kodwa ngebhadi sidinga imali ukuze siphile ngale kwalokho abantu ngekhe bathenge umkhiqizo wethu.*

[Yes, Consequently, this negatively affects the message and originality of the Ndebele culture**.** In the past, you will notice by the shapes and colours that this is pure isiNdebele mural art and beadwork, but unfortunately, we need money to survive. Otherwise, people will not buy our products.]

WP2 & WP3*: Iye, baveza amasiko wamaNdebele.*

[Yes, they portray Ndebele culture.]

WP1: *Iye, ngicabanga ukuthi banencazelo ukuthi kunesizathu sokubakhona.*

[Yes, I think they do have meaning; there is a reason why they exist.]

WB1 & WB2: *Iye (Yes)*

RQ: *Nangebi uyavuma, anamuphi umlayezo namkha atjho ukuthini?*

[If yes, what meaning do they convey?]

WPB: *Ngoba sifuna ukuveza amasiko wethu ukuze aziwe ebantwaneni bethu lababanye abantu abangamaNdebele ngesiko. Esikhathini esidlulileko / emandulo umnqopho ekugwaleni izinto ebebaphila nazo, izinto ababenezivumelwano nazo ezimpilweni zabo ngamalanga woke, izinto ezigwaliweko noma eziphtothelwe ngomncamo zazingaphakathi kwesiNdebele. Ngokuphambana okukhethekileko kwanamhlanje ekwenzeni izinto zobuciko zamasiko kuqhutjhwa amandla wezomnotho.*

[Because we want to portray our culture to become known to our children and other people who are not Ndebele by culture. In the past, they focused on painting things they were living with, things they were in direct contact with in their daily lives, and things painted or beaded within the Ndebele context. In contrast, economic forces drive today's specialty in making cultural artefacts.]

WP1: *Abantu ababathlama bebasendleleni bazama ukukhulumisana okuthile mhlambe bebaffuna sazi ngezinto abebazisebenzisa kade njengamasungulo.*

[People who created them were, in a way, trying to communicate something; perhaps they wanted us to know about things they used in the past, such as arrows.]

WB2: *Izinto zamasiko zamaNdebele zisefetjhenini futhi zithegiselwaa izivakatjhi kanye nezakhamuzi zaseNingizimu Afrika.*

[Ndebele cultural artefacts are fashionable and sold to tourists and South African citizens.]

WP2 & WP3: *Baveza amasiko amaNdebele, izizukulwana zoke kumele zikwazi.*

[They portray Ndebele culture, and all generations must know it.]

WPB*: Nangabe singasebenzisi sizobe sibhidliza isiko lethu, liyotjhabalala.*

[If we don't use them, then we will be destroying our culture; it will fade away.]

WB1: *Okutjhiwo bujamo akuhlobani nezibalo ihloso bekungekhona ukuveza izibalo ezifundiswa esikolweni kodwa ubuciko besiNdebele.*

[The meaning attributed to the shapes is not mathematics-related. The aim was not to portray mathematics taught at school but Ndebele artist creativity.]

4.2.5.2.4 Process of making Ndebele cultural artefacts

a) Steps to be followed in making Ndebele cultural artefacts

RQ: *Ikhona imihlahlandlela ekufuze uyilandele lokha nawenza iinsetjenziswa zobukghwari beskhethu ozaziko?*

[Are there steps to follow when making your cultural artefacts?]

Nangabe uyavuma, ngimiphi imihlahlandlela ekufuze uyilandele?

[If yes, what are the steps to follow?]

Nangabe uyala, yini ekusizako bana uthome bewuqede?

[*If no, how do you arrive at the final product*?]

WPB, WP 1, 2, & 3, WB1 & WB2 (all): There are steps to follow when making beadwork and painting.

RQ: *Yini le oyenzako?*

[What is it that you are making? (question directed to ladies who were busy with beadwork)].

WB1: *varhe izivalo zewayini.*

[I am making wine lids.]

WB2: *Ngivarhe isivalo sewayini.*

[I am making a wine stopper.]

The researcher asked a probing question to determine whether women count the beads.

RQ: *Uyawubala na umncamo, nangabe uyavuma uwubala ngani?*

[Do you count the beads? If yes, why are you counting them?]

WB1*: Iye, ngibala ngakuthathu nakuhlanu ukuze ngibe nephetheni emrhabiso wami wefilisi noncantathu. Iinomboro 3 no 5 zisetjhenziselwa imirhabiso eminengi.*

[Yes, I am counting in threes and fives to have a pattern in my decoration of *filis* and triangles. Numbers 3 & 5 are used in most decorations.]

WB2: *Iye ngiyawubala, ihlangothi leli ngibale 30, ihlangothi elinye 39, ngasebenzisa umncamo ofanako indawo ezimbili eziphambeneko ukuze kulingane ngobude, ekurhabiseni kwami.*

[Yes, I am counting them; on this side, I counted 30; on this side, 39. In my decoration, I used the same number of beads for the two opposite sites so they would be of equal length.]

WB1: *Ngibuye ngihlukanise godi ngihlele umncamo ngokombala ukuze ngihlukansie ubujamo emrhabiso wami. Umrhabiso wesivalo sewayini ama-zig zags.*

[I also classify and sort the beads according to colours to separate shapes in my decoration. The decoration of the wine stopper is zig zags.]

WB1: *Nangabe senza isibonelo, amacici, Umkhala sisebenzisa umncamo onemibala eyahlukeneko, kufanele siqinisekise ukuthi umncamo uyahlukaniswa, uhlukaniswe ngemibala ngaphambi kokuba sithome ngobujamo. Ukubala kuhlala kubandakanyeka njengengxenye yekambiso ngoba kufanele uthathe isiqunto ngombala nenani lomncamo ozowusebenzisa.*

[When making, for example, earrings, *Umkhala,* we use beads of different colours; we have to ensure that beads are sorted and classified into colours before starting with the shape. Counting is always involved as part of the procedure because you have to decide on the colour and the number of beads you will use.]

WB2*: Ngaphezu kokubala, ngezinye izikhathi siyangezelela noma sisuse, siphindaphinde noma sihlukanise kuye ngephethini esiyifunako lapho senza umsebemnzi womncamo noma kungasinjalo ngekhe uthole ubujamo noma iphehini ofuna ukuyenza.*

[In addition to counting, we sometimes add or subtract, multiply or divide depending on the pattern we want when doing beadwork, or you will not get the shape or pattern you want to create.]

[I am counting them; on this side, I counted 30, and on this side, 39; I used the same number of beads for the two opposite sites to be of equal length in my decoration.]

WB2: *Nangabe senza amahopu anombala owodwa kuphela woke, asikho isidingo sokubala, silinganisa mje mgenani lomncamo esizodinga ukuqedela ubuciko bamasiko, ukuze singaphuthelwa umncamo.*

[There is no must-count when making hoops with only one colour throughout. We estimate the quantity of beads and must complete the cultural artefact to not run short of beads.]

WPB: *Aamahopu ahluka ngesayizi kuye ngobukhulu bomzimba womuntu. kanye nengxenye yomzimba njengamahopu wedini kanye namahopu womlenze.*

[Hoops differ in size depending on the size of the individual's body and the part of the body such as waist hoops and leg hoops.]

She showed me the different hoops for different parts of the body to emphasize her point.

WB1: *Iye, ngakho-ke inani lomnamco elidingekako lizokuhluka, nokho kuyiqiniso ukuthi asibali kodwa silinganisela nje uma senza amahopu. Amahopu wedinini adings umncamo ongezelelweko ngoba makhulu. Amahopu nakamakhulu kulapho kufanele kusetjhenziswe umncamo omnengi.*

[Yes, so the number of beads required will differ; however, it is true that we don't count; we just estimate when we make hoops. Waist hoops need more beads because they are significant. The bigger the hoop, the more beads will be used.]

WPB: *Izindiligi/ amahopu enziwe ngotjhani ngaphakathi, obuvalwe ngetjhila kanye nomncamo phezu kwetjhila wokurhabisa, Isibonelo, Isirholwani, amahopuwentamo anemibala enziwe ngotjhani obugoqiweko bube yindilinga/ yihopu, bubophe ngokuqinileko ngekotini futhi burhabise ngomncamo.*

[The hoops are made of grass inside, covered with cloth, and the beads are on top of the fabric for decoration. For example, Isingolwani (colourful neck hoops) are made by winding grass into a hoop, binding it tightly with cotton and decorating it with beads.]

Researcher probed WPB to find out if grass used is measured:

Wazi njani ukuthi bungangani utjhani ozobusebenzisa kumasayizi ahlukeneko.

[How do you know how much grass you will use for different sizes?]

WPB: *Ngimane ngilinganise inani lotjhani engisbusebenzisa. Ngiqala ubukhulu bomzimba womuntu bese ngilinganise. Ngithatha utjhani obanele ukuze bulingane nomzimba wakhe.*

[I just estimate the amount of grass I am going to make use of. I look at the person's size and estimate of the body. I take the grass enough to fit her body.]

They started by sorting beads according to colours.

Three women were busy painting clothes. They were using brushes and measuring instruments, including the meter stick and the ruler. A pencil is used to draw a straight line with the ruler, and rubber is used to erase in case of a need. They mentioned that they were preparing the order to be collected. Cloths were to be painted using Ndebele painting and framed to serve as pictures to be placed on the wall. Women started by measuring the fabric, length, and distance between the lines. WP1 indicated that she had attended school up to Standard 1; however, she can use a ruler and a meter stick accurately with the help of the other two painting women, demonstrating teamwork, cooperation and collaboration, and synergy within the group.

RQ**:** *Nenzani la bomma?*

[What are you doing here ladies?]

WP1: *Sigwala itjhila.*
[We are painting the cloth.]

RQ: *Ngelani itjhila leli?*

[What is this cloth for?]

WP2: *Letjhila ligwalelwe ukwenza isithombe esikhulu sokurhabisa. Uma sesiqedile ukyigwala, sizoyibeka kufremu besesibeka irhalasi phezu kwayo.*

[This cloth is painted to make a big picture for decoration. When we finished painting it, we put it in a frame and place glass on top of it.]

RQ: *Ikhona imihlahlandlela ekufuze uyilandele lokha nawenza iinsetjenziswa zobukghwari beskhethu ozaziko?*

[Are there steps to follow when making your cultural artefacts?]

WP1: *Iye, kunezinyathelo okumele uzilandele.*

[Yes, there are steps to follow.]

WP2 & WP3*: Iye.*

[Yes]

RQ: *Ngimiphi imihlahlandlela ekufuze uyilandele?*

[What are the steps to follow?]

WP1: *Uthoma ngokukala indawo engutjheni yakho, uthatha isiqunto sobukhulu bendawo oyifunako ngobujamo ozobugwala/ ozobudweba, ukuthi kuzoba yi sentimitha noma 2 sentimitha, 5 sentimitha noma 10 sentimitha.*

[You start by measuring the space in your cloth and decide on the size of space you want for the shape you will draw, whether it will be a centimetre or 2 centimetres, 5 centimetres or 10 centimetres.]

WP3: *Kuyiqiniso, kufanele uthathe isiqunto ngaphambi kobukhulu bamajamo ozowadweba/ozowagwala kodwa into yokuthoma ukufanisa ikaba yetjhila bese merega ukuze zoke iinthombe zingene engutjheni*.

[You have to decide the size of the shapes you will draw; however, the first thing is to identify the centre on the cloth and mark it for all the pictures to fit.]

WP1: *Okokuthoma wenza isilinganiso sangaphambili kanye nomgwalo usebenzisa irula, irabha, kanye nepensela. Esikhathini esidlulileko bebamane balinganisa, futhi akukho mgwalo yangaphambili eynziwa. Umuda wangeqadi omnyama udwetjhwa kokuthoma kusetjhenziswa irula nepensela. Okwesibili ikaba iyazinikela futhi kamuva ifake ezinye izibalo zejiyomethri*.

[You first make prior measurements and sketches using the ruler, rubber and a pencil. They were just estimating in the past, and no prior sketches were made. The black outlines are first drawn using a ruler and a pencil. Secondly, the centre is determined and later includes other geometric figures.]

WPB: *Esikhathini esidlulileko sasingasebenzisi amathulusi wokulinganisa, sasimane sisebenzisa isilinganiso ukuze sithole ubukhulu bobujamo nobude bemida. Amathulusi wokulinganisa bewangekho esikhathini esidlulileko. Abomma bethu abasange bazisebenzise.*

[In the past, we were not making use of measuring instruments. We were just using estimation to determine the shape, size and length of lines. Measuring instruments were not available in the past. Our mothers did not make use of them.]

The researcher asked a follow-up question:

Kungani abafazi sebezebenzisa amathulusi nje ngoba basengkakwazi ukugwala ngobunono ngaphandle kokusethenziswa kwamathulusi?

[Why are the women using the instruments now? They can still draw neatly without the instruments being used.]

WPB: *Ngibavumele abomama engibabandulako ukuthi bawasebenzise ngoba akhona nje, futhi abomma bangawasebenzisa. Ngibonile ukuthi amathulusi asisiza khulu ngoba ibelo labafazi linyukile, baweda masinyana.*

[I have allowed women that I am training to use them because they are available, and women can use them. I have realized that the instruments assist a lot because women's speed has increased; they finish up quickly.]

WP2: *Angikwazi ukukala isilinganiso. Ngazama kodwa/mara ngahluleka, umsebenzi wami wawumumbi (wahleka). Kudingeka ukuthi wenze isilinganiso sakho ngokunembako nangendlela efaneleko.*

[I cannot use estimation. I tried but failed. My work was horrible (she laughed). You are required to take your measurements accurately and appropriately.]

RQ: *Utjho ukuthini ngokulinganisa ngokufanaleko nangokunembileko? Ngibawa ungihlathululele.*

[What do you mean by measuring appropriately and accurately? May you please explain.]

WP2: *Kufanele ngaso soke isikhathi ngiqinsekise ukuthi ngibeka irula yami ngokunembako endaweni engifuna ukuyikala futhi ngifunde isilinganiso sami ngendlela efaneleko, okungukuthi uma singu-20cm kufanele sibe ngu-20cm ngokulinganako/ncamatjhi.*

[I must always place my ruler precisely on the space I want to measure and read my measurement correctly; that is, if it is 20 cm, it must be exactly 20 cm.]

W4: *Nangabe izilinganiso zakho zingalungi, ubujamo bakho betjhila ngekhe kufane njengoba uhlelile, umgwalo wakho ngekhe ube muhle, ngekhe uthandeke, uzoqinisekisa abantu ukuthi kukhona okungakhambi kuhle ngezilinganiso.*

[If your measurements are not accurate, your shapes on the cloth will not fit as you have planned, your painting will not be beautiful, will not be attractive, and it will sure people that something went wrong with the measurement.]

RQ: *Ngikuzwe utjho nge-cm, ngiziphi izilinganiso ozisebenzisako.*

[I heard you making mention of cm; which units of measurements are you using?].

WP3: *Ungasebenzisa i-mm noma i-cm kuya ngobude bobujamo. Sisebenzisa amamitha kumabanga amade, isibonelo: imida yetjhila.*

[You can use mm or cm depending on the length of the shape. We use meters for long distances, e.g. the lines on the cloth.]

RQ: *Inga ibanga eliphakathi kwemida liyalingana? Futhi kangangani?*

[Is the distance between these lines equal? And how much is it?]

WP2: *Iye kuyalingana. Nokho ibanga eliphakathi kwemida liyama kumuntu ngamunye. Ngissebenzise u-2cm, uma udinga ibanga elifitjhani, uzosebenzisa isentimitha (ekhomba ebangeni eliphakathi kwemida engutjheni).*

[Yes, it is equal. However, the distance between the lines depends on the individual. I have used 2 cm; If you need a short distance, you will use a centimetre (pointing at the distance between the lines on the cloth).]

WP1: *Sibala nenani lemida okufanele siyidwebe/ siyigwale futhi siyisebenzise emdwebeni/ emgwaleni.*

[We are also counting the number of lines we must draw and use in the painting.]

WP1, WP2, and WP3 explained and demonstrated to the researcher using the pictures below.

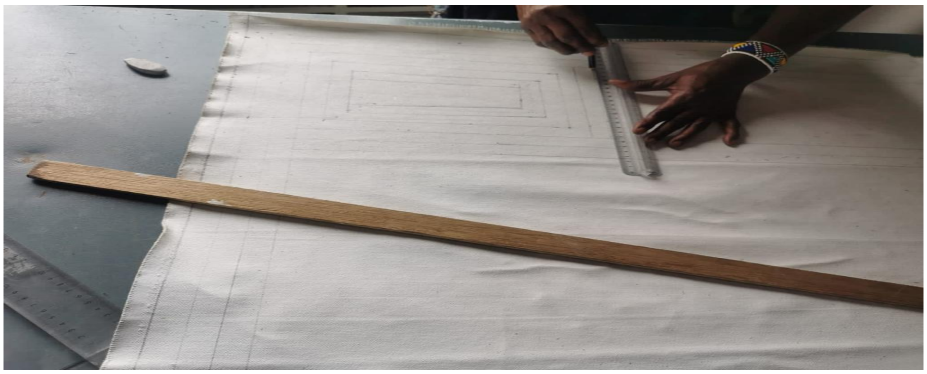


Figure 4.43: WP1 showcasing mural art using measuring instruments

4.2.5.2.5 Using school mathematics in making the Ndebele cultural artefacts

RQ: *Uyalisebenzisa ilwazi leembalo (maths) olifunde esikolweni ukwenza iinsetjenziswa zobukghwari besikhethu ozabaziko?*

[Are you using knowledge from school mathematics to make your cultural artefacts?]

All the ladies said yes, except WPB, who said No:

The researcher probed WPB's response and asked her to elaborate on what she meant to say no to.

Kungani uthi Awa?

[Why are you saying no?]

WPB: *Ngoba angizange ngiye esilkolweni. Ngiyazi nje kodwa ukubala ngikufunde khona la ekhaya emntazaneni wakwami, yingakho ngithi awa.*

[Because I did not attend any schooling, I just know a bit of counting learnt here at home from my daughter; hence, I am saying no.]

RQ: *Sibawa usitjhele ukuthi kungani uthi usebenzisa izibalo ozifunde esikolweni ukuze wenze zakho zobuciko zamasiko.*

[May you please tell us why you are using mathematics learnt at school to make your cultural artefacts?]

WB1: *Umncamo siyabala, ngezinye izikhathi siyangezelela, siyakhipha/ sisuse, siphindaphinde noma sihlukanise kuya ngephetheni futhi lezo zibalo ezifundwa esikolweni, nokho izibalo ziyisisekelo hayi ukurarana*.

[In beadwork, we count and sometimes add, subtract, multiply or divide depending on the pattern. That is mathematics learnt at school; however, it is basic, not complex.]

WB2: *Ubujamo esibenzako buyizibalo. Isibonelo Uncantathu, isik*were*, oncazine, bangamajamo ayi 2D afundwa yijiyomethri esikolweni. Sakha amaphetheni wejiyomethri laho sirhabisa umncamo.*

[The shapes that we create are mathematics. For example, triangles, squares, and rectangles are 2D shapes, which is a geometry learned at school. We create geometric patterns when decorating beads.]

WB2: *Futhi imida esitlhamako iyingxenye yejiyomehri yemida enqophileko. Sakha imida ekhambisanako, imida ejame thwi/eqondileko kanye nemida ethabaleleko/ evundlileko.*

[And the lines we create are part of the geometry of straight lines. We make parallel lines, vertical lines and horizontal lines.]

WB1: *Ngezwi lami kelelo, kufaka phakathi imida eqondile ene-engeli yakwesokudla. Ngaphakathi kobujamo esibakhayo kunama-engeli ahlukeneko njenge – engeli engakwesokudla, engeli ehlabako/ ebukhali Kanye ne-engeli ebuthuntu. Nasakha uncazine ngokwesibonelo Sakha ama-engeli alungileko kiwo, ukuze kube nguncazine wamambala kufanele abe ne-engeli amane angakwesokudla. Irhombus/ ifilisi inama-engeli abuthuntu na hlabako kiyo.*

[My word exactly, including perpendicular lines. Within the shapes we create, there are different angles, such as right angles and acute and obtuse ones. When we create a rectangle, for example, we create right angles; for it to be accurate, it must have four right angles. A rhombus has obtuse and acute angles in it.]

WB1: *Iye liqiniso lelo.yes,*

[That is true.]

WP3: *Izibalo ezifundwa esikolweni ziyasetjhenziswa, nokho yingcosana yazo. Kukhona Isilinganiso/isimedo, ikaba, isiyingilizi, uncazine, isik*were*, Uncantathu kanye ne isungulo, imida, izingxenye ezilinganako. Mathematics learnt at school is used but is a bit of it.*

[There is measurement, the centre, the circle, rectangle, square, triangle and arrow, the lines, equal parts.]

WP2*: Sisabenzisa ukulinganisa ngaso soke isikhahiemgwaleni wethu wokugwala ebodeni. Sisebenzisa ibumbano lokulinganisa okufundwa esikolweni, okutjho ukuthi amamilimitha namamitha asetjhenziswa ekupendeni/ ekugwaleni kodwa lokhu kuvele nokutlhama ukuciko obusebodeni.*

[We make use of measurement every time we create our mural art. We are using units of measurement learnt at school; that is, millimetres, centimetres, and meters are used in painting, but this came with the design of mural art.]

WP3: *Ubujamo buyalinganiswa ukze kuqisekiswe ukunemba kwemida yehlangothi ngalinye futhi ukumeda kuyizibalo. Ilwazi elifundwe ezingxenyeni zesiyingilizi, ikaba isetjhenziselwa ukuqinisekisa ukuthi ikaba yobujamo isororhekile.*

[Shapes are measured to ensure the accuracy of lines for each side, and the measurement is mathematical. The knowledge is learnt on the parts of a circle; the centre is used to ensure that the shape's centre is maintained.]

WP3: *Siphinde sisebenzise izihlobo ezahlukene zetjhuguluko emirhabisweni yethu, kodwa uma sigwala asitjho ukuthi senza itjhuguluko ngoba asitjho ngempela ukuthi manje siyakhombisa noma sitjhugulula ubujamo, sirhabisa nje okwatlanya ngabadala bethu siqinisa ilwazi labo.*

[We are also using different types of transformation in our decorations, but when we paint, we do not say that we are doing transformation because we don’t really tell we are reflecting or translating a shape; it is just decoration invented by our elders, we sustaining their knowledge.]

4.2.5.3 The role played by women, girls, me and boys in the making of Ndebele cultural artefacts

4.2.5.3.1 The role played by women and girls

RQ: *Kubayini abantu bengubo kungibo abathatha amagadango phambili ekwenzeni iinsetjenziswa zobukghwari besiNdebele?*

[Why are women taking a leading role in making Ndebele cultural artefacts?]

WPB: *Umncamo nokugwala bekuloku kumthwalo wabantu bengubo, amadoda afulela izindlu zotjhani. Amadoda nabafana babengavunyelwa ukwenza izinto zobuciko zamasiko esikhathini esidlulileko.*

[Beadwork and painting have always been the responsibility of women; men do roofs of huts. Men and boys were not allowed to make cultural artefacts in the past.]

WP3: *Abomama benza izinto zobuciko zamasiko bazithegise ukuze bathole imali ukuze bakwazi ukunakelela imindeni yabo.*

[Women make cultural artefacts and sell them to generate income so that they can take care of their families.]

WPB: *Abafazi bavikela futhi balondloza ilwazi lwamasiko. Ngikhathazekile futhi nginevalo lokuthi isiko lethu liya ngokuya litjhabalala kancane kancane ngoba abantazana bethu abanengi abakukarekeli ukwenza izinto zamasiko, abawazi, futhi ngekhe bakwazi ukudlulisela ilwazi ebantwaneni babo.*

[Women protect and preserve cultural knowledge. I am concerned and afraid that our culture is gradually fading because most of our daughters are not interested in making the cultural artefacts, do not know them, and will not be able to transfer knowledge to their kids.]

WP1: *Abafazi banaNdebele ngabaphethe ilwazi banesibopho sokudlulisela ilwazi ebantazaneni babo nakwabanye abomama, ilwazi lidluliswa lisuka ebafazini liye ebantazaneni*

[Ndebele women are knowledge holders who have a responsibility to transmit knowledge to their daughters and other women; knowledge is transmitted from women to girls.]

WPB: *Njenganje nginomzukulu oneminyaka ei-10 uhlala angiqalile ngenkathi ngiphothela umncamo fuhti ngigwala.*

[I am currently having a granddaughter who is 10 years old. She is observing me whilst doing beadwork and painting.]

4.2.5.3.2 The role played by men and boys

RQ: *Inga abantu bembaji nabo banendima ebayidlalako ekwenzeni iinsetjenziswa zobugkwari besikhethu?*

[Are men taking part in making cultural artefacts?]

WPB: *Iye*

[Yes]

RQ: *Ngiyiphi indima ebayidlalako ekwenzeni iinsetjenziswa zobukgwari besikhethu?*

[What is their role in making cultural artefacts?]

WPB: *Ngaphambili bebengabandakanywa, kodwa njenganje ngenxa yezinga eliphezulu lokuthlogeka komsebenzi, abantu babulawa yindlala, abakwazi ukuzinakelela bona nemindeni yabo. Ngabe sengithatha isinqumo sokulwa nokuthlogeka kwemisebenzi nobuchaka. Ngibandule idlanzana lamadoda ngendlela yokugwala. Bapenda / bagwala amaboda wabantu futhi bayabhadalwa ukuze baziphilise. Umnqopho wabo wubuciko basemabodeni kuphela.*

[In the past, they were not taking part, but currently, due to high unemployment, people are suffering from hunger and can't take care of themselves and their families. I then decided to fight against unemployment and poverty. I have trained several men on how to paint. They are painting walls of people, and they get paid to make a living. Their focus is only on mural art].

WB1 and WB2: *Awa*

[No]

RQ: *Nangabe uyala, kubayini banganandima ebayidlalako?*
[If no, why are they not taking part?]

WB2: *Abahlanganyeli ekuphotheleni umncamo. Basaba ukuthi abanye bazobahleka, bazokuthi benza umsebenzi wamabafazi/ wabantu bengubo. Ngizamile ukuqatjha abanye kodwa banamahloni ukuthi ekubandulweni.*

[They do not participate in beadwork. They are afraid that others will laugh at them, that they will say they are doing lady's work. I tried to recruit some, but they are too shy to come for training.]

WP2: *Ukungenzi lutho kwabesilisa kungabangwa yinjwayelo yokuthi amadoda abenzi umncamo ngokwesiko lethu.*

[Men's inactive role can be due to the norm that men do not do beadwork as per our culture.]

RQ: *Nangabe uyala, inga kghani lokho kutjhobona abesana abanalo ilwazi elifunekako njengabentazana lokwenza iinsetjenziswa zobukghwari besikhethu?*

[If no, does it mean that boys do not have basic knowledge of making cultural artefacts like girls?]

WP1: *Iye*

[Yes]

WP2: *Iye, abesana abanalo ilwazi oluyisisekelo lokwenza izinto zobuciko ngenxa yesiqhelo sokubandakanyeka kwabesilisa ekugwaleni nomcamo esikweni lamaNdebele.*

[Yes, boys do not have basic knowledge of making cultural artefacts because of the trend of men's involvement with painting and beadwork in Ndebele culture.]

WPB responded: *Iye, ngoba ngisanda kuthoma ukwazisa amadoda ngokugwala.*

[Yes, because I have just started introducing men to painting.]

4.2.5.3.3 Equitable cultural artefact knowledge to all genders

RQ: *Nagabe uyavuma bona abanalo, ukutlhayelwa kwelwazi kungalungiswa njani?*

[If yes, how can the knowledge gap be addressed?]

WPB: *Bekungokwesiko ukuthi amadoda noma abesana abawenzi umncamo ngakho akukho okungenziwa ukubatjhugulula. Nokho-ke njengoba ngike ngatjho ekuthomeni, okwanje ngibandule abobaba abanengi ukuthi benze umgwalo ngemizamo yokuvala isikhala.*

[It has been in the culture that men or boys do not do beadwork; nothing can change it. However, as I said earlier, I currently trained many gentlemen to do the painting to close the gap.]

In support of her statement, WP1 said:

Nginendodana ebandulwe ngugogo Sophy Mahlangu mayelana nokugwala izindlu, amanyathelo namatekkie. Indodana yami ithole ukufundela umsebenzi futhi wathembisa ukuthi uma ingaphumeleli emahlelweni wayo zomsebenzi, izobuya izosebenza nogogo Mahlangu.

[I have a son who Ugogo Sophy Mahlangu has trained on how to paint houses, shoes, and tekkies. My son got a learnership and promised that if he does not succeed with his career plans, he will return and work with Ugogo Mahlangu.]

WPB showed the researcher the gentleman available at the art centre that he was one of those trained to do Ndebele painting. She told the researcher she went with him to the Kgodwana cultural village to paint the walls. He was busy painting dishes that had to be collected. The client ordered the dishes with Ndebele paintings on them.

Figure 4.44: Dish painted by a gentleman

The researcher questions the gentlemen:

Uyayisebenzisa irula?

[Do you make use of a ruler.]

Gentlemen: *Awa* [No]

In an attempt to get ideas on how the gentleman makes his lines straight, the researcher asked him a follow-up question.

RQ: *Uyenza njani imida enqophileko?*

[How do you make your lines straight?]

Gentlemen: *Ngokusebenzisa nje amehlo nesandla, ngisebenzisa ukulinganisa isikhathi esinengi.*

[Just by hand-eye coordination, I usually use estimation.]

4.2.5.3.4 Sharing knowledge and skills with teachers and learners

This theme captures women's sharing of knowledge and skills with teachers and learners on knowledge of different Ndebele cultural artefacts. The WKH emphasized that culture must be preserved so that it can be passed down to the next generation, which can be possible through sharing knowledge with teachers and learners.

RQ**:** *Ungalidlulisela bunjani ilwazi kanye namakghono wokwenza iinsetjenziswa zobukghwari besikhethu ebantwaneni besikolo kanye nabafundisi/titjhere?*

[How can you share your knowledge and skills in making cultural artefacts with learners and teachers?]

In responding to the question of how women can share their knowledge and skills in making cultural artefacts with learners and teachers, women indicated that they are prepared and willing to work with schools.

WPB*: Uma utitjherenabafundi besnesifiso sokuba nelwazi namakghono wokwenza izinto zobuciko zamasiko, kufanele bakubonise, basondele kithi futhi bahlale batholakala lapho sibadinga. Itjhisakalo nothando lobuciko basemabodeni nomncamo kumele babenze baragele phambili, basondelle kithi ukuze bathole isizo futhi lidlule ngokubandulwa.*

[If teachers and learners desire knowledge and skills in making cultural artefacts, they must show it, approach us, and always be available when we need them. The interest and love of mural art and beadwork must make them approach us for help, which will be provided through training.]

WP2: *Ngingahlala nabo, ngibabandule, abanye bazodosa umoya lula futhi masinyana, abanye bazothatha isikhathi ukuzwisisa.*

[I can sit with them and train them; some will grasp easily and quickly, and some will take time to understand.]

WP1: *Kuzothatha iskhathi ngoba abafundi bazoqala ngokusiqala sidweba bese kuthi ngokukhamba kwesikhathi banikezwe izinto ezijwayeza ukudweba. Ngekhe kube yinto eyodwa.*

[Yes, it will take time because learners will start by observing us painting, and later, they will be given material to practice painting. It will not be a once-off thing.]

WB1: *kuyobathatha iskhathi ukuthi baqonde indlela yekambiso. Kufanele baqalisise, benze balinge iphutha baze bafunde ikghono.*

[It will take them time to master the process. They must observe trial and error until they master the skill.]

WPB: *Siyazam ukusebenzisana nezikole. Abotitjhere kumele basivumele ukuthi size sizobabandula Kanye nabafundi babo ekwenzeni izinto zobuciko zamasiko. Kufanele kufinyelelwe esivumelwaneni ngesikhathi esidingekayo sokugwala Kanye nomncamo. Emandulo ezinye izikolo beziletha abafundi bazo ngamatekisi ekabeni yobuciko ka Dkt. Mahlangu ukuze bazobandulwa kodwa kwaba kanye nje kuphela. Sathoma ngabotitjhere iveke yoke. Besibathathu, kungimi, Ether Mahlangu no-Esther Mnguni. Okubuhlungu wukuthi ngesikhathi bathi abotitjhere babandule abafundi bathi abakwazi base babawa ukuthi sibandule abafundi babo. Esikolweni samabanga aphasi sizmile ukufundisa abafundi kodwa bebengazimisele. Omunye umfundi wavele wathi akakwazi, wakhetha ukuyekela.*

[We are trying to work with schools. Teachers must allow us to come and train them and their learners on the making of cultural artefacts. An agreement must be reached on the time needed for painting and beadwork. In the past, some schools brought their learners in taxis to Dr Mahlangus' art centre to be trained, but only once. We started with teachers for a week. There were three of us: Esther Mahlangu, Esther Mguni, and me. The unfortunate part was that when they said teachers must train learners, they said they couldn't and requested us to train their learners. We tried to teach learners in primary school, but they were not dedicated. One learner said he couldn't do it and decided to stop.]

4.2.5.3.5 Benefits of sharing knowledge and skills with teachers and learners

According to the views of WKH, the art galleries that attract tourists can assist women in attracting learners and teachers so that the teaching and learning of mathematics can succeed. They indicated that they are readily available and that what is needed is the commitment from the side of teachers and their learners. Knowledge gained and used at home will serve as a baseline to be consolidated at school. There is a common understanding that connecting mathematics learnt at school and mathematics done at home is critical and can help learners retain knowledge and improve performance in a subject.

RQ: *Ngikuphi okuhle okungalethwa kukwaba namkha kudlulisela ilwazi kanye namakghono wokwenza iinsetjenziswa zobukghwari besikhethu ebantwaneni besikolo kanye nabafundisi/titjhere?*

[What will be the advantages of sharing knowledge and skills in making cultural artefacts with learners and teachers?]

WP1: *Amakghono okubala nezilinganiso zabafundi azokuthuthukiswa. Abafundi abanezidingo ezikhethekileko bazozuza. Abafundi abanekghono kwezobuciko namasiko bazobandulwa bathole namathuba emisebenzi. Bangaphelela e-Italy njengami nogogo Mahlangu. Ngekhe soke sibe zifundiswa, asikwazi soke ukuba botitjhere noma sisebnze soke ema-ofisini, abanye bethu kufanele sizibandakanye emsebenzini yezandla.*

[Learners counting and measurement skills will be improved. Learners with special needs will also benefit. Learners who are good at art and culture will be trained and find job opportunities. They can end up in Italy like me and Ms Mahlangu. We cannot all be academics, teachers, or all work in offices; some must be involved in handwork.]

WB1**:** *Abafundi bazokwenza ukubal, ngiyiphi ingxenye yezinto abazifunda ezibalweni zesikole, amaphetheni wezinomboro, amaphetheni wejiyomethri ekhaya nasesikolweni. Izibalo eikolweni zizokwakheka phezu kwaleyo etholakala ngokwenza izinto zobuciko zamasiko. Boke abafundi bazonikelwa ithuba lokuphumelela kulokhu kukhambelana.*

[Learners will do counting, which is part of what they learn in school Mathematics, number patterns, and geometric patterns at home and school. Mathematics at school will build on the one gained from making cultural artefacts. All learners will be given a chance to excel through this connection.]

WB2: *Abafundi bazokugqugquaelwa ukubona ukuthi isiko labo linezibalo, bazokuthoma ukuthanda nokujabulela izibalo. Izibalo zizoba mnandi.*

[Learners will be motivated to realize that their culture has mathematics in it and will start to love and enjoy mathematics. Mathematics will be fun.]

WP2: *Iye, ngokunembako, bayoqaphela ukuthi izibalo ziyingxenye yesiko labo. Kuzobasiza ukuthi bahlanganise izibalo ezenziwe ngendlela engenzeka ekwenzeni izinto zobuciko zamasiko Kanye nezibalo ezenziwa esikolweni.*

[Yes, they will recognize that mathematics is part of their culture. It will help them to connect mathematics done practical in the making of cultural artefacts and mathematics done at school.]

In clarifying her point WP2:

Ukulinganisa kungenye yezinto eziyinselele kuzibalo, ukugwala kuzobanika ithuba lokuzijwayeza ukulinganisa amayunithi, ukuphendulwa, ukusebenzisa amathulusi wokulinganisa ukuqinisekisa izilinganiso ezinembileko. Okungenani abafundisi / abotitjhere bazodosa nzima ukuqinisekisa ukuthi abafundi bayawazwisisa amakhilomitha ngoba bazoza esikolweni banelwazi lwamasentimitha namamilimitha.

[Measurement is one of the challenging things in mathematics. Painting will allow them to practice units of measurement and conversion and learn how to use measuring instruments to ensure accurate measurements. At least teachers will only struggle to ensure learners understand kilometres because they will come to school knowing centimetres and millimetres.]

WP3: *Abafundi bazozwisisa izibalo futhi bazokwazi ukukhumbula ngoba ukufunda kuzokhambisana nemisebenzi yabo malanga woke. Umncamo uzosiza abafundi abanekinga yokubala Kanye nemisebenzi emine eyisisekelo. Bayoba nokuzwisisa okucacileko kwehlangothi* *lobujamo ngokuzibandakanya okusebenzako namajamo, ukuwagwala ngobuciko basemabodeni futhi bawenze ngomncamo.*

[Learners will understand mathematics and will be able to remember because learning will be related to their everyday activities. Beadwork will assist learners who are struggling with counting and the four basic operations. They will have a clear understanding of the sides of a shape through active engagement with shapes, drawing them in mural art and creating them in beadwork.]

WPB: *Amasiko wethu azokuhlonitjhwa futhi ahlonitjhwe ngokunotha kwawo. izophinde ibulungwe futhi igcinwe. Abantwana bethu abawazi amasiko wabo ngoba abambathi / abagqoki izambatho zamasiko futhi abaphoqelekile ukuhti bazimbathe / bazigqoke njengoba kwakunjalo kithi esithini esadlulako, ukuthi lokhu kwabelana kuzoba yindlela efaneleko yokufaka ilwazi kwiqembu lesizukulwana sanje.*

[Our culture will be acknowledged and be respected for its richness. It will also be preserved and sustained. Our children don't know their culture because they don't wear cultural clothes and are not compelled to wear them as they were with us in the past, so this sharing will be the right direction to input knowledge to the current generational cohort.]

WP1: *Ilwazi lamasiko lizokufakwa ehlelweni lwezefundo futhi lizofundiswa ngokusemthethweni kubafundi.*

[Cultural knowledge will be included in the curriculum and be officially taught to learners.]

4.2.6 Results from participant observations

The section presents data generated from participant observations with WKH. The observation tool was completed (cf. Appendix T), and pictures were taken with the permission of WKH.

The following themes were identified: (1) using mathematical concepts and skills, (2) Steps followed in making the cultural artefacts, and (3) Sharing of knowledge.

4.2.6.1 Using mathematical concepts and skills

Women made use of a great deal of mathematical concepts and skills. Those who were involved with beadwork were counting. The four basic operations, adding, subtracting, multiplying and dividing, were used to form 2D shapes and geometric patterns with beads. Skills used included sorting, arranging and classifying. Beads were sorted into colours and arranged into sizes.

Women who were painting used the metre stick as their measuring instrument. Lines were drawn straight with a meter stick and a ruler. Accuracy was emphasized as their first priority. They made use of brushes to paint.WPB, who trained the ladies, indicated that she allows them to quickly use those instruments to make cultural artefacts.

4.2.6.2 Steps followed in making the cultural artefacts

The steps followed were demonstrated by women in the making of cultural artefacts. The usual production technique, mural art and beadwork, was explained to the researcher well. The sketches or drawings were made on the cloth to be painted as part of planning. The steps followed were explained, demonstrated and taught to the researcher.

4.2.6.3 Sharing of knowledge and skills

There was a great deal of teamwork and expertise sharing among the group. Women displayed passion, excitement, and dedication when making cultural artefacts, working as a team, and helping each other achieve the outcomes. They also displayed extreme confidence and outstanding knowledge of making cultural artefacts. I was also taken through the process of beadwork and painting clothes.

Figure 4.45: WPB showing the researcher how to make a beaded headband

Figure 4.46: The researcher practising how to draw straight lines

4.3 Summary

Chapter 4 presented the findings of the study. Ethnomathematical approaches in the teaching and learning of Grade 6 geometry were explored. As indicated in the previous chapter, Chapter 3, data were generated through semi-structured interviews with teachers, learners, and WKH, lesson observations were conducted, the observation tool was completed, and FGDs and participant observations were made with WKH. Interviews were held with each WKH separately to complete the checklist on WKH background, qualifications, highest standard with mathematics, age in years and the number of years or experience in Ndebele mural art and beadwork. The logic behind this decision was that it would be essential to draw upon the rich background information of WKH when contextualizing the findings in Chapter 5. The next chapter, Chapter 5, focuses on analysing and discussing the study's results, answers to the research sub-questions, and recommendations.

CHAPTER 5
FINDINGS AND DISCUSSIONS

5.1 Introduction

The purpose of this chapter is to provide practical implications of the findings, suggestions for future research, conclusions and to provide evidence-based recommendations on data analysed in Chapter 4. Thus, Chapter 5 focuses on findings and discussions of the results of the study, answers to the Research sub-questions and provide recommendations.

The chapter also highlights lessons learnt and the contribution of this study to the body of knowledge. Some limitations identified are also presented. The study was guided by one main research question and four sub-research questions:

The study aimed to explore ethnomathematical approaches in the teaching and learning Grade 6 geometry. In response to the main research question and sub-questions, since the sample of the teachers is not a representative of the population of teachers, the data gathered from teachers were related to the learners' data, and analysis and interpretation done based on the learners taught by the teachers participated referring to TA to TC in this context and data collected from WKH.

5.1.1 Main research question

How can ethnomathematical approaches be used in the teaching and learning of Grade 6 geometry?

5.1.2 Sub-research questions

1. What are the experiences of Grade 6 teachers in using ethnomathematical approaches in teaching geometry?
2. Which Ndebele cultural artefacts can be used to teach Grade 6 geometry?
3. What mathematical concepts are found in Ndebele cultural artefacts that may be used in the teaching and learning Grade 6 geometry?

4. How can such mathematical concepts be used to teach Grade 6 geometry?

5.1.3 Objectives of the study

The research questions were derived from the objectives of this study, which are to explore:

1. Experiences of Grade 6 teachers in using ethnomathematical approaches to the teaching of geometry
2. Ndebele cultural artefacts that can be used to teach geometry in Grade 6.
3. Mathematical concepts found in Ndebele cultural artefacts that may be used in the teaching and learning of Grade 6 geometry.
4. Using mathematical concepts found in Ndebele cultural artefacts in the teaching of Grade 6 geometry.

The findings from this study, on explored ethnomathematical approaches in the teaching and learning of Grade 6 geometry were presented in Chapter 4. This chapter discusses the findings of the study.

The presentation of the discussion is organized according to the main themes that presented the study results in Chapter 4. It commences with the discussion of the participants' demographic information. The literature review conducted in Chapter 2 and the theoretical framework that guided this study are used to support this discussion of findings.

5.2 Participants' Demographic Data

The demographic information of the participants was presented in Chapter 4 of this study. Gender was considered in the selection of all the participants, emphasizing equal representation. I had 50% of boys and 50% of girls. The attempt to achieve gender balance among teachers was hindered by the fact that all sampled schools had only male teachers responsible for grade 6. The decision was attributed to the school management subject allocations. The explanation provided was that female teachers are allocated lower grades because of their ability to foster supportive environment and to connect with foundation phase learners. The reason given reflected a gender biased assumption about teachers teaching abilities and strengths. It also reinforced the stereotype that female teachers are only suitable for lower grades and limiting their opportunities and career advancement. Female teachers may feel undervalued, leading to decreased work satisfaction, poor morale and underperformance in the foundation phase. Schools may must develop and implement policies that address gender biases. Findings strongly supported Gerdes (1995), that women are still underrepresented in scientific and technological careers where mathematical ideas play an important role. According to Gilsdorf (2015), Women were formally and informally excluded from Western mathematics until recent times, people believe that woman and mathematics do not belong together.

WKH were all women because the concept refers to specifically females who posess traditional knowledge, wisdom serving as custodians of the heritage. I found one gentlemen busy painting dishes at the art gallery during FGDs who was not part of the discussion. Data was collected on age, educational qualifications, the highest grade with mathematics, knowledge and experience of WKH (cf. Appendices R and S).

5.3 Findings of the Study

This section presents the discussion of the findings of the study. Previous studies conducted on this topic were reviewed to support the arguments made by the researcher. The section is organized into main themes that were generated from the data collected from teachers, learners, WKH, FGD with WKH and participant observations.

5.3.1 Findings from interviews with teachers, learners and lesson observations

The teachers experience on using ethnomathematical approaches in the teaching of geometry were explored. An investigation was conducted on mathematical concepts found in the Ndebele cultural artefacts and how they can be used to aid learners understanding of geometry. The research study explored how teachers within the Ndebele community can relate what they are teaching in their classrooms to Ndebele cultural artefacts that learners interact with at home, in their everyday life.

The following themes were generated: (1) The experiences of Grade 6 teachers' in using ethnomathematical approaches in the teaching of geometry (2) knowledge of different Ndebele cultural artefact and the ones can be used to teach geometry (3) The importance of using Ndebele cultural artefacts to teach Grade 6 geometry (4) the link between Grade 6 geometry and Ndebele cultural artefacts (5) The relationship between mathematical concepts and home environments (6) Grade 6 geometry concepts and skills that can be developed using Ndebele cultural artefacts (7) using Ndebele cultural artefacts to aid learners understanding of geometry (8) Mathematical concepts found in the cultural artefacts (9) Mathematical skills found in Ndebele cultural artefacts (10) using mathematical concepts to teach geometry (11) importance of ethnomathematical approaches and teachers challenges in using ethnomathematics approaches (12) Teachers challenges in using ethnomathematical approaches.

5.3.1.1 The experiences of Grade 6 teachers in using ethnomathematical approaches in the teaching of geometry

This section interprets and discusses responses from Grade 6 teachers on their experience, views, understanding and use of ethnomathematical approaches in the teaching of Grade 6 geometry. The findings revealed that all participating teachers were unfamiliar with the concept of ethnomathematics, as evidenced by their uniform request for clarification on the concept after being questioned about their application of ethnomathematical approaches to teach Grade 6 geometry. Findings confirm what (Mosimege, 2016) contended that the gap between classroom activities and outside the classroom is still in existence.

Teachers' responses to this question implicated that they were not yet trained on ethnomathematical approaches, indicating the gap in their professional development and experience in ethnomathematical approaches. The findings also revealed that mathematics curriculum has limitations. The curriculum does not incorporate ethnomathematical approaches, limiting learners' exposure and opportunity to connect mathematics found in their culture to mathematics taught at school.

The concept of ethnomathematics was explained to teachers to ensure that they understood the meaning of ethnomathematics. Explanation of the concept was vital because it established a common ground for further discussion and exploration of teachers' knowledge and practices on ethnomathematical approaches. It helped participating teachers connect the research to their own teaching practices and experiences through critical reflection and facilitated data collection. For instance:

TA: *I would say yes, based on the explanation given on ethnomathematical approaches but I did not know that I am using the ethnomathematical approaches.*

According to the research findings, TD and TE indicated that they have never used ethnomathematics approaches even after the concept was explained to them and therefore have no experience at all. For example, TE expressed: *I have never used them before, and I am hearing the concept for the first time.* Teachers cited the main reason for not utilizing ethnomathematical approaches in their teaching practices as lack of training or professional development on ethnomathematical approaches, leading to lack of knowledge on how to incorporate cultural artefacts into their lessons. TD: *I was never trained on using ethnomathematics to teach geometry.*

TE further contended that even with training on ethnomathematical approaches, using cultural artefacts in the classroom would be impeded by limited availability of cultural artefacts, the cost associated with them, and that parents may withhold permission to use their cultural artefacts due to concerns about their safety handling. This response highlighted the need for cultural artefacts as resources to implement ethnomathematical approaches in pursuit of the principle of honouring IKS as described in Curriculum and Assessment Policy Staement (CAPS, 2011:5).

TE and TD suggested the provision of inservice training on ethnomathematical approaches, as well as adequate resources, to facilitate effective implementation of ethnomathematical approaches.

TD expressed: *I need inservice training with focus on ethnomathematical approaches, to be trained on different cultural artefacts and how to use them to teach geometry*.

TE: *The school must make resources available for us to use.*

The three teachers (TA, TB and TC) who said yes after the concept was explained indicated that they used the cultural artefacts; however, they did not know they were applying ethnomathematical approaches. For example:

TB: *I can say yes as per the explanation given on ethnomathematical approaches, although I was unaware I once used bracelets and bangles here at school during this current term (term 2) to teach learners geometric patterns*

TA used Ndebele painting to teach lines of symmetry, TB used bracelets and bangles to teach geometric patterns, TC said 2Ds and 3Ds, and they allustrated that they used cultural artefacts to make learning concrete. TC: *For learning to be concrete and not abstract*.

On an encouraging note, teachers using cultural artefacts, without realizing that they are implementing ethnomathematical approaches demonstrated their natural ability and the unintentional ethnomathematics. It revealed lack of awareness, lack of intention, including inconsistent implementation of ethnomathematical approaches, for example, TB expressed: *I once used bracelets and bangles*. The 'I used it once' also suggested the superficial understanding of the approach, unclear commitment, lack of experience and familiarity.

Three teachers, TA, TB, and TC, reflected on their experiences, highlighting common patterns in learners' behaviour. Specifically, they noted Increased learner engagement, the lesson was interesting, enjoyable and meaningful, and enhanced problem-solving and critical thinking skills. For example:

> TA: *It was interesting to Introduce my lesson of symmetry, trying to teach from the known to the unknown, to make learning concrete, interesting and meaningful, there was increased learner involvement.*
>
> TB: *Learners demonstrated enjoyment, active involvement, and understanding because they could remember the content learnt. This eliminates rote learning and teaches learners how to solve problems in context.*
>
> TC: *Lesson was interesting and meaningful. It helped learners to be creative, encouraged them to explore more and think broadly and independently to be organized, brought about conceptual understanding, enhanced critical thinking skills and problem-solving skills.*

5.3.1.2 Knowledge of different Ndebele cultural artefacts and those that can be used to teach geometry

According to Laridon et al. (2005), cultural artefacts are linked to the culture, are made by different cultural groups for use when dealing with reality and challenges encountered in everyday life, they further argued that the cultural artefacts can be used to make mathematics accessible to learners.

Asher (2018) argued that there must be more understanding behind the artefacts for mathematical aspects to be recognized. It was, therefore, necessary to explore the Ndebele cultural artefacts as cultural tools which can be used to connect mathematics found in culture to mathematics done taught at school to allow for a deeper understanding and enhanced learner performance**.**

Teachers participated in this study, could mention names of different Ndebele cultural artefacts. The following were noted: Isitjhingwana (dancing stick), *Umkhala* [beaded headband], *isirholwani* (beaded hoops), beaded necklaces, *Iphotho* [beaded apron], *Umlingakobe* (tears), *Iporyana* (breast plate) *ibhtjha* [apron], *Inyoka* (Snake long beads), *Isikurwana* [small calabash] *Inaga* (blanket made of animal skin).

TA and TB mentioned few names as compared to other teachers. For example, TB recalled: *Beaded necklace and beaded headband.*

Interestingly, TD and TE displayed a surprisingly strong familiarity with names of different Ndebele cultural artefacts, even though they previously stated that they had not incorporated them into their geometry teaching practice. This contrast between their knowledge and practice suggests an opportunity for further exploration and integration of cultural artefacts into their teaching practice.

Different levels of knowledge of names of Ndebele cultural artefacts among Ndebele teachers who participated in the study may imply that: Some teachers may be disconnected from their cultural roots despite being part of the culture, varying levels of cultural transmission, individual interest and priorities. Limited access to cultural resources may contribute to differences in knowledge among some male teachers. Finding highlighted the importance of education on Ndebele cultural artefacts, community engagement to promote and preserve Ndebele cultural heritage among teachers and broader community.

All teachers who participated in the study mentioned that all Ndebele cultural artefacts can be used to teach various geometric concepts because of the mathematics embedded in them. TC, a principal in one of the sampled schools, demonstrated extreme passion and knowledge in giving names of the cultural artefacts and explaining their significance. His school is conveniently located near Dr Esther Mahlangu Art Center. He indicated that his learners usually visit the Art centre after school hours and further emphasized that the Art centre serves as an informal learning space for personal growth and development. The findings yielded a positive response, indicating that the research is in a suitable space by fostering collaborative partnerships with WKH.

Names, pictures and explanations of Ndebele cultural artefacts referred to by teachers were included in Chapter 4. The pictorial representation was done to contextualise the cultural artefacts within the research, making it easier for readers to understand their relevance. Furthermore, it facilitated the sharing of cultural knowledge with a more expansive audience, promoting cross-cultural understanding and appreciation of Ndebele cultural artefacts' connection and intersection with mathematics.

TC confirmed what D'Ambrosio (2001) mentioned: that many educators may be unfamiliar with the term ethnomathematics. Still, if they have a basic understanding, they can expand their mathematical perceptions and effectively teach their learners. He further alluded that teachers do not say mathematics and culture are connected. Like other teachers, TC noted that he was hearing the concept for the first time, but he managed to infuse the cultural artefacts in his teaching so that learners could interact with them when teaching properties of 2D shapes.

5.3.1.3 The importance of using Ndebele cultural artefacts to teach Grade 6 Geometry

TA, TD and TE highlighted the benefits of incorporating Ndebele Cultural Artefacts into learning, noting that they will make learning more engaging and interesting, serve as concrete objects for hands-on activities, and allow for learner cooperation, collaboration and critical thinking.

> TA: *The cultural artefacts will make learning geometry more interesting; learners will handle the artefacts to explore geometry concepts in them*.
>
> TD: *They will serve as concrete objects.*
>
> TE: *Learners will collaborate and cooperate, share ideas, think critically.*

The responses from TB and TC cited the importance of culturally situating mathematics learning, bridging the gap between abstract concepts and concrete cultural relevance, contextualising geometry within Ndebele culture and relating school geometry to personal cultural experiences.

TB: *Cultural artefacts can help learners to understand how geometric concepts are used in their own cultural context in creating the cultural artefacts.*

TC: *Using cultural artefacts can help learners connect geometry to their own cultural background and experiences, making it more meaningful and relevant to their lives. They can help learners see the practical applications of geometry in their own culture.*

TB and TC responses transcended mere learner enjoyment and interest as they moved beyond surface-level engagement to a rich exploration of the connection and intersection between learners' culture and mathematics.

TC further expressed, *"That which will create love and curiosity for mathematics, eliminating the fear that negatively impacts performance."* Emphasis aligns with (CAPS, 2011) on fostering love and curiosity for mathematics, further stressing eliminating negative emotions associated with mathematics, leading to improved learner performance. The statement connects mathematics to real-life situations and cultural heritage. Data exhibited ideas shared by Brandt and Chernoff (2015) that culturally based mathematics will develop learners' interest. As the interest grows, they will be better positioned to see mathematics beyond the classroom and its importance to real-life situations.

5.3.1.4 The link between Grade 6 geometry and Ndebele cultural artefacts

A common thread among participating teachers responded that there is a close link between geometry and Ndebele cultural artefacts, citing the ATP to strengthen their arguments. Findings from the participating teachers revealed that there is Content Area Measurement, which teaches learners about measuring instruments, measuring units, practical use of measuring instruments and conversion. They also indicated the link between Numbers Operations and Relationships, which include the four basic operations: counting, arranging, and problem-solving in beadwork. Findings also revealed a close link with particular reference to space and shape, two-dimensional shapes (2Ds), and three-dimensional objects (3Ds), including pattern functions and algebra, as well as numeric and geometric patterns. For example:

TA: *Ndebele's art painting links well with geometry through 3D objects, 2D shapes, transformation, Lines of symmetry, straight lines, sides of shapes*, *angles and others appearing in the ATP.*

> TC*: All concepts and skills in the Annual Teaching Plan are found in the Ndebele cultural artefacts, and one will even think that the Ndebele artists used the ATP when making their cultural artefacts or paintings. However, the person who made the artefacts was unaware that she was doing mathematics because we once asked her, and she was surprised to hear that she used mathematics taught at school. It was unbelievable to her that what she did related to Mathematics was taught and learned at school, as she was just drawing. There are a lot of links; when the learner knows a triangle, it is easy for the learner to identify it on the wall painting by counting its sides, numeric and geometric patterns. Learners can identify different 2Ds; learners will not forget as they see them at school and home; once they forget at school, they get reminded at home.*

The response from TC aligns with the insights from WKH, highlighting the unintentional incorporation of mathematical concepts in Ndebele cultural artefacts during the crafting process. This implies that Ndebele cultural artefacts contain inherent mathematical concepts, demonstrating the relationship between culture and mathematics. The response from TC response confirmed his earlier claim on learners visit to the Art center that donated money to the school.

Teachers' ability to recognise the link, even after they indicated a lack of knowledge in ethnomathematical approaches, suggests that they have an intuitive understanding of mathematical concepts embedded in cultural artefacts without formal training on ethnomathematical approaches; it also demonstrated potential for embracing ethnomathematics. Their observations are valuable in identifying connections between culture and mathematics.

The findings are aligned to previous studies, that classroom and learning environment cannot be isolated from communities in which they are embedded because they are part of the community with defined cultural practices (Orey & Rosa, 2011). Most importantly, ethnomathematical approaches will assist learners to be competent in their culture, maintain integrity of their culture Anderson-Pence (2015). Geometry and culture are interrelated, and this makes school geometry closely connected to the environment as well as the culture in which it is taught (Sunzuma & Maharaj, 2019).

The results corroborate with Machaba and Dhlamini (2021:59) that ethnomathematics in mathematics education is the study of how mathematics relates to culture, illuminating the parallel connection between mathematics and culture.

5.3.1.5 The relationship between mathematical concepts and home environments

In ethnomathematics, the relationship between mathematics concepts and home environment is significant. According to Brandt and Chernoff (2015), school mathematics needs to include the mathematics found in the world of learners. The home environment, including daily activities, games, cultural artefacts, water tanks, gates, painted walls, buildings such as huts, and so on, influences the development of mathematical concepts and understanding. In ethnomathematics, the teacher will use the child's mathematics experience at home to build academic mathematical concepts, allowing for a more effortless flow of scientific ideas with learners (Abbas, 2000). Most studies, such as those (Nkopodi & Mosimege, 2009; Cherinda, 2002; Dabula, 2000), revealed that learners have different experiences related to IK activities. Aligned with previous studies, Mosimege (2015) asserted that learners' variety of experiences is shaped by the socio-cultural environments in which they live and interactions which community members. In addition, Brandt and Chernoff (2015) noted that maths is found every where within the environment and further suggested that we must find a way of including those alternatives in the classroom.

During interviews, teachers shared illustrative examples demonstrating the interconnectedness of mathematical concepts and the home environment. For example:

> TB: *There is a link because there is measurement, Sorting paints involves measurement and counting such as 36 beads each side, Woola* [referring to wool] *is used for measurement.*
>
> TC*: There is a lot of links, when the learner knows a triangle, it easy for the learner to identify it on the wall painting by counting its sides, numeric and geometric patterns. Learners can identify different 2Ds, learners will not forget as they see them at school and at home, once they forget at school they get reminded at home.*

The findings revealed a significant connection between mathematics concepts and home environment demonstrating how home environments reinforce and enrich mathematical learning at school. Classroom and learning environments cannot be isolated from their communities (Rosa & Orey, 2011:4). Learners bring in class ideas, concepts and experiences, Piaget (2003) and Vygotsky's (1978) theories of learning, suggesting that construction of knowledge is dependent on what learners already know, previous knowledge serves as a foundation for new learning, encourages analysis, comparison and evaluation of new information relating it to existing knowledge. According to Presmeg (1998), incorporating ethnomathematics in the lesson plan is not an option but a necessity.

Home environment provides opportunities for informal learning, where learners learn mathematical concepts through everyday activities and cultural practices. Mathematics concepts are contextualised, making them more relevant and meaningful. Home environment usually involves parents, local experts and community members who contribute to the development of mathematics through shared knowledge and practices, as this approach will significantly reduce errors and misconceptions identified (cf. Chapter 2).

Ethnomathematics presents mathematical concepts of the school curriculum in a way in which they are related to students cultural and daily experiences enhancing their abilities to make meaningful countries and deepening their understanding of mathematics (Rosa & Orey, 2011) The mathematics hidden in traditional activities from non-western cultures (D'Ambrosio) can be utilized to teach geometry.

Consequently, I strongly advocate for the inntentional incorporation of learners' home experiences, environmental interactions and cultural backgrounds into teaching and learning of geometry to foster a more inclusive, relevant and engaging mathematical education.

5.3.1.6 Grade 6 geometry concepts that can be taught and skills that can be developed using Ndebele cultural artefacts

All teachers who participated in this study commonly cited: the properties of Two-dimensional shapes (2Ds) and Three-dimensional objects (3Ds), Whilst TA and TC emphasized lines of symmetry and transformation. TC, TD and TE highlited enlargement and reduction, with TE noting its connection to congruency and similarity. TE further mentioned patterns using a cirle. However, congruency and similarity are not for the level of Grade 6 according to CAPS (2011:21) specification of content.

Teachers mentioned the geometry concepts that can be taught using Ndebele Cultural artefacts despite lacking training in ethnomathematics. This showed their intuitive understanding of the connection between culture and mathematics even without formal ethnomathematical approach training, responses were informed by individual thinking, surface level of understanding and not emanating from the systematic approach. To maximise the benefits of ethnomathematics, teachers should receive training, support and resources to ensure authentic, informed and practical integration.

5.3.1.6.1 Skills that can be developed using Ndebele cultural artefacts

Teachers partcipated identified a variety of skills that can be developed using the Ndebele cultural artefacts. The skills teachers highlighted include estimation, counting, recognising ordering, sorting, designing, locating, identifying, comparing, naming, describing, drawing, measuring, visualizing, classifying, extending patterns. The Concepts and skills mentioned are found in different content areas as per CAPS Grade 4-6, clarification of content for Grade 6 (CAPS, 2011:213-288).

The findings showed that the skills within the framework of Bishop (1998) counting, locating, measuring, designing, playing and explaining, are used by WKH in making their cultural artefacts. It is possible to recognize each of the six categories for the activities done by women in crafting the cultural artefacts. This implies that WKH have in-depth knowledge of skills in CAPS and can apply them effectively within their cultural context, therefore we are in an excellent space to work in partnership with them in our efforts to improve geometry results.

In all activities WKH *measure* informally, using nonstandard units of measurement, and without measuring tools.

Women *count* the beads in bead work; they decide on the number of beads to be used in a pattern, identify the patterns and designs, geometric and symmetric patterns recalling them from their memory.

***Locating**:* WKH identify the place or wall to be painted, determine where different shapes will be located on the wal, for example, according to W2, when one looks into Ndebele mural art, eg wall painted by W2, there is a part that potrayed Manala design and the one that showed Ndzundza style.

WKH in the process of crafting cultural artefacts, determine ahead of time, the *design* or the pattern they want to create.

Playing in the context of crafting the cultural artefacts is evident in the trial and error, trying different patterns, combining different shapes, integrating new shapes within the environment in their mural art.

Traditional artist learns their skills from previous generations and pass those skills to future generations, through sharing or translating knowledge and skills to generations, *explaining* as a skill is utilized, WKH explain to the young group learning moral art of beadwork and women of different ages.

5.3.1.7 Using Ndebele cultural artefacts to aid learners' understanding of geometry

The findings from individual interviews with teachers revealed that Ndebele cultural artefacts can be used as concrete objects to introduce new lessons, to make learning interresitng, to support the learning of Geometry. Further suggestions included: creating connections to life experiences, to teach geometry in context, and conducting investigations to create rich learning experiences.

> TA: *I can use it to relate new knowledge to everyday life experiences, to contextualize, and mostly when I introduce new concepts*, *to make learning concrete and interesting to learners.*
>
> TB: *I can use them as teaching resources to introduce my lesson on geometry and geometric patterns. I showed my learners repeating patterns with circles and triangles and asked learners to identify and name 2D shapes in them and asked them to identify angles in the 2D shapes.*
>
> TC: *Learners can also be given investigation to look for transformation and describe patterns referring to reflections, rotations, and translations used in patterns.*

TD and TE indicated that they don’t use cultural artefacts. Probing was used, and they responded. For example:

> TD expressed: *I said I don’t use them in my teaching because it never came to my mind that they can be connected to teaching and learning, I have never looked at them critically relating them to geometry. I just saw them as cultural artefacts*.

Teachers have to link mathematics in cultural villages outside the classroom to academic mathematics (Mosimege, 2000). Geometry and culture are interrelated making school geometry closely connected to the environment and the culture in which it is taught (Sunzuma & Maharaj, 2019).

Probing assisted TD and TE in engaging in reflective practice and provided more innovative classroom possibilities**.** For example,

> TE: *Learners can work together actively in groups of four to conduct an investigation, do hands-on activities such as models, identify 2D Shapes, name them, identify angles in 2D shapes, and identify the transformations used. Learners can be given a project on painting using the Ndebele style to practice drawing of 2D shapes, transformation, different lines such as parallel lines and perpendicular lines, measurement using mm, cm, and m, and be allowed to explain the mathematics used in their painting.*

TE suggested investigations, teamwork, and hands on activities such as creating models. He also shared new information on project activity using Ndebele style and practical measurement using units of measurement. Teachers' investigation suggestions are consistent with those of WKH, who also advocated for it. The inquiry will enhance learners' spatial reasoning and promote critical thinking, analysis and problem-solving in geometry. The shared focus on investigation demonstrates the feasibility of a joint approach towards improving learner achievement in geometry. Findings are aligned with constructivist theory (Piaget and Vygotsky).

5.3.1.8 Mathematical concepts found in the cultural artefacts

According to Ferreira (1997), cited in Rosa and Orey (2011), it is necessary to investigate the mathematical practices of a particular social group to incorporate their mathematical concepts into the mathematics curriculum.

The findings from participating teachers revealed that the cultural artefacts are embedded with the following mathematical concepts: Properties of 2D shapes (regular and irregular polygons) such as triangles, squares, rectangles, parallelograms, rhombus, kite, pentagons, hexagons, octagons, number of sides in shape, length of sides, and angles of different sizes such as acute, right, obtuse, straight, reflex and revolution, similarity and congruency, transformation, rotations, reflections and/or translations, symmetry tessellations. Enlargement and reductions in the shapes. Geometry of straight lines such as parallel, perpendicular, vertical, and horizontal lines. 3D objects. Measurement as a content area integrating with space and shape

Mathematical concepts found in the Ndebele cultural artefacts, other than geometry concepts (Space and Shape), were mentioned; for example, TA and TB mentioned common fractions. For example,

> TB: *Length that is the measurement, numeric and geometric patterns, different 2D, shapes regular and irregular polygons, for example, triangles, squares, rectangles and other quadrilaterals, 2Ds are packed in common fractions such as one shape at the top, other three at the bottom proper fractions* $\frac{1}{3}$*, improper fraction* $\frac{3}{1}$ *, especially in beadwork for Dr Mahlangu,*

TB, TD and TE expressed measurement (length, perimeter of 2D shapes, surface area and volume), TD: counting, and specifically counting forward, TC and TE, counting, estimation, addition, subtraction, multiplication and division forming part of Numbers operations and Relationships (NOR). The results on counting, estimation and the four basic operations resonates with the findings from WKH.

Among the teachers interviewed, TB uniquely identified numeric and geometric patterns (Patterns Functions and Algebra). *Numeric pattern is found when for example counting in twos, 2, 4, 6, 8, 10.*

The researcher argues that learners should be able to relate mathematical knowledge from real-life situations outside the classroom to mathematics learning in the classroom. According to Cherinda (2002), mathematics teachers must get involved in (re) inventing or (re)discovering mathematics (hidden) in cultural artefacts.

Teachers' responses confirmed that Ndebele cultural artefacts contain mathematical concepts and geometric patterns that are inherent to their design and creation by WKH. If these mathematical concepts and geometric patterns are recognized and explored, learners can gain a deeper appreciation for creativity of Ndebele culture, the importance of preserving the traditional knowledge and the love of mathematics. These artefacts can serve as fantastic tools for teaching geometry as they provide a tangible and culturally relevant way to explore mathematical concepts.

5.3.1.9 Mathematical skills found in Ndebele cultural artefacts

Capabilities of classifying, ordering, inferring and modelling are incorporated in the making of cultural artefacts (D'Ambrosio and Bishop) (cf. 5.3.1.6.1).

5.3.1.10 Using mathematical concepts and skills to teach Grade 6 Geometry

Teachers shared insights on how mathematical concepts and skills identified in the culture can be used to teach Grade 6 geometry. The following suggestions were noted: (1) Giving learners beads to count, using the beads counted to create 2D shapes, identify and name the 2D shapes created, calculate the perimeter of shapes created (2) educational excursions with learners to Ndebele museum, including (cultural sites, cultural villages, art centres or art galleries) (3) Identify 2D shapes in a composite shape, count the number of beads used on the edges/sides, compare the length of sides of the 2D (4) extend the pattern in the beadwork or wall painting (5) recognize and describe lines of symmetry, rotations, reflection and translation in them (6) identify enlargement and reduction (7) be given a project such as making the model of the cultural artefact using their own creativity and mathematical knowledge. For example,

> TA*: Give them the beads to count and create 2D shapes with beads counted, Find the perimeter of shapes created tell them to identify and names the 2D shapes, ensuring that the cultural artefacts, their significance and mathematical concepts are explained to learners.*

TA suggested that learners can be engaged in a hands-on activity using beads to develop their mathematical concepts and skills. The first suggestion, for example, integrates multiple mathematical concepts and skills, which include: (1) counting, learners can count the beads to practice numeracy skills (2) Creating 2D shapes with beads counted and naming them enhances shape recognition and reinforces their understanding of terminology used in geometry (3) In finding the perimeter of the shape created, learners will count the number of beads around the outside of a shape. The approach described by TA, can help reduce the occurrence of errors mentioned in Chapter 2.

Teachers who participated in the study mentioned that Ndebele beadwork has geometric shapes such as zigzags, chevrons, and diamonds, which can be used to teach learners symmetry, angles in a shape, and others.

TA: *We can also go for educational excursions with learners to cultural sites, cultural villages, art centers or art galleries.*

TD: *Do excursions, visit to Ndebele museum.*

TA and TD recommended a visit to cultural sites, cultural villages, art centers, art galleries, Ndebele museum as valuable places with cultural resources for exploring the intersection between culture and mathematics. The recommendation by TD aligns with the perspectives shared by WKH on support to schools, cooperation and collaboration whereby they mentioned that they are readily available to work with school and that what is needed is commitment from the side of teachers and their learners. This finding implies that teachers and WKH have something in common, which is improvement of learner performance hence thy are all prepared to join hands.

TE: *Learners can count beads, create own cultural artefacts and ask them to present to the class.*

The response by TE on counting beads and creating own cultural artefact, connect bead counting to artefact creation which develops deeper understanding and creative expression in applying mathematical concepts to real-life situations. In their presentation of own created cultural artefact, learners will tell its name, explain the step followed in their creation, tell the number of beads used, the shapes used in the cultural artefact, the mathematical concepts use and so on.

TA: *count the triangles in a rectangle, find the fraction of black to grey triangles.*

TA in his response mentioned an example of the wall painted by W2 to validate his suggestion.

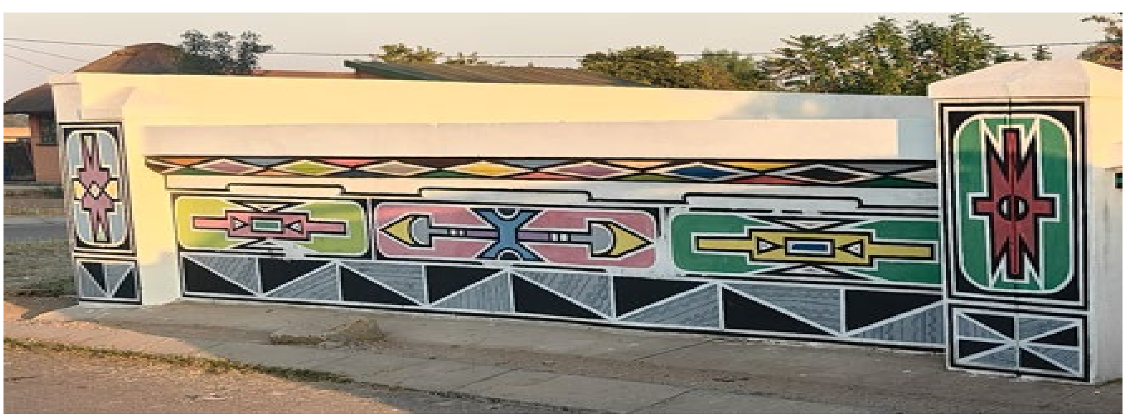


Figure 5.1: W2 wall

I think the response from TA above, unpacked, is an example of problem-solving, which requires learners to critically and creatively engage in logical reasoning and analytical thinking, interpreting the symbols in mural art, connecting own culture to mathematics learned at school, For example, learners can be given part of the wall as in picture below extracted from the wall, to investigate, *find the number of rectangles in a shape, the number of triangles in a big (central)rectangle, find the fraction of black to grey triangles and so on.* Investigation will also develop learners observational, recording skills and encourage curiosity. Some of the learners may go to an extent of asking questions on the beauty of mathematics inherent in their elders mural art.

The findings confirmed that ethomathematics can be used to enhance learners critical thinking and analysis skills that can be applied to all areas of life to solve real-world problems as (Rosa & Orey, 2011:48). Ethnomathematics fits well with constructivist and sociocultural theory, all emphasize the importance of individuals constructing their own meaning and understanding of mathematical concepts, contextual learning, problem-solving and application of mathematical knowledge to real-world problems. Mudhefi et al. (2024), assert that teachers should use constructivist teaching approaches to enhance conceptual understanding instead of traditional methods that promote rote memorization of concepts. Knowledge is constructed not absorbed, learning is an active process whereby learners engage with the environment, explore and make meaning based on experiences and perspectives (Vygotsky and Piaget).

The wall was painted by W2, using feathers. The wall potrays some of the 2D shapes mentioned by teachers such as triangles, rectangles, squares, has angles noted such as right angles, obtuse angles, acute angles etc, Teachers also noted symmetry, reflection, translation, rotation (geometry of straight lines, similarity and congruency for Senior phase). Consistent with the findings from (Mosimege, 2003), WKH also referred to straightness of lines in making some of the artefacts (Mosimege, 2009; Dabula, 2000) painting and beadwork reflect symmetrical geometry.

5.3.1.11 The benefits of using mathematical concepts and skills found in Ndebele cultural artefacts to teach geometry

This section interpretes and discusses teachers' responses on the benefits of using mathematical concepts and skills found in Ndebele cultural artefacts in the teaching and learning geometry.

Teachers interviewed shared several benefits such as Mathematics will be taught in a contextualised and relevant manner, making it more relatable to learners' lives, will improve learners understanding, mathematics will be meaningful to learners, arouse learners' interest there will be a lot of enjoyment, For example:

> TA: *Learning and teaching are contextualized, improves understanding, learning is meaningful, arouses learners' interest to learn mathematics and helps learners to remember, learners will not forget what they have learned because they see 2Ds every day at home. Learners see 2D shapes within the environment on the community walls and houses painted, and I think some are directly involved at home when assisting parents in painting and beadwork.*

Furthermore, the findings suggested that this approach will foster love for mathematics and spark curiosity in learners leading to motivation to learn mathematics.

> TD: *It encourages the love of Mathematics curiosity, makes mathematics meaningful, learners can relate Mathematics to real-life situations they come across daily, mathematics is taught in context, and learning is concrete.*

Results resonated with (D'Ambrosio, 2016), that ethnomathematics bring mathematics closer to the reality and culture of learners. Teachers emphasized that mathematics concepts and skills found in the cultural arterfacts play a critical role in connecting learners' culture to school mathematics. The findings supported (Mosimege), that there is a potential to make use of cultural artefacts in teaching mathematics. Similarly, Tatira et al. (2012) argued that the incorporation of cultural activities, games and plays in mathematics will help learners realise that mathematical concepts have strong connection to their everyday life.

School ethnomathematics practices encourages respect, solidarity and cooperation with each other, it is associated with peace (D'Ambrosio, 2016). Teachers who participated mentioned that using mathematical concepts and skills found in the cultural artefacts will enhance cooperation, respect to all the school community, which revealed that learning is a product of social process that involves people interaction and cultural influence (Vygotsky). The concept of Zone of

Proximal Development (ZPD) introduced by Vygotsky, will facilitate learners learning, range of knowledge and understanding from the guidance of WKH who made the cultural artefacts, who are in this context the more knowledgeable others and the teachers. The more experienced individuals will be able to provide scaffolding through active interaction, providing temporary guidance and support to help learners bridge the gap between their current understanding of geometry to the desired level of knowledge as outlined in the policy document. Learners will construct knowledge through social interactions, negotiate meaning and underatanding with WKH, teachers and other learners. Interaction will facilitate collaborative learning whereby learners will work together to achieve a common goal, sharing knowledge and expertise using the cultural artefacts.

5.3.1.12 Teachers' challenges in using ethnomathematical approaches

During engagement with teachers, they indicated that they would encounter challenges in the process of implementing ethnomathematics to teach Grade 6 geometry. They reported limited access to resources and that the cultural artefacts are often costly.

The teacher (TD & TE) indicated that the resources are not available within the school and that it might be challenging to borrow them from the community members as they may be afraid they can get lost. TD said: *They are expensive to buy unless we borrow them from parents, and it might not be possible because some will not agree for safety reasons.'*

Research findings also revealed that teachers were never trained on using ethnomathematics to teach geometry. TD said: *I was never trained on using ethnomathematical approaches and as a result I have no information on the approaches.* Teachers (TD & TE) lack information and knowledge on ethnomathematics approaches, do not know how to use cultural artefacts and have never thought of using them as concrete resources to teach Mathematics.

In suggesting ways in which they think their challenges with ethnomathematical approaches may be addressed, teachers suggested the need for training that could help them to know, understand ethnomathematics and ethnomathematical approaches, know strategies to implement ethnomathematical approaches, learn how to use Ndebele cultural artefacts to aid learners understanding of geometry and that the school must buy cultural resources for them.

5.3.2 Findings from interviews with learners

The section presents a discussion of insights gathered from learners' interviews on (1) Learner's knowledge of Ndebele cultural artefacts (2) Learning geometry with using cultural artefacts as resources (3) Ndebele cultural artefacts and learners' understanding (4) Mathematical concepts found by learners in Ndebele cultural artefacts (5) Learners views on how the mathematical concepts found in the Ndebele cultural artefacts can help them in the learning of Grade 6 geometry.

5.3.2.1 Learners' knowledge of Ndebele cultural artefacts

One of the principles of CAPS highlights the valuing IKS (DBE, 2011:5). It is in line with this principle that teaching and learning has focus on the cultural artefacts as a way of prioritizing IK. Mosimege (2016) contends that teachers should realise the principle of valuing IKS through integration of ethnomathematical studies for teaching and learning of mathematics to be fully realized.

The findings revealed that learners possess limited knowledge of Ndebele cultural artefacts, with most of them mentioning painting as a cultural artefact. The concept of painting was explained to learners after the interview. Some mentioned only one cultural artefact and could not think of others even with probing utilized. Three learners mentioned one each, three mentioned two each which included the headband, Ndebele bangles, Ndebele bracelets, Ndebele necklace and Ndebele dolls. It was fascinating that L9 and L10, who were TE learners, mentioned entirely new and different cultural artefacts that had not been mentioned by other learners, L9: *Ikhaba* [Calabash], *Isigubu* [Drum], *Umkhala* [Headband], *Segoloane* thick *beaded bangles, Irasi* [beaded necklace] L10 *Ibetjhe* [apron] and *Ikhapho (half calabash*). L9 stood out among 10 learners by mentioning five cultural artefacts. L9 was a female learner who demonstrated exceptional knowledge on the names of cultural artefacts, suggesting that girls might have a deeper understanding of cultural artefacts than their male peers, with the knowledge gained from grandmothers as part of tradition. The findings support (Abbas, 2000:142), who argued that girls can perform better than boys when appropriate mathematics is used in teaching school mathematics. Ethnomathematics often draws on cultural practices which may be more familiar to girls, especially where woman play a significant role in passing doen cultural knowledge. This suggests that girls may gain learning strengths from cultural activities in real-life situations during interactions with mothers or grandmothers. If these strengths can be supported through ethnomathematical approaches, our geometry performance will improve.

The findings necessitate what Gerdes (1995:187) claimed, that African cultural heritage should be the starting point in the development of Mathematics curriculum to improve its quality to enhance the cultural and social self-confidence of all pupils, both girls and boys.

Findings from learners who participated revealed that most of the cultural artefacts are used by women as accessories such as Ndebele bracelets, Ndebele bangles. Examples and explanations of pictures of Ndebele cultural artefacts referred to by learners were included in Chapter 4.

Six learners were not involved in making cultural artefacts (L2, L6, L7, L8, L9, and L10). The reason given by learners was that no one made the Ndebele cultural artefacts at home**.** L6 is a boy who said his grandmother tried to teach him how to make bangles and ties, but unfortunately, he could not grasp the process. L6: *My grandmother was teaching me how to make bangles and ties.* However, this is further confirmed in the section on the roles of men and boys.

One learner (L5) said her grandmother taught her, but she found it difficult and frustrating. The learner faced challenges in understanding the process, highlighting the need for community progammes, and inclusion of IK into curriculum.

Two learners (L1 and L3) were taught by their sisters-in-law, and they indicated that their mothers are not involved in the making of Ndebele cultural artefacts. The finding resonates with the insights gathered from WKH during the interviews, where they shared concerns on their children, leading them to focus on passing down their knowledge grandchildren instead.

It emerged that two other girls who are involved are helping sisters-in-law; their mothers are not involved. L5 also expressed that her grandmother taught her. Learners who said they were not involved indicated no one was engaged in their homes. Findings correlate with Vygotsky's theory on ZPD and MKO in that the learner needed assistance for learning to occur (Allahmagani et al., 2017).

Findings regarding using geometry learnt at school in making cultural artefacts, four learners indicated that they made use of it whilst one learner said no. Four learners said they used: *rectangles, squares and triangles, lines and circles.*

Involvement of learners who articulated that they were involved in the making of cultural artefacts allowed for active engagement with cultural heritage of Ndebele people fostering a sense of pride and appreciation for their own culture. It also provided a practical and hands on approach to learning geometry. By creating Ndebele cultural artefacts, learners can explore geometric concepts in a relevant context to make learning process more engaging and enjoyable, allowing learners to see practical applications of mathematical concepts in real-world contexts.

The researcher argues that it is essential for both boys and girls to participate in the making of cultural artefacts and mural art based on the following reasons: When IKS is introduced in the curriculum, both genders will benefit, both genders must be able to connect knowledge acquired in the cultural artefact with academic mathematics, it helps preserve and pass on the cultural heritage of the Ndebele people, engaging both genders in this learning process promotes inclusivity and equality breaking down gender stereotypes associated with specific skills or crafts.

5.3.2.2 Learning geometry with using cultural artefacts as resources

The ethnomathematics approach aims to create a meaningful shift from formal and conventional academics to mathematics built from culture. Three learners responded with yes, meaning that the cultural artefacts were used. Both learners from one school said yes, whilst in one school, learners responded differently; L3 said no, and L4 said yes. Different responses have some implications; however, it might be possible that one learner could not remember, as this was taught during term 3 of 2021, which was also affected by COVID-19. The findings correlate with teachers' (TA, TB) use of ethnomathematical approaches after the concept was explained to them—no correlation with TC learners. Teachers (TD and TE) said they had never used the cultural artefacts, and their learners also supported their statements because they said they had never learned geometry with using cultural artefacts.

5.3.2.3 Ndebele cultural artefacts that teachers used

Some studies suggested that teaching must be related to learners' culture (Mosimege, 2003; Gerdes, 1999; Asher & Asher, 1994; Bishop, 1988). This can be achieved by drawing on learners' cultural practices or incorporating cultural artefacts embedded with mathematics concepts.

Findings revealed that five learners could not respond or explain how cultural artefacts were utilized as learning tools for Grade 6 geometry. This indicated a possible disconnect between their cultural knowledge and mathematical understanding or limited exposure to the ethnomathematical teaching approach.

L4 said pictures. L1, L2, & L6 said Ndebele painting from the textbook and Ndebele tie. Inconsistencies were noticed. For example, TC reported using necklaces and bangles, whereas his learner cited Ndebele painting and tie. Furthermore, despite repeated prompts, TC learners could not mention concepts taught, raising doubts about the effectiveness or actual use of cultural artefacts claimed by TC.

Three learners, L5, L7 and L9, said they were unused. Only two learners from one school responded. L1 and L2 expressed: *We* were *asked to identify and name the different 2D shapes and 3D objects and lines of symmetry from the picture*. The learners' interviews revealed a consistent pattern: their teachers' lack of knowledge of ethnomathematical approaches. This correlation highlights a significant teacher gap, highlighting the need for professional development and training in culturally responsive teaching practices.

In his plenary address on mathematical conditions and contexts at the Institute for Science and Technology Education (ISTE) 2012 International Conference at Kruger National Park in South Africa, Professor Mosimege reiterated that mathematics teachers cannot make connections in their mathematics classrooms and attributed that to teachers' shallow Indigenous content knowledge.

5.3.2.4 Concepts which* were *taught to learners using the Ndebele cultural artefacts

Three learners, L1, L2, and L4, mentioned 2Ds, 3Ds, transformation, translation, and reflection. LC learners and others could not respond. Ethnomathematics focuses on how culture relates to mathematics and how recognising culture could enhance the learner's learning of mathematics (Machaba & Dhlamini, 2021).

5.3.2.5 Ndebele cultural artefacts and learners' understanding

Research findings revealed that learners lack information on how using Ndebele cultural artefacts may help them understand geometry. Only one learner responded and said measuring length. Two learners said they didn't assist them, three said I don't know, and four did not respond. Learners could not mention the potential of Ndebele cultural artefacts in enhancing their understanding of geometry. The findings substantiated Gerdes's (1995:187) claim that one of the challenges to Mathematics educators is that many boys and girls in schools' experience mathematics as a strange and useless subject imported from outside Africa. Gerdes (2001) further noted that when students and teachers believe that mathematics has no roots in their culture, a cultural, psychological blockage hinders the teaching and learning mathematical thinking. This blockage makes realising the full development of the mathematical potential of the learners impossible.

5.3.2.6 Mathematical concepts found by learners in Ndebele cultural artefacts

The research findings on the interviews conducted with learners revealed several mathematical concepts found in Ndebele cultural artefacts and mural art. Learners identified 2D shapes such as rectangles, rhombi, triangles, Pentagons, hexagons, octagons, angles, 3D objects, and lines of symmetry. Mathematical concepts beyond geometry included counting, estimation, geometric patterns, and length.

The research findings revealed that even though some learners (TD and TE learners) mentioned that they were never involved and that there is no one making the cultural artefacts at home, they could still respond to the question on mathematical concepts found in the cultural artefacts and this could be attributed to memories of what they see at home on the houses, walls within the environment, relating it to the mathematics learnt in the classroom. According to Piaget (2003) and Mogari (2002), learners do not enter the classroom with blank minds but bring along with them ideas, conceptions and experiences about mathematical concepts. Machaba and Dhlamimi

(2021:59) further reiterated that relationship develops between ‘abstract mathematics learnt at school’ and everyday mathematics ‘experience and knowledge learnt from home and the environment’ including using language in a socially guided classroom**.** In the context of this research, using language refers to the correct mathematical language, which will mitigate the errors and misconceptions noted (cf. Chapter 2).

5.3.2.7 Learners’ views on how the mathematical concepts found in the Ndebele cultural artefacts can help them in the learning of Grade 6 Geometry

Learners shared their thoughts on how mathematical concepts embedded in Ndebele cultural artefacts can be used to facilitate their learning of geometry: L1 and L2 expressed a common idea that mathematical concepts will help them to understand and remember the content learnt.

L2 explained: *As they are part of my culture, I see them daily, and they will help me remember what the teacher taught me. L3 indicated that she will not forget them because she sees them dail*y at home and around the surroundings. Vygotsky's (1978) theories of learning also suggest that learners construct knowledge by relating it to what they already know and relate new knowledge to prior knowledge. Learners taught in ethnomathematics see school’s mathematics as part of their own culture and do not rely on rote learning, which is used when ethnomathematics is not employed (Abbas, 2000:142)

In probing learners further, L2 and L3 mentioned that they will help them to learn enlargement and reduction. L4 indicated that it will teach him triangles of different sizes, triangles with sides of equal length, and those with sides of varying length. Learner L7 said that she will measure the sides of triangles and compare their length, which is the most critical step in identifying various types of triangles at the level of Grade 6.

The findings are aligned to Mogari (2002), that the learning of mathematics facilitated by contextualized teaching approaches enhance logical, critical thinking and problem-solving skills through building new mathematical knowledge to learners’ existing knowledge. Mudhefi, Mabotja and Muthelo (2024), assert that the 21st century mathematics classrooms should equip learners with well grounded knowledge and thinking skills pertaining to geometry.

5.3.3 Lesson observations findings

The section presents the findings on the practical implementation of ethnomathematics as a fundamental approach in the teaching and learning geometry. Mosimege (2012), Mogari (2014, 2002), and Cherinda (2002) brought to light mathematics instruction that is grounded in cultural perspectives. Learners' backgrounds and immediate environment are practically integrated with Euro-centric mathematics. According to Machaba and Dhlamini (2021), ethnomathematics can be a teaching approach focusing on learners' culture integrated with Euro-centric mathematics practically per curriculum requirements. Mudhefi et al. (2024) stressed that teachers should develop learners' broad knowledge of geometry to overcome the errors and misconceptions related to geometry. Furthermore, I contend that teachers should move beyond merely identifying errors and misconceptions and instead critically analyse their root causes and implications with the objective of mitigating the identified challenges. This deeper understanding will enable teachers to design targeted interventions and make informed decisions about instructional approaches to an effective learning environment, which suggests using ethnomathematical approaches (cf. Chapter 2).

5.3.3.1 Analysis of Ndebele cultural artefacts

The findings revealed that four teachers from the five sampled, TA, TB, TD, and TE, did not use Ndebele cultural artefacts in their lesson presentations. TC divided his learners into four groups (four rows). Each group gave names of the cultural artefacts they were having within their groups. Some responses were similar, and some were different depending on what the group was having. Examples include beaded bracelets, beaded hoops, necklaces, and beaded earrings.

Mudhefi et al. (2024) recommended that learners be allowed to manipulate natural objects to enhance their visualisation and thinking skills. The real object referred to in the context of this study was the Ndebele cultural artefacts. TC learners analysed the cultural artefacts to find mathematical concepts embedded in them. Mathematical concepts from the Ndebele cultural artefacts analysed included two-dimensional shapes such as triangles, quadrilaterals, hexagons, octagons, properties of 2D shapes, circles, lines, parallel lines, lines of symmetry, rotation, translation, reflection, tessellation in pictures, enlargement and reduction in triangles and rectangles. Constructivist theory suggests that learners bring past encounters and cultural factors to develop new knowledge in the learning process (Khalid & Azeem, 2012).

5.3.3.2 Using Ndebele cultural artefacts in teaching, learning and assessment

The results of this study regarding the four teachers (TA, TB, TD, TE) correlate with the notion in the literature review that teachers' perception of how learners should learn mathematics seems to be a challenge (Mamathe, 2021:196). The study's findings revealed that TA, TB, TD and TE hold the instrumentalist perspective. They believe that learners should be told the facts about the concept rather than exploring it and that learners are used to the telling method. If instructed to explore the concept independently, they find it difficult to understand what the activity requires (Mamathe, 2021:197). Understanding ethnomathematics is a prerequisite for teachers to utilize its approaches effectively. The findings confirmed (Zaslavsky, 1994:6) that the Western European influence has generated cultural, psychological blockage that disturbs efforts to promote knowledge of mathematics from a cultural perspective. Students are not allowed to recognize the role of human beings or various cultures in creating mathematical ideas.

TA, TD and TE assessment was not based on the cultural artefacts. TA used a textbook, whilst TD and TE referred learners to Department of Basic Education Workbook (DBE Book 1 Term 1 and 2) TB did not make use of cultural artefacts in his concept development; however, assessment activity given to learners was on the Ndebele wall picture whereby learners were instructed to identify the 2D shapes and transformation.

Only one teacher of the five teachers exposed his learners to cultural artefacts. These findings support (Madudise, 2015), who mentioned that teaching in schools rarely brings the interconnection between mathematics and culture in pedagogically informed ways.

Ethnomathematical teaching approaches reflect both constructivist and sociocultural perspectives. New knowledge is built from prior knowledge (Van de Walle et al., 2010:21). The TC lesson investigated 2Ds and the transformation of the Ndebele cultural artefact. Learners reported their findings, and marks were allocated. Learners' prior experience with cultural artefacts was related to classroom mathematics, aligning with the socio-cultural learning theory of Vygotsky, which emphasized the importance of culture and social interaction in learning.

Knowledge construction depends on what learners already know and what they are expected to learn from the new content (Vygotsky, 1978). Meaningful mathematics learning is enhanced by Mogari (2002) through previous experiences. Connecting the classroom mathematics to everyday mathematics at home was done with passion. Learners should be allowed to realise their elders' role in developing mathematical ideas (Rosa & Orey, 2012). The tools to build understanding are existing ideas and knowledge for constructing ideas (Van de Walle et al., 2010). Ndebele cultural artefacts serve as materials to build awareness because they are things that learners can see and touch within their environment.

The approach used by TC was learner centered, he encouraged active participation and positive interactions with learners and amongst learners in the classroom (cf. Appendix N) New knowledge is formed through social interaction with others (Potgieter, 2020). Learners were working in groups, discussing and sharing ideas. ZPD as a space, was created through interaction with learners, with MKO and the culture that precedes them (Van de Walle et al., 2010:21). TC is one of the educators who according to D'Ambrosio (2001) may be unfamiliar to the term ethnomathematics but if they have basic understanding or can be given support, they will be able to expand their mathematical perceptions and provide effective teaching to their learners.

There is a consensus among researchers such as (Mosimege, 2003; Gerdes, 1999; Bishop, 1988) that culturally relevant teaching is essential, with many studies highlighting the importance of connecting mathematical instruction to learners' cultural backgrounds and experiences similarly. Madudise (2015:15) maintained that culturally relevant pedagogy incorporates learners' cultural background into teachers' daily instruction, reinforcing the discovery made by Rosa and Orey (2011:45), that ethnomathematics aims to raise learners' awareness to how people mathematise and think mathematically in their culture and apply this awareness to learn mathematics in the classroom.

Learners can be given a project, such as designing a vegetable garden to complement the existing food provision within the school. In designing the vegetable garden, they should use the geometric concepts inherent in Ndebele Mural art and cultural artefacts. The project will assess a range of skills and competencies (CAPS, 2011:295), allow learners to demonstrate their understanding of different mathematical concepts and apply them in real-life situations. For example, the garden's shape, various geometric shapes' seedbeds, the portrayal of other types of angles in their vegetable garden, seedbeds showing rigid motions of transformation, accurate measurements, counting, estimation and so on.

WKH employ geometry in different ways to create visually striking and meaningful designs. They use geometric shapes such as triangles, rectangles, and others, as well as transformation, reflection, and rotation, and they draw precise, smooth lines to define the shapes and patterns using a feather.

According to Van de Walle et al. (2010:400), Geometry has four content goals that apply to all grade levels according to NCTM content standards, which are shapes and properties, transformation, reflection, rotation (slides, flips and turns); the study of symmetry and location to coordinate geometry and visualization which identifies the recognition of shapes in the environment. Van de Walle et al. (2010:419) further posit transformations are changes in the position or size of a shape. He described movements that do not change the size or shape of an object as rigid motions and further mentioned that the three rigid motions of transformation are translation or slides, reflections or flips and rotations or turns. The terms slide, flip and turn are adequate at the primary level. WKH can draw rigid movements without formal schooling.

Van de Walle et al. (2010:420) state that if a shape can be folded on a line so that the two halves match, it is said to have lines of symmetry or mirror symmetry. The fold line is the line of reflection. A portion of the shape on one side of the line is reflected onto the other side.

In reflection, they flipped a shape over to form a mirror image; the result is a mirror image of the original shape (congruent to the original shape). WKH often divide the wall into sections and mirrors the design on either side of the central axis. Examples below were taken from the W2 wall and can be given to learners to investigate rigid movements and other geometric concepts.

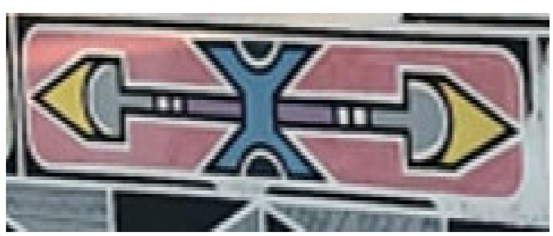


Figure 5.2: Examples taken from W2 wall

Zaslavsky (1994) sheds light on how she used the shape of an African house in her curriculum unit. She explained that her students were tasked with finding the most significant area a given perimeter could enclose. Zaslavsky further indicated that the approach used to solve mathematical problems allowed her students to appreciate how builders in Africa arrive at the solutions of problems they encounter in building houses of such structures.

The huts of different ages (cf. Chapter 2) can serve as resources for problem-solving in mathematics hence they were included in the research on a list of referred cultural artefacts that can be used to teach and learn mathematics. For example, (with huts numbered A-C), Hut A has a circular base with a diameter of 8 meters, the thatched roof is conical, with the height of 5 meters. Find (a) the diameter of the circular base of the roof (b) calculate the radius**.**

5.3.3.3 Learners' participation, interactions and communication

The research findings revealed that learners taught with using Ndebele cultural artefacts demonstrated active engagement, conceptual understanding and enjoyment as compared to their counterparts. TC learners were actively involved, demonstrated interest and enjoyment in learning using the cultural artefacts. According to the social cultural perspective, learning is dependent on learners working with the ZPD, the social interactions in the classroom and the culture within and beyond the classroom (Van de Walle et al., 2010:21).

Learners become more involved when they feel that mathematical content is related to their lived experience and its meaningful to their everyday lives (Anderson-Pence, 2015). Learners create and construct own knowledge or understanding through interaction with prior knowledge and involvement with content (Mogashoa, 2014).

There was effective communication with the teacher and amongst learners in their groups. TC believes in social contructivist perspective, that people learn new behaviours and attitudes observing and imitating others in their social environment. Social interaction plays a critical role in cognitive development (Vygotsky).

According to Mogari (2002:53) learners learning of mathematics will remain enjoyable if teachers teach mathemastics in the context that is familia to them. Teachers should review their instructional strategies and intergrate learners' cultures with mathematics (Machaba & Dhlamini, 2022:64). Madudise (2015:12) contends that there is a must investigate the mathematical ideas and practices of the cultural ethnic and linguistic conmmunities of learners, for teachers to incorporate mathematics in real-world to mathematical activities in the classroom. Ascher (2018) echoes the same sentiments, that for mathematical aspects to be recognized an understanding of the artefact plays an important role. Learning mathematics cannot be free of social influence (Rosa & Orey).

5.3.3.4 Using mathematical language to replace everyday language used in cultural artefacts

An observation was done to check as to whether learners use the everyday language used at home by elders when making cultural artefact. The research findings revealed that learners use the language learnt and used at school. Names of the 2D shapes were referred to as in CAPS document. Learners did not make any mention of everyday language used by the WKH. Semiotic mediation involves interaction through language, diagrams, pictures and actions. Language is considered as a one of the tools of mediation (Van de Walle et al., 2010:21). The correct mathematical language was used to mediate geometric concepts; cultural artefacts were utilized, TC also made use of actions while emphasizing mathematical concepts, learners were also allowed to wear the cultural artefacts and showcase the mathematical concepts identified by each team (cf. Chapter 4).

The findings from interviews and lesson observations suggest that knowledge of cultural artefacts can be used to link Mathematics in the classroom and Mathematics in everyday real-life situations. Zuya and Kwalat (2015), Ozerem (2012) and Adolphus (2011) recommend that teachers should relate lessons to real-life situations to reduce the abstract nature of the subject. Learners' performance in mathematics depends on teachers support and the ability to connect home, community experience of mathematics to school mathematics (Anderson-Pence). Socio-cultural theory says focus is on social and cultural context (Vygotsky, 1978).

The results of the TC lesson observation are in line with what Mosimege (2000) indicated that teachers are in an excellent space to link mathematics taught in the classroom and Mathematics in learners' daily experiences. The most critical challenge that we are currently facing, or which might be seen as a limitation is that learners are not actively taking part in the making of cultural artefacts at home and as such, they have no knowledge of mathematics used to make the cultural artefacts, which therefore make the link difficult. In contrast to what is expected in ethnomathematical approaches, as per literature review, there is a reversal trend, the findings revealed that learners use mathematics learnt at school to interprete the cultural artefacts instead of using mathematics from the cultural artefacts to understand mathematics learnt at school, to connect and make learning meaningful. There is a must activate the learners focus on mathematics found in cultural artefacts.

5.4 Findings from Interviews with Women Knowledge Holders, Focus Group Discussions and Participant Observations

5.4.1 Participation of youth in Ethnomathematical activities

Women's leadership in ethnomathematical activities has inspired a new generation of cultural maths practitioners and fostered a deeper appreciation for the intersection of maths and culture.

The study revealed that even younger members of the community are knowledgeable and actively taking part in ethnomathematical activities. The graph below represents the ages of Nine (9) WKH who participated in the study.

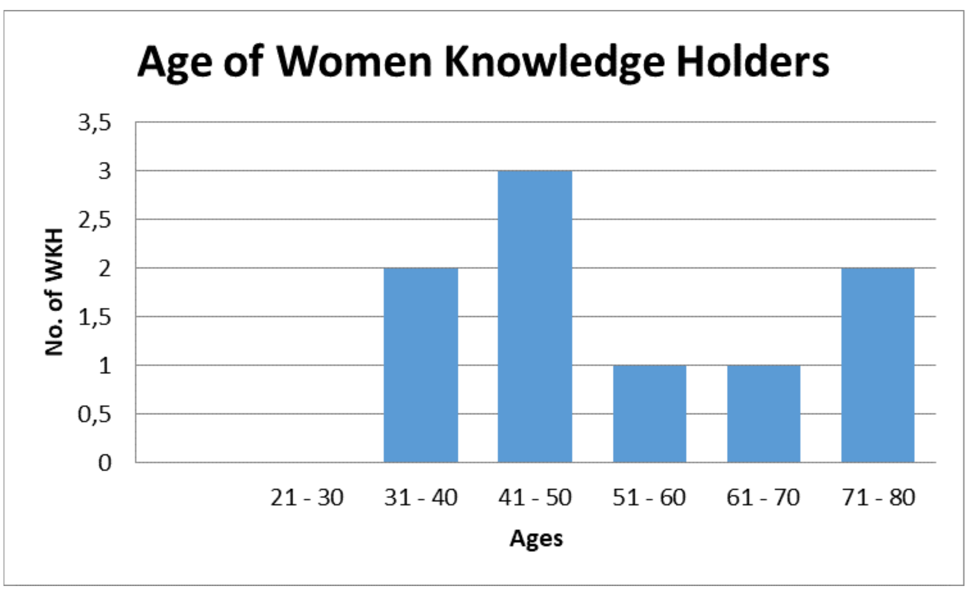


Figure 5.3: Age of Women Knowledge Holders

The WKH consisted of five, ladies between the ages of 31 to 80 (cf. Appendix S), with more than 10 years of experience in making the cultural artefacts, two (2) btween 51 and 70, and 2 from 71 and above. Younger participants brought new ideas, innovative approaches in crafting the cultural artefacts. The findings support what Mosimege (2017:669), indicated that it is incorrect to assume that IK is known only by the elderly people.

Youth participation in ethnomathematical activities was further supported by women's accounts during the interviews. For instance, W5 expressed *Njenganje ngisiza umma ukubandula itjha* [I currently assist Umama in training youth]. The findings on youth participation in ethnomathematics have positive implications, such as

1) Breaking stereotypes and promoting a more inclusive understanding of mathematics and culture. This is a complete turn around finding as compared to what was revealed in (Bhuda, 2019), that the majority of participants in Indiginous knowledge were elderly people.
2) Job creation opportunities. W2 mentioned that she has a team of youth that she is training at Kghodwana, learning how to make beadwork and mural art using Ndebele art designs.
3) Youth participation fosters community involvement, social cohesion and reduced rate of crime, youth work under the supervision of older women who are supportive.
4) Participation in ethnomathematical activities developed in them a stronger connection to their cultural roots and identity including respect to elders.

5.4.2 The implications of using language in ethnomathematics

Professor Mosimege, in his address during the 13th International Congress on Mathematics Education (ICME 13) in Hamburg, Germany, argued that knowledge holders tend to be more relaxed and able to show more when they express themselves in their languages (Mosimege, 2016), building on his earlier study (Mosimege, 2012). Grounded in his vision, this study allowed WKH to use the language they were comfortable with. Allowing WKHs to communicate in their comfortable language had several implications for the research on ethnomathematics, which were practically observed during interaction:

a. Increased authenticity: WKH shared their knowledge and experiences without barrier of language, which enabled me to gain more profound information on ethnomathematical approaches and the cultural context.
b. The information provided was accurate and context specific. They were not forced to translate their thinking into a different language, which could have led to loosing some of the information during the struggle of translation.
c. Enhanced trust: Speaking in their comfortable language established trust and rapport. It helped me to gather rich, more accurate data and promoted a more inclusive and empowering research environment. WKH shared even more than the questions posed (Mosimege, 2016). For example, there was no question on life achievements such as awards, but women freely related the information (cf. Chapter 4).

Mosimege (2003), in his interview with Mr Mothubi, explored how a container made of grass 'sesiu' was constructed using the Sesotho language, the primary language used in the village. In his second episode, during interviews with the ladies at the Lesedi Cultural Village, it was indicated that the ladies knew both Sesotho and Isindebele; therefore, ladies expressed themselves in IsiNdebele, and questions were directed to them in Sotho, which they also understood.

5.4.3 Acquiring and transferring Indigenous knowledge

In the interview with WKH it was found that knowledge is transmitted from mother to daughter, and other women of different age groups. W2 said: *I grew up observing my mother doing beadwork and painting, I started while I was 10 years old, Umma wami naye ufunde kummakhe (My mother was taught by her mother)*, W3 said she started approximately by the age of 14. The findings of this study resonate with what the ladies at Lesedi cultural village indicated that they were taught by their grandmother's, ladies also showed their knowledge is translated from mother to daughter (Mosimege 2003), Similarly (Mosimege, 2017: 682, Fouze and Amit, 2017) noted that IK is passed from generation to generation, from mother to daughter from the age of 10 years.

W3 explained that she has assembled a team of eight women to work alongside with her. *Nginabomma abayisishiyagalombili (8) engiberega nabo* [I have a team of 8 ladies that I work with]. This, demonstrate knowledge sharing and collaboration among WKH, fostering a supportive community of experts in Ndebele art.

The interviews with WKH provided additional interesting information. For instance, W2 shared that traditional clothing was worn daily in the past, and when garments became worn out, the self-repair was a norm. This made it essential for mothers to impart their IK, teach their daughters how to do beadwork sothat they can repair own garmets, passing down this practical knowledge to ensure continuation of the cultural practice. The aim of transmission, according to Bhuda (2019:132), is to preserve cultural identity.

Ndebele women are mathematicians who shared their skills from one generation to the other, ensuring that all are capacitated (Mosimege, 2003). Consistent with Mosimege, Bhuda (2019:65) confirms that Ndebele women are ethnomathetimaticians and custodiance, transmitting ethnomathematical knowledge and skills to other women of different age groups to preserve their culture.

The epistemological underpinning of the study was evident in how woman shared their IK demonstrating a deep understanding of the interconnectedness of culture, mathematics and community (Vygotsky, 1978).

The two learners (L1 and L3) are girls, who according to the Ndebele Culture are in the process of women to girl capacitation on how to make the cultural artefacts. However, it appeared that learners (L1 and L3) were not informed of their cultural practice, or were not aware that they learn making of cultural artefacts as part of their cultural practice because they could not mention it in their reasons given for helping their sister-in-laws and this implied or demonstrated cultural knowledge gap with girls.

5.4.4 Impact of working with the mother

In the interview with WKH 5, she revealed that she has not yet started her own business, and that presently she works with her mother. When questioned about the impact of this partnership, W5 expressed that working with her mother in IK has had a profound positive impact, drawing from her personal observations and insights such as enhanced mother to daughter relationship, capacitation and empowerment in cultural activities. She indicated that her mother recognizes her as her daughter and a partner in business and that led to holistic mutual understanding, to both partners. W5 further alluded that her mother supports her emotionally and economically. She mentioned that she was unemployed, but her mother created job opportunity for her to be able to take care of her children. This, reinforces what Chapter 2 on IK policy emphasized in terms of Women as custodians of cultural knowledge, passing it down to future generations and their role to economic development.

> W3 explained that: I *transferred knowledge to my daughter who is currently staying with me and selling the artefacts to make living. I went with her to Japan to do beadwork and painting. We* were *booked together in a beautiful hotel.*
>
> W5: *I keep record of visitors on daily basis in the visitor's notebook, whenever there are orders, or projects we do them together.*

W5 keeps control of the visitors' book, which has a list of visitors, dates, names and surnames, addresses, and contact details, using her ability to read and write. Intergenerational knowledge transfer brought in the spirit of cooperation and collaboration between a mother and her daughter while ensuring the continuation of IK. W5 also indicated that she assists her mother in training other ladies.

The findings revealed that working with mothers allowed for personal growth in W5, new perspective and deeper understanding of IKS. It also provided W5 with employment opportunity, skills that have positive economic impact on her life as an individual and the Village of Matempule. W5 learning from her mother's experiences and expertise ensured continuation of traditional knowledge, cultural preservation empowerment and improved family economic conditions.

5.4.5 Process of making Ndebele cultural artefacts

Interestingly, the study discovered that the three WKH with limited formal education, that is the two with no formal schooling and one with only Standard 1 (Grade 3) level in the current curriculum context, possess impressive ability to effortlessly employ mathematical concepts showcasing their inherent mathematical abilities and adaptability. The findings therefore implicate that the value of non-formal learning pathways should be recognized, challenging the dominance of Western epistemologies and promoting cultural way of learning mathematics.

Findings revealed that Ndebele beadwork and mural art is constructed using mathematical concepts and skills, this is in line with the research conducted by Dabula (2000) and Mosimege (2017) on mathematical concepts. The findings revealed the application of four content areas in making the Ndebele cultural artefacts (CAPS, 2011:9) The content area Numbers operations and relationships, is applied in beadwork whreby WKH use counting and the four basic operations, Patterns Functions and Algebra , includes Numeric and Geometric patterns in beadwork patterns used for decoration, Space and shape is evident in the shapes used in beadwork, painted artefacts and and Measurement which is evident in the space used for painting in mural art, the length of cultural artefacts like *Umlingakobe* and others.

The women custodians of traditional knowledge shared that they use feathers to paint. When asked to give reasons behind the utilization of feathers, they explained that their elders taught them that it has been traditionally passed down through generations and that chickens are always available to provide feathers. Knowledge Holders further noted that not all chicken feathers are suitable for painting, but specific types are carefully selected for their unique qualities. Knowledge Holders also mentioned that feathers create a distinct texture and effect on the artwork, which is difficult to develop using brushes. They also indicated that continuing traditional practice maintains a spiritual connection to their ancestors.

For example, W5 said:

> *A feather is a traditional material used in Ndebele mural art, it was used by our elders and therefore we are following a long standing cultural practice, feathers hold a cultural significance, are easily accessible, paint brushes* were *not available in the past, we have own chickens which we get feathers from, and more importantly feathers can can be used to draw curved lines which may be difficult to achieve with paint brushes.*

WKH responses to using feathers have some implications, such as:

1) Demonstration of commitment to preserving cultural heritage and traditional practices;
2) Respect to elders and ancestors; and
3) Resistance to modernization, that is, they may be resistant to adopting modern tools, preferring to maintain traditional ones for sustainability.

The research findings revealed that there are steps to follow in making the cultural artefacts, similar patterns were noted, for example in beadwork they first decide on the artefact to make, decide on the colours needed, count the beads and sort them according to colours. For instance, WB1 said. *I am counting in threes and fives to have a geometric pattern in my decoration of rhombus and triangles.* WB2 said: *this side I counted 30, this side 39, I used the same number of beads for the two opposite site for them to be of equal length, in my decoration*. WB1 further explained that counting is always involved as part of the procedure because you must decide on the colour and the number of beads that you are going to use.

W3 mentioned that in the context of mural art there are two kinds of designs used and they are incorporating both in their work. She expressed that the two designs belong to Ndebele culture, from the two tribes, one representing Amandebele tribe known as Manala, and the other one represent Ndzundza. She further explained that the two were siblings, both belonging to the royal family *[AmaNdebele simihlobo emibili, Manala namaNdzundza, bentwana bomuntu begodu boke ngebebukhosini]*.

The Ndzundza and Manala chiefdoms are collectively known as the Southern Ndebele. Ndzundza and Manala are the two sons of Chief Musi who married two women. After Chief Musi's death, his eldest son Manala (first bon son of the great wife) was named a future chief. This was challenged by his other son Ndzundza (first born son of the second wife, born before Manala) and resulted in a struggle between the two sons. The struggle led to the formation of the two tribes. Ndundza were under the leadership of Chief Mabhoko referred to by the Boers as Mapoch. Ndebele people were forced I to life of oppression after the Boer war (South African History Online). Their artwork became a way of communicating secretely with each other. Their painting went from expressing grief to cultural resistance and continuity. Symbols used were the beginning of the African Art form. Wall painting done by women were secret code to their people. They made their particular identity viscible through their homes and dress (archives, evergreen). Ndzundza are well known for their striking wall painting, which is the expression of identity, resistance and claim of space. Their mural art reveals a pattern of forced relocation and a fight to preserve cultural identity (elephant).

5.4.5.1 Shapes used by Women Knowledge Holders and their Significances

The study revealed that WKHs use unique descriptive terms for their shapes, which differ significantly from formal mathematics concepts and terminology used in educational settings. The following examples were identified: *Ifillis, Isirayithoni*, *Ipewulani,* and *makasana*.

This is in line with what Rosa and Orey (2011) argued, that in the context of ethnomathematics many cultural differentiated groups know mathematics in a way that are different from academic mathematics taught in schools.

According to elders, *Ifilis,* known as *ilihlo*, is placed inside the more oversized shape to make the shape beautiful to attract clients. The study's findings show that shapes are used on the things around the environment, things they interacted with, and objects they use in everyday activities. W2 said*: Isirayithoni, with steps, resembles a razor blade, and Filisi is the name taken from cards.* W3 said *that her painting represents waves of the sea; we just give ourselves names, such as kettle, spanner used to hold a boat and frame.* Mathematical thinking is culturally motivated by human experiences (Chahine, 2013).

The other significant finding was that Women indicated that *the main aim is to differentiate Kwamanala and Ndzunza painting,* W3: *there is no particular specific meaning for the culture, it is just creativity from my head.' we have Ks, such as those two Ks'.* According to Bhuda (2019), discovery, shapes found in Ndebele art have symbolic meaning associated with the cosmos.

The triangulation process uncovered a substantial gap in knowledge, a significant discrepancy emerged revealing that learners interviewed lacked familiarity with the traditional concepts used by women within their own cultural context. Not a single concept was mentioned by any of the ten learners interviewed, revealing the striking absence of familiarity with the traditional concepts used by women knowledge or elders in their culture. These findings answered the question asked by Gerdes (1995:63), on the terminology that is used by women in their Indigenous activities 'What terminology do women use?'.

Concepts are known to adults who are in this context, teachers and WKH only, which implies that If teachers can refer to them in teaching or naming 2Ds, they will form part of new concepts to be learned; however, learners will be included if the teacher incorporates the Concrete

Pictorial Abstract method (CPA), Semiotic mediation which involves interaction through language, diagrams, pictures and actions (Van de Walle et al., 2010:21), and ZPD.

5.4.5.2 Counting in Ndebele Culture

Zaslavsky (1994:5) contents that every society develops its own particular mathematics, factors that are involved in the development include heritage, environment, religious beliefs, technological advances, artistic inclinations of how people make living, all have an effect on the development of their mathematics. Mathematics is a human endeavour (D'Ambrosio, 2000), meaning that mathematics is a product of human culture, history and experience, has been developed and shaped by people across various societies. In her book entitled Africa counts, Zaslavsky (1999) reported that Africans contributed to the development of counting. Hindu Arabic (indo- Arabic) numerals and Roman numerals are developments from societies on own particular mathematics which found their way into school curriculum, yet most learners have no idea as to their origin (Zaslavsky).

It is essential to introduce ethnomathematical perspectives into the mathematics curriculum for learners to recognize that mathematical practices and ideas arose out of the real needs and interests of human beings and that the mathematics that they learn at school originated in Asia and Africa centuries before Europeans were aware of more than the most elementary mathematics (Zaslavsky, 1994:6).

The study revealed that W2 and W3 could count to 100 without formal schooling. For example, W2 said*: Ngingakwazi ukubala kufika ekhulwini (I can count up to 100).* Each of the two women confidently counted loudly to demonstrate their proficiency. When asked how they learnt to count to 100 because they never had the opportunity to attend formal schooling, women credited their proficiency in counting to their everyday experiences such as counting livestock, managing household items, counting the stock (stock checking), business transactions which involved handling money and calculating change for clients. Findings supported what Keyser (2011) found: that early humans counted animals and other everyday objects by making tally marks on bones, etc.

Findings also resonate with Zaslavsky (1994), who states that economic considerations generally govern the extent of counting. Further noted is that it profited the hungry European merchants responsible for expanding some numeration systems. Mathematical thinking is culturally motivated by human experiences (Chahine, 2013).

WKH emphasized that counting plays an integral role in Ndebele culture when crafting cultural artefacts for achieving desired designs and patterns.

> W2 said: *Kubala kusebtjhenziswa u1, 2,3,4,5 okubusako. Esinye siyafika kwikhulu linye (100) kuyango mfanekiso ofuna ukuwenza.*
>
> [Counting is used,1 2,3,4, 5 are numbers that are dominantly used. From one to hundred depending on the pattern you want to make.]
>
> W3: *Umfanekiso ufaka izinombolo ezincane njengokubala kufikela kumatjhumi amabili (20).*
>
> [The patterns involve small numbers like counting to 20.]

W2 and W3 shared a common understanding that numbers 1 to 5 are frequently used in everyday counting when doing beadwork. However, their perspective differed on the maximum numbers used, with W2 suggesting up to 100, whereas W3 believed that patterns typically involve smaller numbers, up to 20. The different ideas of women, W2 and W3, on the maximum number to be counted when making beadwork in Ndebele culture may imply varying levels of mathematical understanding, leading to differences in perceived numbers or personal experience and skill level, which may impact their counting and working with more significant numbers. The implications highlight the complexity and richness of Ndebele culture and the importance of considering multiple perspectives when exploring mathematical understanding and cultural practices.

> W3: *If I don't count like this, I will not be able to create a pattern. There is nothing that you can do without counting.*

W3 in this statement, was implying that counting is a fundamental skill required for creating patterns in beadwork, that in Ndebele culture, counting is deeply tied to the creation of patterns in beadwork. The findings validated (Mosimege, 2003), that ladies interviewed in Lesedi cultural village have not attended school but could demonstrate their counting skill by counting from one to five and they further expressed that counting determines the pattern and the shapes. In contrast, the women in this study reported being able to count to 100, demonstrating incremental growth in numeracy skills through informal learning experience.

WKH' possess the natural ability to apply to count forward in intervals of 2s, 3s, 4s, etc., in their beadwork creations, illustrating mathematical knowledge obtained from the mother informally, having no educational background in mathematics. For example:

> W3: *Uma udobha okubili kumele wazi ukuti izibalo zingu 2, 2, 2. Lapho wakha umfanekiso ngibala ngezinye izikhathi kabili, kabili, lapho umncamo obuyi-3 isikhathi ngasinye 3, 3, 3, nagu 4, 4 lapha 5, 5.*
>
> [If you pick up two, you must know that your maths score is 2, 2, 2. When creating a pattern, I sometimes count two, two, here three beads each time 3, 3, 3 here is 4, 4, here 5.]

The counting system applied by W3 is similar to what Keyser (2011) recorded, which is that certain aboriginal tribes counted to two only. Any number larger than two was called much or many. Keyser further noted that South American Indians along the tributaries of Amazon could count up to six and had no independent number names for groups of three, four, five or six. Three was called 'two-one', and four was called 'two-two'. The Bushmen of South Africa had a similar system to count to ten. Their ten was counted as 2+2+2+2+2. Numbers were used for trading, such as exchanging cows for pigs—one cow for two pigs, two for four pigs, which brings in another concept of ratio.

It is also fascinating to learn that counting was done through tallies. Scratches were made on bones, stones, and caves, knots were tied in strings of different colours and lengths, and tallies were arranged in groups of five. Counting by groups of 2 or pairs came first, then it was abandoned in favour of groups of 5, 10, and 20. Counting in groups improved counting in ones (Keyser, 2011). Counting progressed from using fingers to tally marks

WKH further stated that only one colour is used in circular waist hoops, therefore there is no counting. Waist hoops need more beads because they are significant. The bigger the hoop the more beads to be used. This implies an essential element of comparing whole numbers in numbers of operations and relationships (CAPS, 2011).

5.4.5.3 Using fundamental arithmetic operations in Ndebele culture

Through in-depth interviews with WKH and FGDs, it emerged that women also emphasized the application of fundamental arithmetic operations such as addition, subtraction, multiplication and division in their creative process of designing patterns in Ndebele beadwork. WB2 expressed that in addition to counting, they sometimes add or subtract, multiply or divide depending on the pattern they want to create in beadwork or else one will not get the shape or pattern they must make. Ndebele women are ethnomathematicicians with knowledge of mathematics (Bhuda 2019:120).

Multiplication is a mathematical operation that represents the repeated addition of a number. In the context of beadwork, multiplication might be used to calculate the number of beads needed for a pattern, determine the number of rows or columns required, scale up or down a design and so on. When explaining how she applied multiplication, W2 said:

> *Uthatha oyisithupha (6) uhlanganise nomunye oyisithupha (6) iyokunikela itjhumi nambili (12), itjhumi nesithupha (16) uhlanganise netjhumi nesithupha (16) iyokunikela amatjhumi amathathu nambili (32).*
>
> [You say 6 plus another 6, and it gives you 12. The following pattern is 16 plus 16, providing 32.]

The implications of WKH's ability to use fundamental arithmetic without formal schooling are as follows: Knowledge Holders developed mathematical skills through informal learning in everyday real-life situations, and basic arithmetic skills are also rooted in cultural artefacts. This finding, therefore, challenges the traditional notions that emphasized that formal education is the sole means of acquiring mathematical knowledge. Finding recognizes the importance of IKS. D'Ambrosio (2016) contended that the ethnomathematics of the invincible society of the non-elite population is present, and craftsmen practice it, retailers selling essential goods, relying on traditional wisdom passed from generation to generation.

5.4.5.4 Estimation in Ndebele culture

Estimation emerged as the predominant mathematical strategy employed by WKHs in the creation of beadwork and mural art. Womens' application of estimation demonstrated a level of mathematical literacy obtained informally. Estimation has been passed down through generations as a traditional practice. It implies that WKH relied on visual judgement and spatial reasoning to create balanced and harmonious designs.

When describing their mural art and beadwork process, women uniformly revealed that they use estimation as their primary method. WKH said that they measure through hand span. Hand span refers to the practice of using length of ones' hand or *fingers*s as a unit of measurement, it is a traditional method used. The length of the hand or a *fingers* is used as a rough guide to estimate distances. It is convenient and used for approximations. WKH use non-standards measurements. According to Van De Walle et al. (2010:368), non-standard units are beneficial at all grades, such as providing good rationale for using standard units at school. This finding implicates and motivate that WKH can share their inherent knowledge of mathematical concepts, work with teachers to improve the mathematics performance.

> *We use a hand span, seven fingers and a thumb stretched, according to the length you want to draw a shape. Rope is also used to measure the length of the wall; fold the rope in the middle (tie it) to determine the centre, and then you will know the shapes to draw; we don't use measuring instruments.*

For example: W5 expresssed that they are not using measuring instruments. When questioned about her estimation practices W5 reflected on her mothers's teachings (*My mother taught me how to estimate using my eyes and I am comfortable with it*').

Umlingakobe [tears] and *Umkhala* [Headband] were also given as examples of informal measurement in beadwork.

> W3 expressed: *when making Umlingakobe (tears, we just estimate the length that we want, they have different lengths depending on your chosen estimation.*

> W2 said: *When crafting Umkhala* [Headband] *Women Knowledge Holders said that they measure the head with a rope, fold it to determine the centre.*

Van De Walle et al. (2010:372-374) contend that estimation plays an essential role in measurement that learners must estimate before actual measurement, further noted examples of non-standard units that can be used, such as measuring ropes, to measure the perimeter and circumference of round or oval shapes such as the head.

It was found that making circular hoops with only one colour throughout needs no counting, women just estimate on the quantity of beads they will must complete the cultural artefact, so that they do not run short of beads.

WPB said that the hoops are made of grass inside, which is covered with the cloth and the beads on top of the fabric for decoration, the amount of grass needed is also estimated by looking at the person's size of the body, they use the grass enough to fit her body.

> WPB*: I just estimate the amout of grass I am going to make use of, I look at the person's size of the body and estimate*.

Another fascinating aspect found from WKHs was that in mural art there is the difference between the thickness of two lines drawn by two different people. The finding challenges the idea of obsolute measurement and precision in art, stressing that artistic expressin can thrive without adhering to strict measurements.

> W3: *When I am using my thumb all the lines are of the same thickness. However, if I request my daughter to decorate on my behalf, the thickness of her lines will be different to mines).*

The findings revealed a reccuring pattern in estimation skills. In the interview on the making of 'Sesiu' (Mosimege, 2003), several mathematical concepts were referred to, with using estimation being prominentinn the amount of grass needed to craft different sizes. The accuracy of estimation was said to were gained from the experience, number of years working with grass.

5.4.5.5 Changes from Estimation to measurement

Participant observations from this study, revealed that WKHs working with W2, make use of measuring instruments, brushes and feathers in their painted art.

WPB explained that she intentionally allowed women she works with, to use measuring instruments and brushes because of their availability and her observation that tools significantly enhance their productivity, allowing them to complete orders within the planned time frame. The response from WPB implied that commercialization pressures have significantly influenced cultural practices, requiring them to adapt to a faster pace to meet deadlines, which has transformed how they approach their traditional craft to ensure speedy delivery.

In contrast to the traditional approach of the elderly, who painted without prior sketching, W2 contemporary women artist initiated their creative process by drawing a sketch, marking a significant shift in methodology. The findings on unrestricted creativity by W2, resonates with Chikare, Osuagwu, Oguegbubulam and Ngozi (2012), perspective that IK is not static, generations can bring about adaptations an improvement to earlier practices.

> WP1 said: *You start by measuring the space in your cloth, you decide on the size of space you want for the shape that you are going to draw, whether it will be a centimeter or 2 centimeters, 5 centimeters or 10 centimeters.*

ZPD refers to a range of knowledge that may be out of reach for a person to learn on their own, but it is accessible with support of a peers or MKO (Van De Walle et al., 2010:21). WP1 attended formal schooling up to Standard 1. She did not know the measuring instruments, units of measurements and how to read them on the measuring instruments, she did not know Ndebele mural art and beadwork. She was able to learn all those activities and grow with guidance from WPB who taught her mural art using informal measurements and learned using formal measurements from colleaques, who introduced her to formal measurements and helped her reach her full potential within her ZPD. Her colleaques provided scaffolding and support enabling her to move from novice to expert with her ZPD.

It was discovered that women working with W2 have foundation in formal education including mathematics. The graph below, represent the WKH highest grade with mathematics.

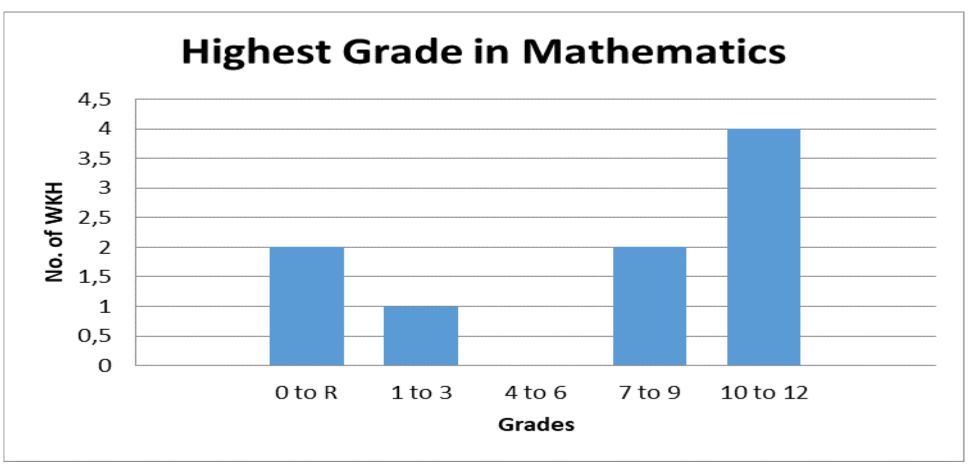


Figure 5.4: Highest grade in Mathematics

Women who attended formal schooling, reported that they were motivated to work with WPB due to cicurmstances such as unemployment, inability to secure bursaries for further education and financial necessity. Their educational background and mathematical knowledge played a significant role in their decision to suggest the incorporation of measuring instruments and brushes in their painted art to WPB who is their leader.

In my participant observation, women who were painting the cloths indicated that if they do not make use of squares and rectangles the picture will not fit properly, that the shapes must be of equal size on the cloth. Same thing applies to measurement. If they don't measure appropriately lines will not be of the same length.

5.4.5.6 Using mathematical concepts learnt at school in Ndebele art

During FGDs and participant observations with WKHs, women with a formal educational background and mathematics education up to Grade 9 or higher showed a remarkable capacity to translate mathematical concepts and skills learnt in school into practical applications in their painted art whilst painting clothes using Ndebele art designs.

> WP3 expressed that *We are using different types of transformation in our decorations.*
>
> WB1 said: *My word exactly, including perpendicular lines. Within the shapes we create, there are different angles, such as right angles and acute and obtuse ones. When we create a rectangle, for example, we create right angles in it. It must have four right angles to be a real rectangle. A rhombus has obtuse and acute angles.*

In their responses, WP3 and WB1 revealed that they have a solid mathematical foundation and the ability to recall and build upon previously learned concepts. Their responses can highlight a deep understanding and long-term retention of mathematical knowledge. In the context of ethnomathematical approaches, their ability to apply maths learned at school demonstrate the interconnectedness of Ndebele Culture and Mathematics.

Using mathematical concepts and skills learned at school is vital because maths develops problem-solving skills which will assist the WKH to overcome technical challenges and contraints in Ndebele art. Applying mathematics based mural art may create stunning artefacts and attract more clients, which will lead to massive expansion or growth of the business. It showcases the beauty of mathematics in practice. More people with interest in matheatics including our learners, will start to realise that mathematics is embedded within culture and their interest in pursuing mathematics might increase, which will inturn help us reach National Development Plan (NDP's vision for 2030).

5.4.6 Women Knowledge Holders experiences and reference to mathematical concepts

The findings of this study have shown that Ndebele art is constructed using mathematical ideas and concepts. WKH have never attended any formal schooling, but they can use mathematical concepts and ideas in their creation of cultural artefacts; however, they are not aware that they are applying or doing mathematics that is taught at school in a formal setting.

The research findings derived from a triangulation of data collection instruments including interviews with WKH, teachers and FGDs consistently showed that Knowledge Holders who had no formal schooling background, were using, applying mathematical concepts in their everyday activities in mural art and the crafting of cultural artefacts, but when made aware of the mathematics that they are doing, they expressed a sense of surprise and excitement. They described my engagement with them as a confirmation to what they were once told, which was unbelievable to them. Women explained that they were not aware until they were told by a particular lady, now today is me, which means this is real.

To Women Kowledge Holders, it is just a decoration. For example, W3 said: *I did not attend schooling; I was just decorating without knowing that there is Maths in my decorations.*

In addition, WP3, who has a formal education background, expressed, "*When we paint, we do not say that we are doing transformation because we don't really tell now we are reflecting or translating a shape; it is just decoration invented by our elders, we sustain their knowledge."* It, therefore, implies the application of unconscious mathematics. Women use mathematical concepts without realizing it; they don't see mathematics done at school as part of their creative process. Their statements exemplify that Women have natural abilities which they can put into practice without noticing,

Further evidence of correlation can be observed in TC's response, which aligns with and reinforces the perspectives shared by the women. TC indicated that:

All concepts and skills in the Annual Teaching Plan are found in the Ndebele cultural artefacts, and one will even think that the Ndebele artists used the ATP when making their cultural artefacts or paintings. However, the person who made the artefacts was unaware that she was doing mathematics because we once asked her, and she was surprised to hear that she used mathematics taught at school. It was unbelievable to her that what she did related to Mathematics taught and learned at school, as she was just drawing.

5.4.6.1 Discussion and illustration of mathematical concepts used by WKH in making the Ndebele cultural artefacts

An example of the cultural artefact below is a tie (cf. Chapter 2), the artefact exhibits diverse range of mathematical concepts such as counting, the four basic operations, 2D shapes, transformations, tessellations and other mathematical concepts. WKH mentioned that they use estimation, counting, addition and subtraction, multiplication and division in their process of making the cultural artefact. For example, W3 expressed: *Counting is used, 1 2, 3, 4, 5 are numbers that are dominantly used. From one to hundred depending on the pattern you want to make, you use addition and subtraction* The mathematical concepts mentioned are evident in the Ndebele tie below, created by W2.

Figure 5.5: Ndebele tie

The white and black beads were used to create triangles. When one looks at the black dots in a single triangle, they portray counting forward, from 1 up to 6; the first raw has one black bead, the second raw has two black beads, and the third has three up to six beads on the last row. Each side of a shape created has the same number of beads, meaning all sides have the same length. There is a structured arrangement of beads that embodies several mathematical concepts. The arrangement of beads also shows a geometric pattern. For example,

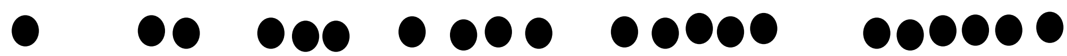


Fig: 1 Fig: 2 Fig: 3 Fig: 4 Fig: 5 Fig: 6

Numeric pattern: (1; 2; 3; 4; 5; 6)

The rule is the input number multiplied by 1

1 x 1 = 1

2 x 1 = 2

3 x 1 = 3

Gerdes (1995) reported that women who design items use basic squares, symmetry and other geometric concepts; mat weaving by Venda women showed horizontal and vertical symmetry, which are also evident in the designs made by WKH.

5.4.7 Support to schools, cooperation and collaboration with WKH

WKH indicated that they are readily available and that what is needed is commitment from the side of teachers and their learners. Knowledge gained and used at home will serve as a baseline to be consolidated at school. There is a common understanding that connecting mathematics learnt at school and mathematics done at home is critical and can help learners retain knowledge and improve performance in a subject.

> W3 expressed: *I have about 20 learners that I also taught in the past, I help those who come and ask me questions on Ndebele culture as part of their schoolwork, they interview me like you are doing today, and I give them answers.*

The findings revealed that the mathematical concepts in cultural artefacts will help teachers and learners embrace the school cultural context, will make learning concrete, aid understanding and help learners to remember, learner will realize that mathematics is a human creation or human activity.

Cultural villages can be used as contexts for mediating culture and mathematics (Mosimege, 2012). In addition, he indicated great potential for using rural artefacts in mathematics classrooms (Mosimege, 2017:9).

W3: *Learners can be given an activity to compare mathematics at home and school.*

The response from W3 implied that mathematics is not limited to the classroom; learning mathematics can occur in different settings, including the home of the learner, and learning occurs when learners see the connection between mathematics at home and mathematics at school. Comparing mathematics in different contexts at home and school can help learners develop a deeper understanding of mathematical concepts.

According to Gerdes (1995:187), the female heritage of southern Africa constitutes a fundamental starting point for the importance of the quality of Mathematics education. The findings revealed that Women could share their cultural practices, provide insights into mathematical knowledge, help build connections between schools and local communities, offer real-life examples of cultural artefacts to use as teaching resources and serve as role models to girls and female teachers.

Women can assist teachers, are prepared and willing to assist, and have innovative ideas. For example, W2 said she could develop a programme to train teachers in cultural artefacts.

W3, when asked how she can support schools in using mathematical concepts in cultural artefacts to help learners in Geometry, said she could offer cultural artefacts for learners to investigate mathematics in them when prompted to elaborate on her response to the investigation. She noted that learners can be given an activity to compare mathematics at home and school.

The response from W3, is significant, as it provides valuable solution to the pressing need for ethnomathematical resources expressed by teachers during their interviews. Cultural artefacts are useful resources for effective implementation of ethnomathematical approaches. Investigation as mentioned by W3, is one of the forms of assessment in mathematics, which will encourage development of essential skills such as critical thinking, problem-solving, logical reasoning etc leading to a positive attitude towards mathematics. Earlier, during the interviews with W3, she mentioned that she assists learners with their research homeworks on culture, henceforth mentioning investigation. Using the Ndebele cultural artefacts will help learners to connect with their culture. Gerdes (1994) defines ethnomathematics as the field of research that tries to study mathematics in their relationship with the whole of cultural and social life.

5.4.8 Implications of the relationship between WKH and the schools

The relationship between WKHs and schools in ethnomathematics has several implications based on the data collected. Collaborators can help preserve cultural knowledge and practices passing them down to future generations, whch in ths case will be Primary school learners n Grade 6. WKH can provide contextualized mathematics education, making it more relevant to learners' lives. *W3: In 2011 I went to Enkosini to teach teachers, some schools* were *selected. We trained teachers at Esther Mahlangus art center and went to school to train learners at schools. I was with Umama Esther Mahlangu and Ms X, we* were *three. The aim was to teach art and culture to schools, Hellet Smart paid us as it was her project.*

Collaborations with Women Knolegde Holders, can inform teacher trainings, provide resources for trainings, share insights on mathematical concepts in the cultural artefacts to enhance cultural competence and understanding of ethnomathematical approaches. The findings confirmed Gerdes (1994), that ethnomathematics tries to study mathematics in its relationship to the whole of cultural and social life. Gerdes (1995:187) further reiterated that the main objective is to improve the teaching of mathematics.

Working in partnership will showcase local mathematicians, scientists and community members as role models to mathematics learners, providing support to their communities and schools for the improvement of learning. The findings regarding the relationship between WKH and schools were further validated by the experience shared by TC, during interviews with individual teachers, allowing for in-depth understanding.

TC mentioned that learners visit the centre to learn Ndebele painting on Saturdays or some afternoons. He noted that the school once donated R7500 from Dr Esther Mahlangu.

> WP1: *Learners counting, and measurement skills will be improved. Learners with special needs will also benefit. Learners who are good at art and culture will be trained and find job*

opportunities. They can end up in Italy like me and Ms X. We cannot all be academics, cannot all be teachers or all work in offices, some of us have to be involved in hand work.

The finding above, from WP1's response brought to light that ethnomathematics, inclusive education, mathematics and learners with barriers to learning are interconnected. Providing culturally relevant mathematical skills to learners with barriers to learning has a potential to eradicate poverty, dependence and allow for a more dignified and sustainable livelihood.

W1 said that she can use beads to teach learners counting, addition, subtraction, multiplication and division. Vygotsky's ZPD suggested that learners can accomplish more with the help from knowledgeable person.

W4 said she would teach learners straight lines, accuracy, and measuring lines using measuring instruments and ensure that learners understand the units of measurement so they can use them correctly. W5 said she would show them that 1cm equals 10mm, allowing them to draw and practice lines. According to Vygotsky's (1978) theory, learning is a product of social processes involving interaction and cultural influences.

WKH stressed that teachers must teach their learners upon completing their training, ensuring sustainability. They noted that in the past, teachers received training but failed to transfer knowledge to learners and instead relied on repeated external training sessions.

During the interviews with learners, some mentioned they had an opportunity to engage in painting activities at the art center for Dr Esther Mahlangu.

5.4.9 Benefits of collaboration between WKH and schools

WKH shared their insightful perspectives on the advantages of collaborative relationships between WKH and schools, which were documented as follows:

> WB1: *Learners will do counting, which is part of the things they learn in school Mathematics, number patterns, geometric patterns at home and at school. Mathematics at school will build on the one gained from making cultural artefacts. Learners will be motivated to see realize that their culture has mathematics in it, will start to love and enjoy mathematics. Measurement is one of the challenging things in mathematics, painting will give them opportunity to practice units of measurement, conversion, how to use measuring instruments to ensure accurate measurements.*

At least teachers will only struggle to ensure that learners understand kilometers because they will come to school having knowledge of centimeters and millimeters.

WP3: *Learners will understand mathematics and be able to remember because learning will relate to their everyday activities. Beadwork will assist learners who are struggling with counting and the four basic operations. They will have a clear understanding of sides of a shape through active engagement with shapes, drawing them in mural art and creating them in beadwork.*

WPB: *Our culture will be acknowledged and be respected for its richness. It will also be preserved and sustained; this sharing will be the right direction to input knowledge to the current generation.*

WP1: *Cultural knowledge will be taught to learners*

The findings reinforced D'Ambrosio's (2001) view that teachers use ethnomathematics in the classroom to empower those whose voices and ideas have traditionally been marginalized. D'Ambrosio (2001) meant that it would give power, authority, and representation to groups or individuals excluded from the decision-making process, ignored, denied the opportunity for expression and participation, and historically oppressed or discriminated against. This may include women themselves, Indigenous people, minority cultures, low-income communities and so on. Frozen Mathematics (D'Ambrosio, 1985) can be unfrozen through relevant connections to diverse cultures and real-world problems.

5.4.10 The roles of Women and Men in ethnomathematics

IK Policy encourages the participation of women at all levels. Women's empowerment, autonomy and decision-making power over their own lives and circumstances (Mosimege, 2007, 2004). According to the IK Policy (2004:10), women were Indigenous knowledge custodians. The practical implementation of the IKS Policy regarding the role of women was observed during the data collection. Data was collected during the male initiation period *Ukuwela,* which marks the passage from childhood to adulthood. WKH indicated that they were busy preparing to welcome men from initiation schools, which included, among others, repainting houses and walls, crafting cultural artefacts such as beads for initiates (cf. Chapter 4), crafting *umlingagobe* (tears) for women (cf. Chapter 4) and additional roles prescribed by cultural tradition during rites of passage. The policy highlighted that Women are regarded as the primary natural resource managers with insightful knowledge of the environment. IKS Policy encourages the participation of women at all levels. The following were noted from engagement with WKH:

> WPB: *Beadwork and painting have always been the responsibility of women*
>
> WP3: *Women make cultural artefacts and sell them to generate income so that they can take care of their families*
>
> WPB: *Women protect and preserve cultural knowledge.*
>
> WP1: *Ndebele women are knowledge holders who have a responsibility to transmit knowledge to their daughters and other women; knowledge is transmitted from women to girls*
>
> WPB: *I am currently having a granddaughter who is 10 years old. She is observing me whilst doing beadwork and painting.*

According to IKS Policy (section 2.7), many researchers have recognized women as the primary natural resource managers with profound knowledge of the environment. It further noted that women play a crucial role in maintaining livelihoods and cultural continuity, which is the ongoing transmission and preservation of cultural practices, traditions and values. The findings revealed that women play a significant role in ethnomathematical activities, developing and transmitting IK and creating Ndebele cultural artefacts with mathematical concepts, patterns and designs. Women design beadwork and some clothing during cultural ceremonies, weddings and rituals.

According to Gilsdorf (2015), shared cultural contacts in which women's skills are highly regarded in different cultures, such as Aztec culture, show that the importance of wearing as a form of activity is respected in Mesoamerica.

Gerdes (1995) believes that beading, pottery, and decorating houses are traditionally a woman's responsibility.

5.4.10.1 Male involvement in ethnomathematics

According to Bhuda (2019:132), taboos and Ndebele customary laws exclude men from learning the knowledge and secrets of the female profession, further indicating that, as such, boys were chased away when girls were taught beadwork and mural art Bhuda.

This study correlates with the findings from interviews with learners and WKH. The individual interviews with learners highlighted a concerning lack of knowledge of cultural artefacts among boys, and the FGDs reinforced this finding. WKH mentioned that boys do not have information on Ndebele art.

> WP2: *Boys do not have basic knowledge of making cultural artefacts because of the trend of men's involvement with painting and beadwork in Ndebele culture.*

She further explained that:

> *Men's inactive role can be due to the norm that men do not do beadwork as per our culture.*

WPB believes

> *Men do roof of huts; men and boys* were *not allowed to make cultural artefacts in the past.*

A new insight gained from this study is that men currently participate in ethnomathematics to mitigate the effects of high unemployment. They paint walls and houses to generate income, ensuring their own economic stability and that of their families. A remarkable aspect of this trend is that women, such as WPB, play a pivotal role in empowering men to engage in ethnomathematics, a testament to the impact of women's role in IKS. WPB has trained several men, contributing to their economic and cultural empowerment.

> WPB*: Currently, due to the high unemployment rate, people are suffering from hunger. They can't take care of themselves and their families. I then decided to fight against unemployment and poverty. I have trained several men on how to paint. They are painting walls of people, and they get paid to make a living. Their focus is only on mural art.*

> WP1*: I have a son who has been trained by Ugogo (WPB) on how to paint houses, shoes, and tekkies. My son got a learnership and was promised that if he did not succeed with his career plans, he would return and work with Ugogo.*

One gentleman was found at the art centre on the day of FGDs. He was busy painting dishes that had to be collected. WPB explained that he was one of those who had been trained in Ndebele mural art. WP1 also confirmed that the WPB training program included his son, among other young boys. Findings proved that commercialization opened many job opportunities for all, including men.

Men are currently involved in ethnomathematics in various ways. For example, several male researchers are contributing to ethnomathematics, exploring and examining its applications in diverse cultural contexts, such as D'Ambrosio, regarded as the father of ethnomathematics. Gerdes (1995:84) indicated that Sotho men are responsible for building the house and further suggested realising the mathematical potential of women and men in Southern Africa.

The research conducted by Mosimege at Basotho Cultural Village revealed the extent of using mathematical concepts in the making of 'Sesiu' done by male inhabitants. Participants in Indigenous games and sports festivals at Basotho Cultural Village in the Free State included young men and boys playing *morabaraba*, *kgati* (skipping rope) and others.

At the 13th International Congress on Mathematical Education held in Hamburg, 24-31 July 2016, ethnomathematics and its pedagogical action, D'Ambrosio (2016) expressed that ethnomathematics aims at building up a civilization free of discrimination and inequality. School ethnomathematics practices encourage respect, solidarity, and cooperation with each other (D'Ambrosio, 2016), and they are associated with pursuing PEACE.

5.4.11 Ndebele cultural sustainability is a vital concern for Women Knowledge Holders in ethnomathematics

Preserving cultural heritage is a priority for WKH in ethnomathematics. They always ensure the continuation of their cultural heritage for future generations and empower others, themselves and their children. This is done to resist cultural marginalization by promoting Ndebele culture, countering Western epistemologies. Women noted a growing concern about their daughters not behaving like them and a declining pattern of involvement in ethnomathematics, which will negatively impact the preservation and continuation of their culture, with particular reference to beadwork and mural art embracing mathematical concepts.

> WPB: *I am concerned and afraid that our culture is gradually fading away because most of our daughters are not interested in making cultural artefacts; they do not know them, and they will not be able to transfer knowledge to their kids.*
>
> W2*: Our kids don't like wearing traditional clothes.*

The findings correlate with Bhuda (2019), who said that participants raised concerns about people slowly losing interest in preserving the Ndebele culture. W1 expressed that she tried to teach learners knitting, but unfortunately, she failed because those learners went away with her wool and cross needles.

The individual interviews with each of the ten learners yielded a common thread on the lack of participation by their mothers' in making the cultural artefacts. This trend was further validated by WKHs, supporting the findings from learners during separate interviews.

5.4.12 Commercialization of Ndebele Art

The IKS Policy 2004 stressed the importance of IK to the economy, its role in employment and wealth creation. Mosimege and Onwu (2004:2) contend that ethnomathematics is an inherent component of IKS. They further defined it as an all-inclusive knowledge system covering technology and practices that were and are still used by Indigenous and local people for existence, survival and adaption in different environments.

South Africa's economy benefits significantly from Women's knowledge and innovation. The Cultural heritage of Mabhoko village is the direct result of the dedication and expertise of its WKH. The contributions of women in ethnomathematics were a driving force behind the field's personal growth and economic development.

WKH are entrepreneurs who use Mathematical concepts and ideas in the Ndebele art to meet their essential needs, improve their socio-economic conditions, and enhance their financial stability. W3 said: *I make the cultural artefacts and sell them, and that assisted me in taking care of my family because my husband was disabled and unemployed.* The ethnomathematics of the invisible society of the non-elite population produced and provided basic needs of the people and the upper classes is present and practised (D'Ambrosio, 2016). Ndebele women are breadwinners who generate income from selling art to local and international buyers (Bhuda, 2019:169).

WKH specialises in both beadwork and painted art, has its art galleries, sells its art to local people with interest, and has traditional celebrations and tourists. W2 and W3 said people all over the world visit their art galleries. W1 is currently unemployed. Fortunately, she has discovered her own pathway to entrepreneurship through the commercialization of IK. She designs and sells clothes and hats on different platforms, such as during traditional weddings, ceremonies, and door-to-door selling. The commercialization of Ndebele art has opened job opportunities for many who can care for their families (Bhuda, 2019).

Regarding the commercialisation of Ndebele art, WKH indicated that they blend traditional shapes with modern things within the environment to attract clients and create marketable cultural artefacts that generate income while preserving their cultural heritage. In contrast to the olden days, today's speciality in making cultural artefacts is driven by economic forces. Ndebele cultural artefacts are fashionable and sold within South Africa and worldwide.

> WPB said: *Currently, we are mixing original shapes with modern things to meet the demands of the modern era because we are selling and doing business to generate income. The aim is to attract and satisfy the clients. Unfortunately, we need money to survive; otherwise, people will not buy our products. We are now including a variety of colours and shapes, which are actually not for Ndebele culture, with an aim to accommodate all blacks and whites. We include colours for the Xhosas as well and no longer concentrate on Ndebele culture only.*

W2 expressed that she is currently allowing her team of ladies in mural art to use brushes to save time; the aim is to complete orders within the given time frame for prompt payment.

The responses implicate that financial pressures and survival needs directly influence culture and cultural practices.

The findings from this study revealed that currently, several unemployed youths, including men, benefit from commercialization, with young ladies doing beadwork and men painting. For example*, Learners L1 and L3 help their sisters-in-law save time by completing orders and delivering them to clients.* South Africans use IK for survival. International world organisers recognize IKS as a top global priority to empower Indigenous and local communities for survival and development (Chahine, 2013). IKS aims to empower Indigenous and local communities in their quest for survival and development.

Dr Esther Mahlangu used Ndebele art to brand commercialized products. The implications are (1) Economic empowerment and sustainable development, which provides economic opportunities for Ndebele artists and communities (2) Global recognition, which promotes Ndebele art globally, increasing recognition and appreciation (3) Commercialization of culture (4) Intellectual property, rights and ownership of Ndebele art by WKH.

5.4.13 Popularity and acknowledgement, brought by IKS on Woman Knowledge Holders life experiences

Indigenous Knowledge Systems has brought attention to the significant contributions of women in traditional societies, recognizing their roles as custodians of cultural knowledge and practices. Recognized women can serve as role models, mentoring younger women and inspiring future generations to see the role of mathematics in culture in promoting growth in individuals academically and socially. For instance, Dr Esther Mahlangu was honoured with an honorary doctoral degree in March 2018 from the University of Johannesburg (UJ). She obtained another honorary degree in 2018 from the Durban University of Technology (DUT) (cf. Chapter 2).

According to SA News (2024), President Ramaphosa bestowed National orders at Sefako M. Makgatho Presidential Guesthouse in Tshwane on the 30th of April 2024. W2, one of the participants, was one of the awardees of the Order of Ikhamanga 2024 Silver recipients, Silver (category 2) (cf. Chapter 4).

W3, another participant in this research, obtained a Legendary Award in 2024 from the Department of Culture, Sports & Recreation, Mpumalanga (cf. Chapter 4).

> W4 said*: I benefited more than others. I went to Italy to do painting on behalf of Ugogo* [referring to W2]. *I went to Persia through South African Airways on her behalf. She was supposed to go there but then she couldn't due to family commitments. She then requested me to go on her behalf. I knew nothing about mural art and beadwork, and she trained me.*

5.5 The Benefits of Being a Participant Observer

I gained an in-depth understanding of crafting the cultural artefacts using counting and estimation, which I learned from the best teachers through direct involvement, and practically engaged with mathematical concepts embedded in the cultural artefacts. It was an authentic experience whereby I participated in real-life situations unrehearsed and unscripted. Using nonstandard measurements and incorporating unusual methods, such as wool, to measure the head added a layer of depth to my investigation, demonstrating a creative problem-solving strategy. Participant observation built a strong, trusting relationship with the teachers, learners, and WKH who participated in the study.

5.6 Summary of Findings

The study's findings revealed, among others, that the teachers interviewed lacked knowledge of ethnomathematical approaches and experience in using ethnomathematical approaches in the teaching and learning of Grade 6 Geometry.

Teachers might be unfamiliar with the term ethnomathematics. Still, if they can be capacitated with basic understanding or given support, they can expand their mathematical perceptions and teach their learners effectively.

Findings reported that all the Ndebele cultural artefacts can be used to teach geometry, revealed the mathematical concepts and skills in Ndebele cultural artefacts and provided guidelines on how the mathematical concepts can be used to teach grade 6 geometry.

Combining ethnomathematics and academic mathematics teaching can help learners overcome cognitive difficulties in learning formal mathematics, promote creativity, problem-solving, and critical thinking, stimulate motivation and curiosity, enrich learners' knowledge of their own culture, and support cultural identity formation.

Ethnomathematical approaches are precisely not only for making the lesson more interesting and fun but also for students to see that making of cultural artefacts have mathematical concepts inherent in them, which they can use to connect to geometry learned at school as tools to learn mathematical concepts.

The vital role that WKH can play in teaching and learning mathematics is fostering a deeper connection between learners' culture and mathematical concepts involving geometry and beyond through collaboration and cooperation with mathematics teachers.

Historically, traditional attire was an integral part of daily life, requiring girls to develop practical skills to alter and mend their own clothes; therefore, it is assumed that girls may possess innate mathematical learning abilities nurtured through cultural practices and real-life experiences during interactions with grandmothers while passing down knowledge, which can help to improve learner performance if used accordingly.

WKH are prepared to share their cultural artefacts with teachers and to allow them to use their art galleries

WKH were unknowingly applying mathematical concepts through their cultural designs in pursuit of cultural expression, highlighting the interconnectedness of culture and mathematics

5.7 Suggestions for Future Research

Future research should focus on developing a culturally relevant mathematics framework with particular reference to Ndebele culture so that teachers can explore and understand the relationship between Ndebele culture, mathematics, and learning.

A longitudinal study examining the long-term impact of using ethnomathematical approaches in teaching Grade 6 geometry will include tracking the academic performance and attitudes towards maths learners taught with ethnomathematical approaches compared to those taught using traditional methods.

Future research can further explore how ethnomathematics learning is related to other cultures in Mpumalanga.

5.8 Recommendations

Teachers should be provided with training opportunities on incorporating ethnomathematical approaches to the teaching of geometry.
TD said: *I was never trained on using ethnomathematical approaches and as a result I have no information on the approaches*

The use of ethnomathematical approaches to teach geometry. Ndebele Cultural artefacts should be used to make teaching and learning of geometry concrete, meaningful and interesting, for learners to connect mathematics in their everyday life to geometry learned at school.

Equitable cultural artefacts knowledge for all genders

> W2 said: *As grandparents, we must teach our granddaughters so they can teach their children. We must also teach boys mural art to sustain our culture. When all are involved at home, they will master the mathematics in mural art and beadwork.*

Partnership, collaboration and cooperation with WKH. Inviting them to share their knowledge and experiences in mathematics, mentorship and teacher programmes with the subsequent evidence included from interviews with WKH to substantiate the recommendations.

> WPB: *If teachers and learners desire to have knowledge and skills in making cultural artefacts, they must show it, approach us, and always be available when we need them. The interest and love of mural art and beadwork must make them pursue or approach us for help, which will be provided through training. We are trying to work with schools. Teachers must allow us to come and train them and their learners on the making of cultural artefacts. An agreement must be reached on the time.*

Using art galleries as resource centres to mediate ethnomathematical approaches.

Acknowledging the mathematical contributions of Women Knowledge Holders, recording and preserving their mathematical knowledge and practices for future generations

5.9 Conclusion

The study on the exploration of ethnomathematical approaches revealed a profound intersection between culture, mathematics, learner performance, and identity. By recognizing and valuing learners' cultural knowledge and practices, ethnomathematics can transform mathematics education, fostering a more inclusive and equitable learning environment. The findings suggest that ethnomathematical approaches can improve learner performance by building on their existing knowledge and experiences from culture, enhancing cultural identity and pride, and promoting a sense of belonging and connection to mathematics. It will also challenge the dominant Western mathematical narratives and offer a diverse perspective and problem-solving strategies. Learners from marginalized communities will be empowered to reclaim their mathematical heritage and contribute to the development of mathematics education. Developing a mathematics curriculum should consider African cultural heritage as the starting point to improve all learners' cultural, social and self-confidence (Gerdes, 1995:187).

Ethnomathematics should be practiced in schools to demystify school mathematics as final, permanent, absolute and unique form of knowledge (D'Ambrosio and Rosa). The curriculum was created to assist students of color towards the process of developing critical consciousness and self awareness (DaCunha, 2016). According to Knowles et al, 2023 as cited by Heleta and Chasi (2023), the historical framing of knowledge gives authority to white, male Eurocentric knowledge which results in us not recognizing ourself in this knowledge and alienated from our own rich cultures and histories. Eurocentric education has silenced and misconstrued the history and truth of marginalized communities (DaCunha, 2016). Heleta and Chasi (2023) argued that the propagation of knowledge from Global North as universal through conceptually vague framings of curriculum internationalization is contributing to the maintenance of Erocentric hegemony.

Our government need to recognise the impact that Eurocentric curriculum has on racial minorities and continue to reshape the curriculum to better reflect the diversity of learners and identities. Integrating Ethnomathematics into mathematics education is a critical step towards valuing IKS, yet we have not yet started this journey, leaving us far from realizing the principle. South African teachers still rely on Eurocentric methods of teaching mathematics (Meeran, 2024).

While efforts to incorporate Ethnomathematical approaches are still unfolding, we are optimistic that recommendations will inform policy-making decisions and enhance teacher awareness, paving the way for more culturally responsive mathematics education. The research srudy will build awareness of the important role that mathematics plays in real life situations (CAPS, 2011:9) to develop essential mathematics skills. I fully embrace the spirit of Gerdes 'Aluta Continua; the fight for ethnomathematical approaches is far from over.

5.10 Limitations of the Study

5.10.1 Challenges of booking participants

Challenges arose in scheduling bookings with the first team (WKH), which necessitated identifying alternative participants for the research process.

5.10.2 Postponing the Interviews

Postponing and unavailability of some participants delayed the research project's scheduled time for data collection and analysis.

5.10.3 COVID-19 pandemic

The COVID-19 pandemic and its effects negatively impacted the research project planning and implementation, causing delays in data collection and extending the study's duration.

5.10.4 Research compensations

One of the participants requested an advance payment of R500 for a single interview session.

The limitation of this study is not only found in the limited data of teachers but also on the limited ethnicities. The study cannot provide a comprehensive understanding of ethnomathematics learning in the Mpumalanga context which has many cultures.

5.11 Lesson Learnt

1. Mathematics is a universal language deeply rooted in cultural practices and traditions.
2. Respect and value of IK are priorities for all.
3. WKHs are people with in-depth knowledge of cultural artefacts.

5.12 Contribution of this Study to the Body of Knowledge

The study provided examples of practical applications in real-world settings which can support teachers in integrating ethnomathematics into their practice and can serve as guidelines to curriculum developers in their modification of curriculum.

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APPENDICES

APPENDIX A: GHREC RESEARCH APPROVAL

GENERAL/HUMAN RESEARCH ETHICS COMMITTEE (GHREC)

28-Feb-2022

Dear Mrs Freda Poo **Application Approved**

Research Project Title:

An exploration of ethnomathematical approaches in the teaching and learning of Grade 6 Geometry

Ethical Clearance number: **UFS-HSD2021/1789/22**

We are pleased to inform you that your application for ethical clearance has been approved. Your ethical clearance is valid for twelve (12) months from the date of issue. We request that any changes that may take place during the course of your study/research project be submitted to the ethics office to ensure ethical transparency. furthermore, you are requested to submit the final report of your study/research project to the ethics office. Should you require more time to complete this research, please apply for an extension. Thank you for submitting your proposal for ethical clearance; we wish you the best of luck and success with your research.

Yours sincerely

Dr Adri Du Plessis
Chairperson: General/Human Research Ethics Committee

205 Nelson Mandela
Drive
Park West
Bloemfontein 9301 South Africa

P.O. Box 339
Bloemfontein 9300
Tel: +27 (0)51 401 9337 duplessisA@ufs.ac.za **www.ufs.ac.za**

APPENDIX B: REQUEST OF PERMISSION TO THE DISTRICT, TO CONDUCT RESEARCH

12 December 2021

The Head of Department: Nkangala District

Dear Sir/Madam

Re: Application for a Permission to conduct research in Nkangala District Schools

My name is Freda Mmapula Poo, SES for Mathematics GET, Intermediate phase from Nkangala District. I am a registered student at the University of Free State, studying Doctor of Philosophy in Mathematics education. I am requesting a permission to conduct a research study in Nkangala District schools. The research intends to involve 5 schools located within Weltevrede circuit. The title of my research is: An exploration of ethnomathematical approaches in the teaching and learning of Grade 6 geometry.

Ethnomathematical approaches are techniques that build on learners' prior understanding and experience, the role played by the environment on content, as well as past and present experiences of their immediate surrounding (D'Ambrosio, 2001). Teachers' experience on using ethnomathematical approaches in the teaching of geometry will be explored; and mathematical concepts found in Ndebele cultural artefacts will be investigated to determine how they are used or can be used to aid learners' understanding of geometry.

The research will entail collecting data from teachers and learners. Data will be collected through interviews, observations and focus group discussions. Data collection will take place after school hours or on Saturdays. Participant's responses will be audio and video recorded.

Participants will be asked to give their written consent before the research begins. Their responses will be treated confidentially, and identities (their names and the name of the organisation) will be anonymous. Individual privacy will be maintained in all published and written data resulting from the study. The research participants will not be advantaged or disadvantaged in any way. They will be reassured that they can withdraw their permission at any time during this project without any penalty. There are no foreseeable risks in participating in this study. The participants will not be paid for this study.

Thanking you in anticipation.

Should you have clarity seeking questions regarding the project please contact:

Freda Mmapula Poo. Cell number: 082 4750544. Email address: mapulapoo@webmail.co.za

Supervisor: Professor Mogege Mosimege. Cell number: 0823879013. Office number: (051) 401 9088

Email address: MosimegeMD@ufs.ac.az

APPENDIX C: DISTRICT APPROVAL TO CONDUCT RESEARCH

ENQ: Skhosana SS
013 947 1615
Email:sib.skhosana@gmail.com

20 December 2021

Dear Sir/Madam

Permission to conduct research in institutions of Mpumalanga Department of Education.

The purpose of this letter is to inform you that the permission has been granted to Ms Freda Mmapula Poo to conduct a research titled: An exploration of ethnomathematical approaches in the teaching and learning of Grade 6 geometry at Nkangala District, 6 sampled Primary schools located within Weltevrede circuit. This also serves as an assurance that the schools comply with requirements of Protection of pupil Rights Amendment (PPRA). The Department will ensure that these requirements are followed in the conduct of this research.

Hope you find this in order.

Yours sincerely

________________ **20 DECEMBER 2021**

MRS SKHOSANA SS DATE

CES : GET

APPENDIX D: REQUEST OF PERMISSION TO THE CIRCUIT MANAGER, TO CONDUCT RESEARCH

07 March 2022

The Circuit Manager: Weltevrede Circuit
Dear Sir

<u>Request for permission to conduct a research study in your schools</u>

My name is Freda Mmapula Poo, SES for Mathematics GET, Intermediate phase from Nkangala District. I am a registered student at the University of Free State, studying Doctor of Philosophy in Mathematics education. I am requesting a permission to conduct a research study at the following Primary Schools: Andisa, Mabhoko, Simunyembiwa, Sakhe and Magodongo.

The title of my research is: An exploration of ethnomathematical approaches in the teaching and learning of Grade 6 geometry. The research will entail collecting data from teachers and learners. Data will be collected through interviews and observations. Data collection will take place after school hours or on Saturdays. Participant's responses will be audio and video recorded.

Participants will be asked to give their written consent before the research begins. Their responses will be treated confidentially, and identities (their names and the name of the organisation) will be anonymous. Individual privacy will be maintained in all published and written data resulting from the study. The results will be communicated in the dissertation to be completed. The research participants will not be advantaged or disadvantaged in any way. They will be reassured that they can withdraw their permission at any time during this project without any penalty. There are no foreseeable risks in participating in this study. The participants will not be paid for this study.

Find attached the approval for ethical clearance from General /human research ethics committee (GHREC), and the approval from the District Office.

Thanking you in anticipation.

Should you have clarity seeking questions regarding the project please feel free to contact me or my supervisor:

Freda Mmapula Poo. Cell number: 082 4750544. Email address: mapulapoo@webmail.co.za

Supervisor: Professor Mogege Mosimege. Cell number: 0823879013. Office number: (051) 401 9088

Email address: MosimegeMD@ufs.ac.az

APPENDIX E: REQUEST OF PERMISSION TO THE SCHOOLS, TO CONDUCT RESEARCH

07 March 2022

The Principal

Dear Sir/Madam

Request for permission to conduct a research study in your school

My name is Freda Mmapula Poo, SES for Mathematics GET, Intermediate phase from Nkangala District. I am a registered student at the University of Free State, studying Doctor of Philosophy in Mathematics education. I am requesting a permission to conduct a research study in your Primary School.

The title of my research is: An exploration of ethnomathematical approaches in the teaching and learning of Grade 6 geometry. The research will entail collecting data from Grade 6 teachers and learners. Data will be collected through interviews and observations. Participant's responses will be audio and video recorded.

Participants will be asked to give their written consent before the research begins. Their responses will be treated confidentially, and identities (their names and the name of the organisation) will be anonymous. Individual privacy will be maintained in all published and written data resulting from the study. The results will be communicated in the dissertation to be completed.

They will be reassured that they can withdraw their permission at any time during this project without any penalty. There are no foreseeable risks in participating in this study.

Find attached the approval for ethical clearance from General /human research ethics committee (GHREC) Approval number: UFS-HSD2021/1789/22, and the approval from the District Office.

Should you have clarity seeking questions or concerns regarding the study, please feel free to call me or my supervisor using the contact details below:

Freda Mmapula Poo. Cell number: 082 4750544. Email address: mapulapoo@webmail.co.za

Supervisor: Professor Mogege Mosimege. Cell number: 0823879013. Office number: (051) 401 9088

Email address: MosimegeMD@ufs.ac.az

APPENDIX F: PARTICIPANTS' INFORMED CONSENT

Title of the research project: An exploration of ethnomathematical approaches in the teaching and learning of Grade 6 geometry

The study is conducted with the University of the Free State under the faculty of Education, department of School of Mathematics Natural sciences and Technology Education

The participants will be interviewed, observed and be involved in focus group discussions. The study involves audio/video taping focus group discussions and semi-structured interviews

Your participation in this study is entirely voluntary and you have the right to withdraw at any time and without any penalty or consequence. If you do decide to participate, you will be given this information sheet to keep and be asked to sign a written consent form. By proceeding with this study, you acknowledge that you have read and understood the information provided to you. You consent to participate voluntarily. There is no penalty or loss of benefit for non-participation. Participants will not be subjected to any harm/risk if you decide to participate in this study.

Participants will remain anonymous. Names and identifying information will not be revealed, not appear on the report and the study results. Any information collected during this study will be kept strictly confidential and your data will be stored securely.

Should you have clarity seeking questions or concerns regarding the study, please feel free to me or my supervisor using the contact details below:

Freda Mmapula Poo. Cell number: 082 4750544. Email address: mapulapoo@webmail.co.za

Supervisor: Professor Mogege Mosimege. Cell number: 0823879013. Office number: (051) 401 9088

Email address: MosimegeMD@ufs.ac.az

Participant’s name: ______________________ Signature:_______________________

Contact number: ________________________ Date: __________________________

APPENDIX G: PARENT/GUARDIAN INFORMED CONSENT FORM

Dear parent/Guardian

Invitation to learners to participate in a research study.

My name is Freda Mmapula Poo. I am a Ph.D student at the University of the Free State under the faculty of Education, department of School of Mathematics Natural sciences and Technology Education

I am herein inviting your child _________to participate in the research study titled: An exploration of ethnomathematical approaches in the teaching and learning of Grade 6 geometry. Before the child can participate, we require consent as their parent or legal guardian. Your child is one of the 10 sampled learners. Learner's were chosen because they have knowledge of their own culture acquired through observation, direct involvement and interaction with parents and WKH within the community. Participants will be interviewed and be observed The study involves audio/video taping of interviews and lesson observations.

Parents are assured of the following:

1. Child's participation is entirely voluntary; child can withdraw from the study at any time without any penalty or consequence.
2. Any information collected will be kept strictly confidential, your child's identity will be anonymized and their data will be stored securely
3. There are no foreseeable risks associated with participating in this study; however, your child may benefit by gaining knowledge and there will be an improved understanding of geometry content, concepts and skills and improved retention
4. Nothing will be painful or scary to the child. Explanation will be given to learners that they must tell their parents if they are sick or in pain during the course of the study.

The study has received an approval letter from the Department and the approval for ethical clearance from General /human research ethics committee (GHREC), Approval number: UFHSD2021/1789/22, the approval from the District Office and the schools' principal aproval.

Should you have clarity seeking questions or concerns regarding the study, please feel free to me or my supervisor using the contact details below:

Freda Mmapula Poo. Cell number: 082 4750544. Email address: mapulapoo@webmail.co.za

Supervisor: Professor Mogege Mosimege. Cell number: 0823879013. Office number: (051) 401 9088

Email address: MosimegeMD@ufs.ac.az

Informed consent by parent/guardian

I________________________________, the parent/guardian of ____________________declare that I give my informed consent for my child to participate in this research.

Signature: __________________ Date:_________________

APPENDIX H: CHILD ASSENT FORM

<u>PLEASE RETURN</u>

Name of child:____

Name of Parent: ____

- Do you understand this research study and are you willing to let your child participate in it? Yes ☐ No ☐
- Has the researcher answered all your questions? Yes ☐ No ☐
- Do you understand that you can withdraw from the study at any time? Yes ☐ No☐
- I give the researcher permission to make use of the data gathered from my child's participation Yes ☐ No☐

______________________________ ______________________

Signature of Parent ***Date***

I, the undersigned Parent, further confirm that–

1. the Researcher has explained the nature, procedure, potential benefits and anticipated inconvenience of my participation in the Study;
2. I have read (or had explained to me) and understood the Study as explained in the attached information sheet;
3. I have had sufficient opportunity to ask questions and am prepared to participate in the Study;
4. I understand that my participation in the Study is entirely voluntary and that I am free to withdraw at any time without penalty (if applicable);
5. I voluntarily provide the UFS and the Researcher with my personal information and consent to the UFS and the Researcher collecting, disclosing and processing my personal information in order to conduct the Study and any related activities in relation thereto;
6. I hereby acknowledge and confirm that I understand the purpose for which the UFS and the Researcher may collect, store, use, delete, destroy, outsource, transfer or otherwise process, as the context and circumstances may require and as contemplated in terms of POPIA, my personal information as set out herein;
7. I am aware that the findings of the Study will be anonymously processed into a research report, journal publications and/or conference proceedings and that my personal information will be aggregated and identified at such stage;
8. I also give the UFS permission to share, without notification, the collected data with other researchers at the UFS or other Higher Education Institutions. This permission is dependent on the same principles of ethical research practices, anonymity/confidentiality, safekeeping of information, and other issues listed above applying.

I, _________________________the Parent, agree to the recording of the interviews and observations

Full Name of the learner ____

Signature of the learner: ____________________________________ Date: ____________________

Full Name(s) of Researcher(s): ____

Signature of Researcher: ___________________________________Date: ____________

APPENDIX I: TEACHERS' INTERVIEW PROTOCOL

Date	Time	Participant	Contact No	Name of the School

Focus and time allocation	Area of discussion	Content
Introduction: 5 min	Establish rapport	My name is--------. I am the subject advisor responsible for Mathematics --------
	Purpose	The purpose of this meeting is to ask you questions on ethnomathematical approaches in the teaching and learning of geometry by Grade 6 learners. By exploring ethnomathematical approaches, we aim to enhance learners' engagement, understanding and appreciation of geometry through incorporating culturally relevant examples in real-life world contexts into curriculum. You are free to to ask clarity seeking questions. Should you have any further questions or require additional information, please do not hesitate to contact me on this number:…………
	Structure of an interview	The interview has four sections. The first section is on the consent forms ----, the 2nd session on -------- the 3rd on------- and the 4th session is 0n ----
	Duration	The interview will take 50 – 60 minutes.
Backround information	Participants' background information	With whom am I speaking to? How long have you been teaching mathematics? Which grades are you responsible for? Which content area do you like most and why? How is your learners performance in mathematics as compared to the other subjects?
Research questions	Main research Question	How can ethnomathematical approaches be explored in the teaching and learning of Grade 6 geometry?

Teachers experience on ethnomathematical approaches (15)	Sub – questions	1. Have you ever used ethnomathematical approaches to teach Grade 6 geometry**?** a. If you have used them, where and how did you use them? b. If no, why did you not use them? 2. What are your experiences on using ethnomathematical approaches in the teaching of Grade 6 geometry? (Own experiences)
Knowledge of Ndebele cultural artefacts (15)		3. What are the different Ndebele cultural artefacts that you know? 4. Which Ndebele cultural artefacts can be used to teach Grade 6 geometry? 5. According to your view, how does Grade 6 geometry link with Ndebele cultural artefacts? 6. Which Grade 6 geometry concepts and skills can be developed using Ndebele cultural artefacts? 7. How can you use Ndebele cultural artefacts to aid learners understanding of geometry concepts and skills?
Mathematical concepts found in Ndebele cultural artefacts (20)		8. What are the mathematical concepts found in Ndebele cultural artefacts? 9. Which mathematical skills can be found in the in Ndebele cultural artefacts? 10. How can such mathematical concepts and skills be used to teach Grade 6 geometry? 11. What are the benefits of using mathematical concepts found in Ndebele cultural artefacts in the teaching and learning of Grade 6 geometry?

Probing (3 min)	Probing questions	1.2. You said … what do you mean? May you please explain with an example. 1.3. You mentioned that-----, can you tell me more about it? 1.4. What do you mean by ----, can you explain more on the link? 1.5. Can you elaborate on that?
Closure (2 min)	Acknowledgement of participation	I want to extend my sincere gratitude for your participation in the interview on exploration of ethnomathematical approaches in the teaching and learning of Grade 6 geometry. Your dedication and willingness to share your thoughts and experience made a significant impact on our work. Please feel free to reach out if you have any further questions. My contact details are ……

APPENDIX J: LEARNERS INTERVIEW PROTOCOL

Learner	Gender	Name of the School

Focus and time allocation	Area of discussion	Content
Introduction: 5 min	Establish rapport	My name is--------. I am the teacher responsible for Mathematics --------
	Purpose	The purpose of this meeting is to ask you questions on ethnomathematical approaches, the Ndebele cultural artefacts that you know and how they are used to help you connect mathematics found in them and mathematics done in the classroom. You are free to to ask any question on the information which you do not understand in our conversation.
	Structure of an interview	The interview has four sessions. The first session is on the assent forms ----, the 2nd session on -------- the 3rd on------- and the 4th session is 0n ----
	Duration	The interview will take 40 – 60 minutes.
Backround information	Learners' background information	What is your name? Do you enjoy learning mathematics? Which topic do you like most in geometry and why?
Research questions	Main research Question	How can ethnomathematical approaches be explored in the teaching and learning of Grade 6 geometry?
Learners knowledge andinvolvement in making Ndebele cultural artefacts (18)	Sub – questions	1. What are the different Ndebele cultural artefacts that you know? 2. Have you ever been involved in the making of Ndebele cultural artefacts? If you were, explain how you were involved. 3. Which Ndebele cultural artefacts can you make or were you involved in their making? 4. How were the Ndebele cultural artefacts made? 5. Did you make use of geometry learnt at school in making

		cultural artefacts?
Ndebele cultural artefacts as learning resources (18)		6. Have you ever learnt Grade 6 geometry with using Ndebele cultural artefacts? 7. Which Ndebele cultural artefacts did you use to learn Grade 6 geometry? 8. How were the cultural artefacts used to learn Grade 6 geometry? 9. Which Grade 6 geometry concepts were developed using Ndebele cultural artefacts? 10. How does using Ndebele cultural artefacts aid your understanding of Grade 6 geometry?
Mathematical concepts found in Ndebele cultural artefacts (14)		11. What are the mathematical concepts found in Ndebele cultural artefacts? 12. How can the mathematical concepts found in the Ndebele cultural artefacts help you in the learning of Grade 6 geometry.
Probing (3 min)	Probing questions	1. You said you have never been involved. Why….? 2. How did you help your sister-in-law? 3. Why were you helping your sister-in-law? 4. How was it to learn …… ?
Closure (2 min)	Acknowledgement of participation	Thank you so much for your participation. Your input and contributions were invaluable in helping us gather the necessary information for the research study.

APPENDIX K: LESSON OBSERVATION SCHEDULE

Rating scale of observed behaviours and interaction on ethnomathematics approaches during teaching and learning of geometry

1= Not at all, 2= Very little, 3= Little, 4= A lot, 5 = A great deal

Teacher A (TA)

Date: 22/08/2022

Items *(Seating arrangements: pairs)*	**1**	**2**	**3**	**4**	**5**
Learners naming of different Ndebele cultural artefacts	√				
Learners identification of geometric forms found in Ndebele cultural artefacts	√				
Using Ndebele cultural artefacts in teaching Grade 6 geometry *(Cutural artefacts not available, no concrete objects used)*	√				
Teaching activities relevant to ethnomathematics approaches	√				
Assessment activities relevant to ethnomathematics approaches Textbook used	√				
Learners analysis of Ndebele cultural artefacts	√				
Emerging mathematical concepts from Ndebele cultural artefacts analyzed	√				
Learners participation, interest and excitement in learning geometry *(Passive listners)*	√				
Learners interactions, communication with the teacher and amongst themselves *(Used only telling method used,*	√				
Using mathematical language to replace everyday language used In cultural artefacts	√				
Relating prior experiences obtained from making cultural artefacts to classroom mathematics	√				
Linking mathematics in the classroom to mathematics done every day at home when making cultural artefacts	√				
Improved learner performance in geometry concepts and skills		√			

APPENDIX L: LESSON OBSERVATION SCHEDULE

Rating scale of observed behaviours and interaction on ethnomathematics approaches during teaching and learning of geometry

1= Not at all, 2= Very little, 3= Little, 4= A lot, 5 = A great deal

Teacher E (TE)

Date: 23/08/2022

Items *(Seating arrangements: pairs)*	**1**	**2**	**3**	**4**	**5**
Learners naming of different Ndebele cultural artefacts	√				
Learners identification of geometric forms found in Ndebele cultural artefacts	√				
Using Ndebele cultural artefacts in teaching Grade 6 geometry *(Not available, no concrete objects used)*	√				
Teaching activities relevant to ethnomathematics approaches	√				
Assessment activities relevant to ethnomathematics approaches *Workbook 1*	√				
Learners analysis of Ndebele cultural artefacts	√				
Emerging mathematical concepts from Ndebele cultural artefacts analyzed	√				
Learners participation, interest and excitement in learning geometry *(Partly passive lisners)*	√				
Learners interactions, communication with the teacher and amongst themselves *(Telling method used)*	√				
Using mathematical language to replace everyday language used In cultural artefacts	√				
Relating prior experiences obtained from making cultural artefacts to classroom mathematics	√				
Linking mathematics in the classroom to mathematics done every day at home when making cultural artefacts.	√				
Improved learner performance in geometry concepts and skills		√			

APPENDIX M: LESSON OBSERVATION SCHEDULE

Rating scale of observed behaviours and interaction on ethnomathematics approaches during teaching and learning of geometry

1= Not at all, 2= Very little, 3= Little, 4= A lot, 5 = A great deal

Teacher B (TB)

Date: 23/08/2022

Items *(Seating arrangements: pairs)*	**1**	**2**	**3**	**4**	**5**
Learners naming of different Ndebele cultural artefacts	√				
Learners identification of geometric forms found in Ndebele cultural artefacts	√				
Using Ndebele cultural artefacts in teaching Grade 6 geometry *(Cultural artefacts not available, no concrete objects used)*	√				
Teaching activities relevant to ethnomathematics approaches	√				
Assessment activities relevant to ethnomathematics approaches *Used Ndebele wall picture*		√			
Learners analysis of Ndebele cultural artefacts	√				
Emerging mathematical concepts from Ndebele cultural artefacts analyzed	√				
Learners participation, interest and excitement in learning geometry	√				
Learners interactions, communication with the teacher and amongst themselves	√				
Using mathematical language to replace everyday language used In cultural artefacts	√				
Relating prior experiences obtained from making cultural artefacts to classroom mathematics	√				
Linking mathematics in the classroom to mathematics done every day at home when making cultural artefacts	√				
Improved learner performance in geometry concepts and skills		√			

APPENDIX N: LESSON OBSERVATION SCHEDULE

Rating scale of observed behaviours and interaction on ethnomathematics approaches during teaching and learning of geometry

1= Not at all, 2= Very little, 3= Little, 4= A lot, 5 = A great deal

Teacher C (TC)

Date: 25/08/2022

Items *(Seating arrangements:pairs working in groups of 4)*	**1**	**2**	**3**	**4**	**5**
Learners naming of different Ndebele cultural artefacts					√
Learners identification of geometric forms found in Ndebele cultural artefacts				√	
Using Ndebele cultural artefacts in teaching Grade 6 geometry					√
Teaching activities relevant to ethnomathematics approaches *(Teacher wearing Ndebele hat, learners analysed it as introduction)*				√	
Assessment activities relevant to ethnomathematics approaches *(30 minutes allocated to groups to engage in activities)*				√	
Learners analysis of Ndebele cultural artefacts *Same activity allocated to each of the four rows, groups to report back after 30 minutes.*					√
Emerging mathematical concepts from Ndebele cultural artefacts analyzed					√
Learners participation, interest and excitement in learning geometry					√
Learners interactions, communication with the teacher and amongst themselves *(Discussed, shared ideas), instructed to work in groups of 4, for cooperative learning*				√	
Using mathematical language to replace everyday language used In cultural artefacts				√	
Relating prior experiences obtained from making cultural artefacts to classroom mathematics			√		
Linking mathematics in the classroom to mathematics done every day at home when making cultural artefacts			√		
Improved learner performance in geometry concepts and skills *Good perfornce in responding to questions and classwork written*				√	

APPENDIX O: LESSON OBSERVATION SCHEDULE

Rating scale of observed behaviours and interaction on ethnomathematics approaches during teaching and learning of geometry

1= Not at all, 2= Very little, 3= Little, 4= A lot, 5 = A great deal

Teacher D (TD)

Date: 25/08/2022

Items *(Seating arrangements: pairs)*	**1**	**2**	**3**	**4**	**5**
Learners naming of different Ndebele cultural artefacts	√				
Learners identification of geometric forms found in Ndebele cultural artefacts	√				
Using Ndebele cultural artefacts in teaching Grade 6 geometry *(Cultural artefacts not used)*	√				
Teaching activities relevant to ethnomathematics approaches	√				
Assessment activities relevant to ethnomathematics approaches *Workbook 1*	√				
Learners analysis of Ndebele cultural artefacts	√				
Emerging mathematical concepts from Ndebele cultural artefacts analyzed	√				
Learners participation, interest and excitement in learning geometry	√				
Learners interactions, communication with the teacher and amongst themselves	√				
Using mathematical language to replace everyday language used In cultural artefacts	√				
Relating prior experiences obtained from making cultural artefacts to classroom mathematics	√				
Linking mathematics in the classroom to mathematics done every day at home when making cultural artefacts	√				
Improved learner performance in geometry concepts and skills		√			

APPENDIX P: WOMEN KNOWLEDGE HOLDERS INTERVIEW PROTOCOL

Date	Time	Participant	Contact No

Focus and time allocation	Area of discussion	Content
Introduction: 5 min	Establish rapport	My name is--------. I am the teacher responsible for Mathematics -------- within ------
	Purpose	The purpose of this meeting is to ask you questions on ethnomathematical approaches in the teaching and learning of geometry by Grade 6 learners. Your insights can help us better understand how to integrate ethnomathematics into classroom in a way that resonates with learners understanding, give them opportunity to benefit from seeing mathematics from their cultural perspective. You are free to to ask clarity seeking questions.
	Structure of an interview	The interview has five sections. The first section is on the consent forms ----, the 2nd session on -------- the 3rd on------- the 4th is on ---- and session 5th
	Duration	The interview will take 50 – 60 minutes
Backround information	Women Knowledge Holders background information	With whom am I honoured to speak with today? Could you please tell me about yourself and your background regarding Ndebele cultural artefacts? What motivated you to pursue the making of cultural artefacts? Do you think is necessary to collaborate with schools? Substantiate.
Research questions	Main Question	How can ethnomathematical approaches be explored in the teaching and learning of Grade 6 geometry?
Women Knowledge Holders knowledge of Ndebele cultural artefacts (15)	Sub – questions	1. What are the different Ndebele cultural artefacts that you know? *Ngibuphi ubukghwari bensetjenziswa zesiNdebele ngokuhlukahlukana kwazo ozaziko?* 2. Which Ndebele cultural artefacts are you able to make? *Ngibuphi ubukghwari bensetjenziswa zesiNdebele okwaziko ukuzenza?* 3. How and when did you acquire knowledge and skills of making the

		cultural artefacts? *Inga ulithole nini begodu njani ilwazi namakghono wokwenza insetjenziswa zobukghwari besiNdebele?* 4. When did you start making your own Ndebele cultural artefacts? *Uthome nini ukuzenzela zakho insetjenziswa zobukghwari besiNdebele?*
Transfer of knowledge (15)		5. How do you transfer your knowledge and skills to your children, neighbours or people with interest? *Ulidlulisela bunjani ilwazi kanye namakghono wokwenza insetjenziswa zobubukghwari besikhethu ebantwaneni, abomakhelwana namkha abantu abanekareko?*
Making of Ndebele cultural artefacts (10 min)		6. How do you make your Ndebele cultural artefacts? *Uzenza njani insetjenziswa zobukghwari besiNdebele okwazi ukuzenza?* 7. Which shapes are you using when making Ndebele cultural artefacts? *Ngimaphi amabumbeko namkha amadizayini owasebenzisako nawenza insetjenziswa zobukghwari besiNdebele?* 8. What is the significance of using those shapes in your Ndebele cultural artefacts? *Kubaluleke ngani ukusebenzisa amabumbeko namkha amadizayini lawo nawenza insetjenziswa zobukghwari besiNdebele?*
Mathematical concepts found in Ndebele cultural artefacts (10 min)		9. Do you think that there is school mathematics within the Ndebele cultural artefacts? *Ucabanga bona zikhona iimbalo ezifundwa esikolweni obuye uzithola hlangana neensetjenziswa zobukghwari besiNdebele?* 10. What are the mathematical concepts found in Ndebele cultural artefacts? *Ngikuphi lokhu okufundwa eembalweni ekutholakala eensetjenzisweni zobukghwari besiNdebele* *11.* How can we ensure the use and mastery of mathematical concepts in cultural artefacts at home to help learners learn geometry at school? *Singaqinisekisa njani ukuthi ubuhlakani bemiqondo yezibalo ezintweni zobukghwari/zobuciko bamasiko ekhaya ukuze sirhelebhe abafundi ukuthi bafunde i-geometry esikolweni?* 12. How can you support schools to use of mathematical concepts in

		cultural artefacts to help learners learn geometry*? Singazirhelebha njani iinkolo ukuthi kuberegiswe imiqondo yezibalo kubukghwari/kubuciko bamasiko, ukuze sirhelebhe abafundi bafunde i-geometry* 13. What is the importance of using mathematical concepts in Ndebele cultural artefacts in the learning of geometry? *Kubaluleke ngani ukusebenzisa imiqondo yezibalo emgwaleni yamasiko esiNebele ekufundweni kwe-Geometry?*
Probing (3 min)	Probing questions	a. You said you use your thumb? May you please demonstrate. b. You mentioned counting, can explain how you do it? c. What do you mean by ----, can you explain more.
Closure (2 min)	Acknowledgement of participation	Thank you for considering participation in our research study. Your valuable input as a WKH will contribute to advancing the field of mathematics education. Should you have any further questions or require additional information please call me at this number:…………..

APPENDIX Q: WOMEN KNOWLEDGE HOLDERS' FOCUS GROUP DISCUSSION PROTOCOL

1. **Introduction**

Establishing a rapport.

A very good morning to everyone. Thank you so much for joining us today for this focus group discussion on exploration of ethnomathematical approaches in the teaching and learning of geometry in a primary school with particular reference to Grade 6. My name is--------. I am the student at the university of the Free State doing ------, I am working as the subject advisor for Mathematics -------- within ------.

Please note that your participation in this focus group is entirely voluntary, you can withdraw from this study at anytime without any prejudice. Your privacy and anonymity will be respected at all times. Any information shared will be kept with strict privacy and confidentiality

2. **Purpose**

The purpose of this focus group is to understand the experiences, thoughts, and ideas you have regarding the integration of our Ndebele culture, using the Ndebele cultural artefacts, your knowledge and experience of the cultural artefacts to help learners learn geometry in a practical way. Your input is incredibly valuable and will contribute to the development of innovative and culturally relevant teaching strategies. I am going to ask you questions on ethnomathematical approaches, Ndebele cultural artefact, to gather your knowledge, perceptions and experience on how they can be used to connect learners' mathematics done at home, found in cultural artefacts with mathematics at school.

3. **Ground rules**

   Please note that this is a collaborative and inclusive environment where all opinions are respected. Let us engage in active listening, give each other chance to speak, one person at a time, respect each others ideas and create a meaningfull dialogue. Negative criticisms are not allowed.

4. **Ice breaker**

My dear ladies, I would like us to start with a fun ice breaker. Let us go around the room and share one interesting fact or experience related to mathematics or geometry. It could be a personal story, a favorite geometric shape, a creative application of geometry etc. This will not only help us to know each other better but also create a positive and engaging tone for our discussion. Who would like to start?

5. **Discussions on ethnomathematical approaches.**

Geometric shapes

5.1. Why are you using geometric shapes in making your cultural artefacts? *Kubayini usebenzisa ihlobo lamadizayini namkha amabumbeko we jiyomethri la wena owasebenzisako ukwenza iinsetjenziswa zobukghwari beskhethu?*

5.2. How did you learn the different shapes that you are making use of? *Uwafunde bunjani amabumbeko namkha amadizayini ahlukahlukeneko la owasebenzisako?*

5.3. Do geometric shapes convey meaning or message? *Inga rhani amabumbeko we-jiyomethri namkha amadizayini la anomlayezo namkha kunento ayitjhoko na?*

5.3.1 If yes, what meaning do they convey? *Nangebi uyavuma, anamuphi umlayezo namkha atjho ukuthini?*

5.3.2. If no, why are they of much interest to you? *Nangabe uyala, kubayini unekareko kiwo?*

Steps followed in making the cultural artefacts

5.4. Are there steps to follow when making your cultural artefacts? *Ikhona imihlahlandlela ekufuze uyilandele lokha nawenza iinsetjenziswa zobukghwari beskhethu ozaziko?*

5.4.1. If yes, what are the steps to follow? *Nangabe uyavuma, ngimiphi imihlahlandlela ekufuze uyilandele?*

5.4.2. If no, how do you arrive at the final product? *Nangabe uyala, yini ekusizako bana uthome bewuqede?*

Using School mathematics in making cultural artefacts

5.5. Up to which grade did you learn mathematics at school? *Uzifunde kufikela kiliphi ibanga iimbalo(maths) esikolweni?*

5.6. Are you using knowledge learned from school mathematics to make your cultural artefacts? *Uyalisebenzisa ilwazi leembalo (maths) olifunde esikolweni ukwenza iinsetjenziswa zobukghwari besikhethu ozabaziko?*

The role of women and men

5.7. Why are women taking a leading role in making Ndebele cultural artefacts? *Kubayini abantu bengubo kungibo abathatha amagadango phambili ekwenzeni iinsetjenziswa zobukghwari besiNdebele?*

5.8. Are men taking part in making cultural artefacts? *Inga abantu bembaji nabo banendima ebayidlalako ekwenzeni iinsetjenziswa zobugkwari besikhethu?*

5.8.1. If yes, what is their role in making cultural artefacts? *Nangabe uyavuma, ngiyiphi indima ebayidlalako ekwenzeni iinsetjenziswa zobukgwari besikhethu?*

5.8.2. If no, why are they not taking part? *Nangabe uyala, kubayini banganandima ebayidlalako?*

5.8.3. If no, does it mean that boys do not have basic knowledge of making cultural artefacts like girls? *Nangabe uyala, inga kghani lokho kutjhobona abesana abanalo ilwazi elifunekako njengabentazana lokwenza iinsetjenziswa zobukghwari besikhethu?*

5.8.4. If yes, how can the knowledge gap be addressed? *Nagabe uyavuma bona abanalo, ukutlhayelwa kwelwazi kungalungiswa njani?*

Sharing knowledge and skills with schools

5.9. How can you share your knowledge and skills in making cultural artefacts with learners and teachers? *Ungalidlulisela bunjani ilwazi kanye namakghono wokwenza iinsetjenziswa zobukghwari besikhethu ebantwaneni besikolo kanye nabafundisi/titjhere?*

5.10. What will be the advantages of sharing knowledge and skills in making cultural artefacts with learners and teachers? *Ngikuphi okuhle okungalethwa kukwaba namkha kudlulisela ilwazi kanye namakghono wokwenza iinsetjenziswa zobukghwari besikhethu ebantwaneni besikolo kanye nabafundisi/titjhere?*

6. Wrap up and closing

Once again, thank you for being here today, we truly appreciate your time, openness and willingness to contribute to this research study. Your contributions will make a significant impact to our learners understanding and performance of mathematics. Should there be any missing information or additional data required, I will reach out to you for further clarification. Your continued support and collaboration are essential to the success of this research.

APPENDIX R: WKH CHECKLIST (INTERVIEWS)

Tick in the appropriate column

Qualification Highest grade/standard	Grade 0-R	Grade 1-3	Grade 4-6	Grade 7-9	Grade 10-12	
Highest standard with Mathematics	√√	√		√	√	
Age in years	21 – 30	31- 40	41 – 50	51 - 60	61 - 70	Above 71
			√	√	√	√√
No years practice / experience in cultural artefacts	0 - 10	11 - 20	21 – 30	31 +		
		√	√√	√√		

APPENDIX S: WKH CHECKLIST (FOCUS GROUP DISCUSSIONS)

Tick in the appropriate column

Qualification Highest grade/standard	Grade 0 - R	Grade 1-3	Grade 4-6	Grade 7-9	Grade 10-12	
Highest standard with Mathematics	√	√			√√√√	
Age in years	21 - 30	31- 40	41 - 50	51 – 60	61 - 70	Above 71
		√√	√√		√	√
No years practice / experience in cultural artefacts	0 - 10	11 - 20	21 - 30	Above 31		
		√√√	√√	√		

APPENDIX T: WOMEN KNOWLEDGE HOLDERS' OBSERVATION SCHEDULE

Rating scale of observed behaviours and steps followed in making cultural artefacts

1= Not at all, 2= Very little, 3= Little, 4= A lot, 5 = A great deal

Date 21 September 2022

Items	**1**	**2**	**3**	**4**	**5**
Using mathematical objects or resources in making cultural artefacts				√	
Using mathematical concepts and ideas					√
Using mathematical skills such as counting, measuring etc					√
Elements of accuracy in making cultural artefacts					√
Display of passion, excitement and dedication when making cultural artefacts					√
Display of confidence and extensive knowledge when making cultural artefacts					√
Availability of plan, sketches or drawing of cultural artefacts *Available, drawn on cloths to be painted*				√	
Explaining the usual production technique of making cultural artefacts					√
Steps followed in making cultural artefacts					√
Teamwork characteristics *2 teams, one for beadwork and the other one for painted art, sharing ideas, helping one another to complete the tasks*					√
Evidence of sharing expertise, exposing learners and others to making cultural artefacts *Women assisting one another, one participant is the product of WPB, all youth participated trained by WPB, WP1 assisted by other women*					√

APPENDIX U: INTERPRETER DECLARATION

Declaration by interpreter

I *(name)* ………………………………………….……… declare that:

- I assisted the investigator (*name*) ………………………………………. to explain the information in this document to (*name of participant*) ……………..…………………………….. Using the language medium of Isindebele.
- We encouraged him/her to ask questions and took adequate time to answer them.
- I conveyed a factually correct version of what was related to me.
- I am satisfied that the participant fully understands the content of this informed consent document and has had all their question satisfactorily answered.

Signed at (*place*) ....….......…………….. on (*date*) …………...………………..

.. **..**

Signature of interpreter Signature of witness

Focus group discussions: 21/09/2022

APPENDIX V: LETTER FROM LANGUAGE EDITOR

CARMEN NEL
REGISTERED PROFESSIONAL LIBRARIAN (SA)

EDITING SERVICES
✆ 072 377 5585
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CERTIFICATE OF LANGUAGE EDITING

This certifies that I have edited the research report detailed below.

Title:

"AN EXPLORATION OF ETHNOMATHEMATICAL APPROACHES IN THE TEACHING AND LEARNING OF GRADE 6 GEOMETRY"

by

POO FREDA MMAPULA

Regards

Carmen Nel

Carmen Nel
27 November 2024

Professional editing of articles, thesis, dissertations and books