EXPLORATION OF GEOMETRICAL CONCEPTS INVOLVED IN THE TRADITIONAL CIRCULAR BUILDINGS AND THEIR RELATIONSHIP TO CLASSROOM LEARNING

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DECLARATION

I declare that this dissertation contains no material which has been accepted for the award of any other degree or diploma in any university. To the best of my knowledge and belief this dissertation contains no material previously published by any other person except where due acknowledgement has been made.

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ABSTRACT

Traditionally, mathematics has been perceived as objective, abstract, absolute and universal subject that is devoid of social and cultural influences. However, the new perspective has led to the perceptions that mathematics is a human endeavour, and therefore it is culture-bound and context-bound. Mathematics is viewed as a human activity and therefore fallible.

This research was set out to explore geometrical concepts involved in the traditional circular buildings in Mopani district of Limpopo Province and relate them to the classroom learning in grade 11 classes. The study was conducted in a very remote place and a sample of two traditional circular houses from Xitsonga and Sepedi cultures was chosen for comparison purposes because of their cultural diversity. The questions that guided my exploration were:

- Which geometrical concepts are involved in the design of the traditional circular buildings and mural decorations in Mopani district of the Limpopo Province?
- How do the geometrical concepts in the traditional circular buildings relate to the learning of circle geometry in grade 11 class?

The data were gathered through my observations and the learners' observations, my interviews with the builders and with the learners, and the grade 11 learners' interaction with their parents or builders about the construction and decorations of the traditional circular houses. I used narrative configurations to analyse the collected data. Inductive analysis, discovery and interim analysis in the field were employed during data analysis.

From my own analysis and interpretations, I found that there are many geometrical concepts such as circle, diameter, semi-circle, radius, centre of the circle etc. that are involved in the design of the traditional circular buildings. In the construction of these houses, these concepts are involved from the foundation of the building to the

roof level. All these geometrical concepts can be used by both educators and learners to enhance the teaching and learning of circle geometry. Further evidence emerged that teaching with meaning and by relating abstract world to the real world makes mathematics more relevant and more useful.

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CHAPTER 1

INTRODUCTION

This chapter gives an overview of what this study is about. I start by giving quick comments about what I have learned from reading literature on mathematics and culture. This is followed by a short background on what prompted me to undertake this study. Thereafter I explain key words or concepts. This is followed by the outline of the study and the dissertation structure. Lastly, I highlight the significance of the study and its relevance to the teaching and learning of circle geometry in grade 11.

1.1. Mathematics and culture

The relationship between mathematics and culture has been of concern to researchers for the past few decades. It was noticed, in Britain for example, that children from minority cultural groups had problem in learning mathematics. The mathematics taught in class was found to have an alienating effect on such pupils, as the context within which learning occurred was foreign to their background experience (Bishop, 1991). Bishop further contends that such children do not only have to be bilingual but bicultural as well, as they have to cope both with their home and school cultures. He further appealed to mathematics teachers to be sensitive to this by acknowledging such diversity in their classrooms.

The same problem noted by Bishop in Britain has been found to exist in South Africa. Adler (1991) found that for every 10 000 black learners who register for Grade 1, only one out of this number gets better Grade 12 mathematics symbol to gain entry into a university. This scenario contributes significantly to South African's poor performance in the overall Grade 12 results. This is disturbing in view of the fact that achievement in mathematics is often used as a screening process for entrance into many career fields.

Amongst the various recommendations that have been suggested by researchers, contextualisation is advocated as an appropriate strategy in addressing the issue of alienation (Bishop, 1998; Shirley, 1995). The argument raised is that mathematics is a cultural product as all people of the world practice some form of mathematics. In helping learners to access mathematical knowledge, their social and cultural contexts should be acknowledged and be maximally exploited to the benefit of the learners.

1.2. Background to the problem

Geometry is a branch of mathematics that deals with the properties and relations of points, lines, surface, space and solids (Thompson, 1995). It is one of the sections of mathematics that learners are expected to learn because it is very useful in their everyday life world. They have to learn properties of space in context so that they could make better connections between in-and-out of school mathematics. Human beings everywhere and throughout time have used geometry in their everyday life. This geometrical knowledge is intertwined with art, craft and traditional buildings like rondavels and granaries for maize.

In Mopani district of the Limpopo Province, most learners are exposed to the traditional circular buildings. Both mathematics' teachers and learners see these traditional circular buildings on a daily basis and some sleep inside these type of houses. It is therefore very interesting that most of the learners in Grade 11 experience problems in learning and understanding circle geometry.

Based on my experience as (i) a mathematics teacher at 4 different schools in Mopani District, (ii) a sub-examiner of geometry Grade 12, and some evidence based on performance in mathematics results, it has been noted that the performance in geometry section is much lower than in other sections in Grade 10, 11 and 12. The reports compiled by examiners after each and every marking session clearly indicate that the performance in geometry section is much lower than in other sections.

This situation gives rise to the following questions: How do educators teach geometry? What are the relevant strategies of teaching geometry? How can educators improve the performance of learners in geometry? Which classroom support materials can be used to enhance the teaching and learning of geometry?

The new South African curriculum that emphasizes the development of learners' critical thinking powers and problem solving skills appears to be the promising solution as it encourages educators to contextualise what they are teaching (Department of Education, 2001). This implies that learners will be able to see geometrical forms or shapes in their everyday life situation.

1.3. Explanation of key words/ concepts

Traditional circular building refers to a building with a circular ground plan especially one with a dome (Thompson, 1995). Tradition refers to custom, opinion or belief handed down to posterity especially orally or by practice (Thompson, 1995). Traditional refers to based on or obtained by tradition and in the style of the early 20^{th} (Thompson, 1995).

Culture refers to the ways of life of the members of a society, or groups within a society. It includes how they dress, their marriage customs and family life, and their patterns of work, religious ceremonies and leisure pursuits (Giddens, 2001). Culture is also perceived as a set of shared experiences among a particular group of people (Mosimege, 1999). Bennet (as cited in Gaganakis (1992:48) sees culture as referring to the "level which social groups develop distinct patterns of life and give expressive form to their social and material experiences… [it] includes the maps of meaning which make things intelligible to its members". Culture is also defined as an organised system of values that are transmitted to its members both formally and informally (McConatha & Schnell, 1995). Cultural diversity or multicultural refers to the different traits of behaviour as aspects of broad cultural differences that distinguish societies from one another (Giddens, 2001). African refers to a person of African descent or related to Africa (Thompson, 1995).

1.4. Outline of this study

This study explores the geometrical concepts involved in the traditional circular buildings and their relationship to classroom learning. Guided by this broad purpose, I attempted to focus on the following two questions:

- Which geometrical concepts are involved in the design of the traditional circular buildings and mural decorations in Mopani district?
- How do the geometrical concepts in the traditional circular buildings relate to the learning of circle geometry in grade 11 class?

1.5. Dissertation structure

This dissertation is organised into four additional chapters as follows:

Chapter 2: The literature review first addresses the question of how to teach mathematics in the context of the new South African curriculum. After this, it examines the theme of ethno-mathematics and the theme: geometry and culture. I conclude the chapter by drawing together the arguments to guide my thinking and analysis for the rest of the dissertation.

Chapter 3: The methodology and methods chapter provides an overview of how the study was conducted. It comments on six sections: study design (including issues of the participants and setting), data gathering techniques, data analysis, access, ethical considerations and quality criteria.

Chapter 4: This chapter analyses the learners' responses, the parents' and builders' responses and reports the findings and interpretations.

Chapter 5: The chapter outlines the summary, implications and some recommendations regarding teaching and learning in similar contexts. It ends by my reflections.

1.6. Significance

The study is significant for the following reasons.

1. It aims at exploring the geometrical concepts in the traditional circular buildings.
2. It is likely to expose the learners to the geometrical concepts in the traditional circular buildings.
3. It is likely to provide information about how the traditional circular buildings can enhance the teaching and learning of geometry.

CHAPTER 2

LITERATURE REVIEW

This study explores the geometrical concepts involved in the traditional circular buildings and their relationship to classroom learning. In the first part of the literature review, I address the question of how to teach mathematics in the context of the new South African curriculum. In the second part of the literature review, I examine the theme of ethno-mathematics followed by the theme: geometry and culture. I conclude the chapter by drawing together the arguments to guide my thinking and analysis for the rest of the dissertation.

2.1. How to teach mathematics in the context of the new South African curriculum?

The South African education system has embarked on a new curriculum initially referred to as Curriculum 2005. It is currently known as the National Curriculum Statements (NCS). The design of this new national curriculum has been influenced by the philosophy of progressive learner-centred education, outcomes-based education (OBE) and an integrated approach to what is to be learnt (Department of Education, 2001). It encourages that learner's critical thinking powers and problem-solving abilities be developed. Learners are to be assisted to construct their own meaning and understanding within created learning environments. Contextualization is advocated as an appropriate strategy in designing teaching and learning activities (Bishop, 1988; Shirley, 1995). Teachers are encouraged to teach content in context so that learners could see the perspective of learning mathematics in real-life. Taking cognizance of and recognizing learners' background experiences are considered crucial for meaningful learning to take place (Ernest, 1991; Bishop, 1988).

In the old curriculum for schools in South Africa (prior to 2001), there was a general understanding that mathematics can be taught effectively and meaningfully without relating it to culture and history. Mathematics teaching was mostly divorced from social and cultural influences. Learning largely took place through memorization without understanding. This has contributed significantly to the South African's poor performance in overall mathematics results. This has led to the former Minister of Education, Prof. Kader Asmal, declaring mathematics as the 'priority of priorities' (Brombacher, 2000).

This general understanding is contrary to the views of Fasheh who sees mathematics as a cultural product as all people of the world practice some form of mathematics. As Fasheh (1982) puts it:

> If culture determines the way we see a camel, and the number of colours that exist, and how accurate our perception of a certain concept is, may it not also determine the way we think, the way we prove things, the meaning of contradiction, and the logic we use?... Teaching math in a way detached from cultural aspects, and in a purely abstract, symbolic and meaningless way is not only useless, but also very harmful to the student, to society, to math itself and to future generations. (p.6)

Fasheh stressed that it should not be understood from the above that mathematics should or could be taught within one culture separate from other cultures. Advances in thought in one culture, he suggested, should be understood and welcomed by other cultures. But these advances should be "translated" to fit the "borrowing" culture (Fasheh, 1982:6). In other words, what Fasheh is emphasizing here is that it is acceptable to import ideas and that should be encouraged, but the meanings and implications of these should be "locally made". He also pointed out that "not only local and cultural meanings should be encouraged, but also personal feelings and interpretations" (Fasheh, 1982:6). What he seems to be emphasizing here is the role of context in mathematics teaching. Culture influences the way people see things and understand concepts (Fasher, 1982). Thus, it would seem, mathematics cannot be divorced from culture. In teaching mathematics more meaningfully and more relevantly, the teacher, the learner, their experiences, and their cultural backgrounds become extremely important factors to create conducive learning environments.

2.2. Ethno-mathematics

Culture and the various elements central in ethnomathematics

'Ethnomathematics, which may be defined as the cultural anthropology of mathematics and mathematics education, is a relatively new field of interest, one that lies at the confluence of mathematics and cultural anthropology' (Gerdes, 1996:909). As a new field of interest, Barton (1996:3) notes that the first use of the term 'ethnomathematics' was by D'Ambrosio at a lecture that he gave at the International Congress on Mathematical Education (ICME 5) in Adelaide, Australia in 1984. The use of the term as compared to other developments in mathematics is therefore relatively quite recent, it is less than 20 years old. Since the first use of the term in mathematics education, many people writing about mathematics and culture have also started to use the term. This has also led to a proliferation of definitions of ethnomathematics, different but largely identifying culture as a central tenet.

One of the earlier definitions of ethnomathematics by D'Ambrosio states:

> [Societies] have, as a result of the interaction of their individuals, developed practices, knowledge and in particular, jargons...and codes, which clearly encompass the way they mathematise, that is the way they count, measure, relate, and classify and the way they infer. This is different from the way all these things are done by other cultural groups...[We are] interested in the relationship... between ethno-mathematics and society, where 'ethnos' comes into the picture as the modern and very global concept of ethno both as race and/or culture, which implies language, codes, symbols, values, attitudes, and so on, and which naturally implies science and mathematics practices.
>
> (D'Ambrosio, 1984)

Here D'Ambrosio looks at the cultural elements such as language, codes, symbols, values, and attitudes which characterise a particular practice. D'Ambrosio (1985:3) defines ethno-mathematics as "the mathematics which is practiced among identifiable cultural groups such as national-tribal societies, labour groups, children of a certain age bracket, professional class and so on." Culture in this context is viewed beyond the traditional perspective of only confining it to ethnicity or geographical location. It includes builders, designers etc. These social groups develop their own jargon, code of behavior, symbols and expectations as well as their own way of doing mathematics.

Gerdes (1994) defines ethnomathematics as ‘the field of research that tries to study mathematics (or mathematical ideas) in its (their) relationship to the whole of cultural and social life’. I think the emphasis here, in the context of his work, is on the whole of cultural and social life. In this case the definition of ethnomathematics relates closely to that of D’Ambrosio.

Focus of ethnomathematical research

Gerdes (1996:915; 1997:343) goes on to indicate that as a research field, ethnomathematics may be defined as the ‘cultural anthropology of mathematics and mathematical education’. Although Gerdes provides this definition, he also stresses the importance of seeing ethnomathematics as a movement and he provides a framework for understanding this notion of an ethnomathematical movement and ethnomathematicians – researchers involved in the movement (Gerdes, 1996:917) as follows:

(i) Ethnomathematicians adopt a broad concept of mathematics, including, in particular, counting, locating, measuring, designing, playing, and explaining (Bishop, 1988);

(ii) Ethnomathematicians emphasize and analyse the influences of socio-cultural factors on the teaching, learning and development of mathematics;

(iii) Ethnomathematicians argue that the techniques and truths of mathematics are a cultural product, and stress that all people – every culture and every subculture – develop their own particular forms of mathematics;

(iv) Ethnomathematicians emphasise that the school mathematics of the transplanted, imported ‘curriculum’ is apparently alien to the cultural traditions of Africa, Asia and South America;

(v) Ethnomathematicians try to contribute to and affirm the knowledge of the mathematical realisation of the formerly colonised peoples. They look for cultural elements which have survived colonialism and which reveal mathematical and other scientific thinking;

(vi) Ethnomathematicians in 'Third World' countries look for mathematical traditions, which survived colonisation, especially for mathematical activities in people's daily lives. They try to develop ways of incorporating these traditions and activities into the curriculum;

(vii) Ethnomathematicians also look for other cultural elements and activities that may serve as a starting point for doing and elaborating mathematics in the classroom;

(viii) In the educational context, ethnomathematicians generally favour a socio-critical view and interpretation of mathematics education that enables students to reflect on the realities in which they live, and empowers them to develop and use mathematics in an emancipatory way.

Mathematics educators working in the area of ethnomathematics have either explored one specific aspect given above or a component thereof. For instance some research projects have investigated how indigenous games may be used in the mathematics classroom. Others projects have explored mathematical knowledge in traditional house building and similar structures.

Vithal and Skovsmose (1997) identified four research strands that have emerged in ethno-mathematical field of study. The first strand is that of the problematic traditional history of mathematics. This includes studies carried out in investigating the history of mathematics in Africa (Zaslavsky, 1973).

The second strand deals with mathematical connections in everyday settings. In this strand everyday practices show some strong connection between mathematics concepts and cultural practices. Mosimege (1999) in his study on string games found that as children play they were able to find mathematical connections in number patterns.

The third strand is that of seeking relationships between mathematics and ethno-mathematics such as found in Gerdes (1996), Vithal & Skovsmose (1997). Here mathematics educators want to formalize ethno-mathematics into main-stream mathematics curriculum. According to Vithal and Skovsmose (1997), this is however, a relatively under-researched strand.

The fourth strand is that which looks for mathematical connections in traditional cultures, which though colonized, continued with their indigenous practices (Vithal & Skovsmose, 1997). These include activities such as those found in weaving, buildings and beading artifacts. Several studies conducted show a link between mathematical concepts and the indigenous practices.

2.3. Geometry and culture

Geometry is a branch of mathematics that deals with the properties and relations of points, lines, surface, space and solids (Thompson, 1995). Human beings everywhere throughout time have used geometry in their every day life-world. Geometry can be observed in the following universal behaviours: locating, measuring, designing etc. These behaviours reflect the culture of people who demonstrate them and are inevitably influenced by that culture (Bishop, 1991). Traditional objects such as baskets, mats, pots and rondavels seem to possess the geometrical forms that clearly indicate that geometrical knowledge was used during their weaving or construction and decorations.

Many studies analyzing the geometry of the traditional cultures of indigenous people who may have been colonized but have continued with their original practices have taken place (Crowe, 1982; Millroy, 1992; Gerdes, 1999; Mosimege, 2000; Mogari, 2002). These studies explored the ethno-mathematics of the traditional culture of basket and mat weaving and plaiting; beadwork; house decorations and mural painting; geometrical knowledge of carpenters; indigenous games; wire artifacts; geometrical knowledge applied in the construction of traditional houses and granaries for maize and beans to name a few. The following geometric patterns and designs were explored around the entire African continent from various traditional buildings and objects:

Crowe (1982) analyzed the Bakuba clothes and woodcarving in Democratic Republic of Congo, and identified the geometrical patterns. Gerdes (1999) has conducted numerous studies in the Sub-Sahara region. These include mat weaving of the Chokwe people in Angola where magic squares and Pythagoras theorem were identified. He also noticed the symmetry patterns on the smoking pipes in the city Begho, southern Ghana and eastern Cote d'Ivoire. Square and rectangular shapes were identified on the clothes. In Republic of Mali, Gerdes (1999) identified horizontal and vertical threads cross each other one over, one under in their weaving. In Lesotho symmetry patterns in Sotho wall decorations (litema) were noticed. Properties of a circle were identified on the basket bowl in Mozambique. Centre of the circle, tangent, radius, diameter and circumference of a circle were noticed on the basket bowl. He further identified regular hexagonal patterns on the light transportation basket called "litenga" in Mozambique. He also discovered attractive geometry design with axial, two-fold or four-fold symmetries. The global form of the design is that of toothed square- a square with adjacent congruent teeth on its sides. The sides make angles of 45 with the sides of the rectangular mats. He further analyzed and noticed the diameter, radius, area and circumference on the circular mats in north of Mozambique.

2.4. Concluding thoughts

In our new South African national curriculum, there is an expectation that teaching should contribute towards the wider development of different cultures. The use of culture in teaching is thus included, for it influences the way people see things, perceive things and understand concepts. Mathematics, therefore, is to be associated with sets of social practices, each with its history, persons, institutions and social locations, symbolic forms, purposes and power relations (Ernest, 1996). Mathematics is thus cultural knowledge, like the rest of human knowledge (Ernest, 1999). Contextualization therefore appears to be the appropriate strategy in teaching and learning mathematics. Mathematics should not be taught as a pure isolated knowledge, which is superhuman, ahistorical, value-free, culture-free, abstract, remote and universal. It should not be seen as divorced from social and cultural influences.

CHAPTER 3

RESEARCH METHODOLOGY AND METHODS

This chapter gives an overview of how this study was conducted. It covers study design, data gathering techniques, data analysis, access, ethical considerations, and quality criteria. Under study design I describe the methodology, the participants and the setting.

3.1. Study design

3.1.1. Qualitative research

According to Leedy (1997), the nature of the data required and the questions asked determine the research methodology we use. The choice between quantitative and qualitative research is influenced by particular assumptions about the nature of reality (ontology) and the nature of knowledge (epistemology). Groenewald (1986) regards our choice of explanation as being one of the most crucial decisions we can make in research. He distinguishes between nomothetic strategy, which focuses on general trends or pattern, and an idiographic strategy, which focuses on unique characteristics. My choice of methods was mainly focused on general trends or pattern not on unique characteristics.

Qualitative research is naturalistic inquiry, the use of non-interfering data collected strategies to discover the natural flow of events and processes, and how participants interpret them (Schumacher & McMillan, 1993). Mouton and Marais (1989) define qualitative research as the approach in which the procedures are formulated and explicated in a not so strict manner, but in which the scope is less defined in nature and in which the researcher does his or her investigation in a more philosophical manner. The point of departure is to study the object, namely man within unique and meaningful human situations or interaction. In this approach it is often observation and interviews that generate the investigation. According to Borg and Gall (1989), man is the primary data-collecting instrument in this type of research.

Denzin and Lincoln (1994) define qualitative research as a multi-method in focus, involving an interpretive, naturalistic approach to its subject matter. This means that qualitative researchers study things in their natural settings attempting to make sense of or interpret phenomena in terms of the meanings people bring to them. According to Denzin and Lincoln (1994), qualitative researchers deploy a wide range of interconnected methods such as case study, personal experience, life story, interviews, observations and interactions that describe routine and problematic moments and meanings in individuals' lives.

Qualitative research is characterized by its flexibility. Therefore; it can be used in a wider range of situations for a wider range of purposes. According to Leedy (1993:148) qualitative approach has the following purposes:

- Reveals the nature of situations, settings, process, relationships, systems or people.
- Enables the researcher to gain insights about a particular phenomenon and develops a new concept about a phenomenon.

Qualitative research attempts to discover the depths and complexity of a phenomenon (Burns & Grove, 1987). In my research, data were collected through observations and interviews with the two builders of the traditional circular buildings from the Xitsonga and Sepedi cultures, and the grade 11 learners' interaction with their parents about the construction and decorations of the traditional circular houses.

3.1.2. Ethnographic research

Ethnographic research, which is an interactive research that requires relatively extensive time in a site to systematically observe, interview, and record processes as they occur at the selected location (Schumacher & McMillan, 1993) was engaged. Uys and Basson (1991) define ethnographic research as the systematic process of observing, describing, documenting and analyzing the lifestyles of cultures in their natural environment. Ethnography is a process, a way of studying human life as it relates to education (Schumacher & McMillan, 1993). The ethnographer systematically works at deriving meaning of events. He or she does not immediately decide the meaning of one student's hitting another.

An ethnographer seeks to understand people's construction, which is their thoughts and meanings, feelings, beliefs, and actions as they occur in their natural context. As an observer of the entire context, the researcher is in a unique position to understand the elements that influence behavior, to articulate them, and to interpret them to reconstruct multiple constructed realities (Schumacher & McMillan, 1993).

In this study both my grade 11 class and I observed the traditional circular buildings, interviewed the builders or people who know how to build these types of houses, and recorded all the information gathered through this process.

3.1.3. Action research

Corey (1953) defines action research as the process through which practitioners study their own practice to solve their personal problems. Teacher action research is concerned with the everyday practical problems experienced by the teachers, rather than the "theoretical problems" defined by pure researchers within a discipline of knowledge (Elliott, cited in Nixon, 1987). Research is designed, conducted, and implemented by the teachers themselves to improve teaching in their own classrooms, sometimes becoming a staff development project in which teachers establish expertise in curriculum development and reflective teaching. The prevailing focus of a teacher research is to expand the teacher's role and to inquire about teaching and learning through systematic classroom research (Copper, 1990).

3.1.4. Participants and settings

The study was conducted in Mopani district, Limpopo province. The Mopani district consists of two different cultural groups, namely Xitsonga and Sepedi speaking people. In my study the focus was on the traditional circular buildings from Xitsonga and Sepedi cultures to accommodate their cultural diversity. A sample of two traditional circular houses, one from each cultural group, was chosen for comparison purpose with respect to construction, decoration and mural painting.

Bessie Maake High School was chosen for the project because the school is situated in a remote place where there are plenty of traditional circular buildings. This would make it possible to undertake a study of traditional houses in a familiar setting. The Grade 11 class was selected due to the circle geometry section which is part of the Grade 11 curriculum. A total number of 25 learners participated in the study.

The other participants involved in the study are the builders of the houses who were interviewed about their knowledge of building traditional houses, and the parents of the learners who were indirectly involved through interacting with the learners on their knowledge about traditional houses.

3.2. Data gathering techniques

Data was generated through the learners' and my observation of the traditional circular houses and also through my interviews with the builders of the houses and through the learners' interaction with their parents about the construction and decoration of the houses.

3.2.1. Observations

Engelbrecht (1981) refers to observation as the research technique in which the researcher attempts to obtain information only by observing (looking, listening, touching, smelling and tasting), without communicating with the observed. Morris (1973) regards observation as the act of noting a phenomenon, often with instrument and recording it for scientific or other purpose. Schumacher and McMillan (1993), further define observation as a technique for gathering data which relies on a researcher's seeing and hearing things and recording these observations rather than relying on subjects' self report responses to questions or statements.

Gardner (in Adler & Adler, 1998:81) contends as follows: "I look for the "click" experience-something of a sudden, though minor, epiphany as to the emotional depth or importance of events or a phenomenon. Observation occurs in a natural context of occurrences, among actors who would naturally be participating in the interaction and follow the natural stream of everyday life. As such it enjoys an advantage of drawing an observer into a phenomenological complexity of the world where connections, correlation causes and effects can be witnessed as when and how they unfold".

In this study the participant observation technique was employed because ethnographic research is a specific type of participant-observation research in which the aim of the researcher is to describe a particular group's way of life, from the group's point of view in its own cultural settings (Wimmer & Dominick, 1994). When doing ethnographic research, the researcher is interested in the characteristic of a particular setting, and in how people create and share meaning (their custom, habits and behaviors).

The following were observed from the traditional circular houses with the aim of gathering essential information for the research problem:

- The outer shape of the foundation, wall and the roof.
- The inner shape of the foundation, wall and the roof.
- The mural decorations of the floor and the wall.
- The decorations of the roof, both inside and outside.

The grade 11 learners were given a project to observe the traditional circular buildings at home or around the village and thereafter answer the questions related to the building **(see Appendix A)**.

3.2.2. Interviews

The research interview has been defined as a two–person conversation initiated by the interviewer for the specific purpose of obtaining research – relevant information, and focused by him on content specified by research objectives of systematic description, prediction, or explanation (Cannel & Kahn, 1968). It is the technique that involves the gathering of data through direct verbal interaction between individuals. Fox (1976) further defines interview as a technique in which the researcher poses a series of questions for the respondents in a face-to-face situation. Cilliers (1973) defines interview as a personal conversation through which research information is obtained. The main purpose of the research interview is to obtain information about the human being, his opinions, attitudes, values and his perceptions towards his environment.

In this research two heads of families, who were also the builders of the traditional circular buildings, were chosen for interviews. These two men came from different cultural backgrounds and different villages which were far apart. Face–to–face interviews with them were conducted in order to get first hand information. In interviewing I started by spending about fifteen minutes with small talk in order to establish a proper relationship. Before asking specific questions I briefly explained the purpose of the interview and asked whether the respondent had any question or concerns. I used semi-structured and unstructured interviews with the aim of giving the participants greater flexibility and freedom to express themselves without restrictions. Semi-structured interviews allowed for individual response and unstructured interviews allowed me great latitude in asking broad questions in whatever order seemed appropriate. See **Appendix B** for the questions that guided the interview.

During the interview, as the participant responded to the question, I recorded the answers by taking abbreviated notes that could be expanded on after the interview was completed. After all questions have been answered, I thanked the respondent and allowed time to make comments or suggestions regarding the interview in general.

Learners, on the other hand, were given a project to interact with their parents or neighbours who knew how to build the traditional circular buildings, about the construction and decoration of these types of buildings. The main purpose was to expose the learners to the geometrical concepts in the traditional circular buildings and to find out how the traditional circular buildings could enhance the teaching and learning of circle geometry. See **Appendix C** for the questions I asked the learners.

After the learners completed the project, I interviewed them about their findings based on their observations and interactions with their parents. The main purpose was to find out if the learners would be able to relate what they observed with what they learned in the classroom situation. For a list of questions that guided the interview see **Appendix D.**

3.3. Data analysis

I used narrative configurations to analyse my data (Polkinghorne, 1995). Configuration refers to the arrangement of parts or elements in a particular form or figure while narrative refers to a type of discourse from which events and happenings are configured into a temporary unity by means of a plot. Narrative is a type of discourse composition that draws together diverse events, happenings, and actions of human lives into thematically unified goal-directed processes (Polkinghorne, 1995). It exhibits human activity as purposeful engagement in the world.

Configurative process employs a thematic thread to lay out happenings as parts of an unfolding movement that culminates in an outcome (Polkinghorne, 1995). This thematic thread is called a plot. Plot is a narrative structure through which people understand and describe the relationship among the events and choices of their lives. Its function is to compose or configure events into story.

Brunner (1985) makes a distinction between paradigmatic and narrative modes of thought in analyzing data. This distinction is used to identify two types of narrative inquiry, (a) analysis of narratives in which the researcher collect stories as data and analyse them to produce categories. (b) narrative analysis in which the researcher collects descriptions of events and happenings and synthesizes or configures them by means of a plot into a story or stories.

I have placed my particular emphasis on the narrative analysis, studies whose data consists of actions, events and happenings because in my research emerging themes and concepts are inductively derived from the data, not from the previous theory. This is the inductive analysis which is more closely identified with qualitative research (Hammersley, 1992).

In this research, concepts are developed from the data rather than imposing previous theoretically derived concepts. I organized my data elements into coherent developmental account. Narrative analysis relates events and actions to one another by configuring them as contributors to the advancement of a plot (Polkinghorne, 1995). As the plot begins to take form, the events and happenings that are crucial to the story's denouncement become apparent. The emerging plot informs me about which items from the gathered data should be included in the final storied account.

This is more closely identified with qualitative research. In this case, inductive and discovery analysis were employed in analysing data. Data analysis is an ongoing cyclical process integrated into all phases of qualitative research (Schumacher & McMillan, 1993). Neuman (1997) cautions that the flexibility of qualitative research should not mislead us to believe that this type of research is an easy option. Although there are no uniformly fixed guidelines, qualitative research requires rigour and dedication.

Qualitative data analysis is primarily an inductive process of organising data into categories and identifying patterns or relationships among the categories (Schumacher & McMillan, 1993). Unlike quantitative procedures, most categories and patterns emerge from the data, rather than being imposed on the data prior to data collection. Schumacher and McMillan (1993), introduces qualitative analysis as a process of interim, discovery analysis, developing coding topics and categories that may initially come from data, pattern-seeking for plausible explanations. Results are presented as a narration of participants' stories or events, a topology, theme analysis, or grounded theory.

Organising and collecting data occurs concurrently and is cyclical. In fact, in qualitative research the distinction between these processes is artificial. The researcher interprets data the moment he or she starts organising it. Interpretation involves reflecting on the possible meaning of data, exploring particular themes and hunches, and ensuring that adequate data has been collected to support the researcher's interpretation (Collins et al., 2000). The researcher refines his or her interpretation each time he or she reworks the data.

Analysis and interpretations develop over time in an identifiable direction that is similar to an upwards spiral (Collins et al., 2000). This process is known as successive approximation. Although the process of interpreting begins during data collection, it intensifies once the researcher has collected his or her data. In a sense there always remains some work, such as drawing strands of thoughts together after all the data have been collected and organised (Davies, 1999; Fielding in Gilbert, 1993).

I am aware that data reflection and data gathering are interwoven. They cannot be divorced from each other. Data gathering is the collection of information and data reflection is the analysis of the information and recording the findings. As soon as the researcher begins to gather data, he also begins the process of sifting the data in search of relevant information to the research itself. As I have already indicated above, I am going to use inductive analysis and discovery analysis to analyse my data.

3.3.1. Inductive analysis

Inductive analysis means that categories and patterns emerge from the data rather than being imposed on the data prior to data collection (Schumacher & McMillan, 1993). Inductive process generates a more abstract description synthesis of the data. Qualitative analysis is a systematic process of selecting categories, comparing, synthesizing and interpreting to provide explanations of the single phenomenon of interest.

Schumacher and McMillan (1993) categorized the process of inductive data analysis into the following phases:

- Continuous discovery, especially in the field but also throughout the entire study, so as to identify tentative patterns.
- Categorizing and ordering of data, typically after data collection.
- Qualitatively assessing the trustworthiness of the data, so as to refine one's understanding of patterns.
- Writing an abstract synthesis of themes and/or concepts.

In my study, inductive data analysis was used to analyse data collected through the researcher's and learners' observations of the foundations, the walls and the roofs of the traditional circular houses, the data collected through the researcher's interviews with the builders of the houses, and the data collected through the learners' interaction with their parents. All answers for the questions were firstly listed down. The whole list of answers was carefully read and the answers which I think belong together were grouped into one category.

3.3.2. Discovery and interim analysis

Discovery analysis and interim analysis occur during data collection. Identifying and synthesizing patterns in the data usually occur after leaving the field.

Discovery analysis strategies are used to develop tentative and preliminary ideas during data collection (Schumacher & McMillan, 1993). No ethnographer reports all the data, refinement of the study focus before, during, and after data collection is necessary (Schumacher & McMillan, 1993). Therefore choosing data collection strategies in the field and assessing the validity of the data as they are collected, aids in focusing the research. Researchers may find that initial theoretical frameworks are inadequate for illumination of the deeper meaning of people's social "reality" and may either narrow, broaden, or change the theoretical thrust during data collection and formal data analysis.

Schumacher and McMillan (1993) identified the following strategies that researchers can employ in discovery analysis:

- Write many "observer comments" in the field notes and interview transcripts to identify possible themes, interpretations, and questions.
- Write summaries of observations and of interviews to synthesize and focus the study.
- Play with ideas, an intuitive process, to develop initial topical categories of themes and concepts.
- Begin exploring the literature and write how it helps or contrasts with observations.
- Play with tentative metaphors and analogies, not to label, but to flush out ideas or capture the essence of what is observed and the dynamics of social situations.
- Try out emerging ideas and themes on the participants to clarify ideas.

Just like discovery analysis, interim analysis occurs during data collection, not after data collection. Interim analysis serves two purposes:

- To make decisions in data collection
- To identify emerging topics and recurring patterns

Researchers do interim analysis as an ongoing activity of data collection, often after each three to five visits, or interviews, using the collected data sets. Schumacher and McMillan (1993) identified the following three strategies ethnographers can employ during the interim analysis:

- Scanning all data collected at that point for possible topics the data contain.
- Looking for recurring meanings that may become major themes or patterns.
- Refocusing the enquiry for this particular data analysis and study

In my study, the discovery and interim analysis were used during the observations and interviewing period. Some of the discovery analysis strategies and interim analysis strategies were followed in analysing information collected through observation and interviews. For example, summaries of observations and of interviews were written down to synthesize and focus the study. All data collected at that point were scanned for possible topics the data contain. Recurring meanings that may become major themes or patterns were looked into. Many "observer comments" in the field notes and interview transcripts were written down to identify possible themes, interpretations, and questions. Emerging ideas and themes were tried out on the participants to clarify ideas. This activity served two purposes:

- To clarify meaning conveyed by participants.
- To refine understanding of these meanings.

The process of analysing data or emerging data started while I was busy collecting data during the observations and interviews stages. This process helped to address the questions that remained unanswered (or new questions which came up) before data collection was over. After the process of data collection was over, all answers for a particular question were listed down. The whole list of answers was carefully read through to establish the categories. All the answers that I thought belong together were grouped into one category. Eventually learners' responses were listed and placed into these three categories:

- Actual construction of the traditional circular houses
- Indigenous knowledge of geometry used by the parents in the construction and decorations of these houses.
- Relating what is observed to what is learned in the classroom situation.

3.4. Access

I never had a problem of accessing the school as well as the learners because I am working at that particular school. The research was conducted as part of my daily activities. Learners were given the project to interact with their parents about the construction of the traditional circular buildings. With the parents, I requested two families of different cultures with this type of houses for observation and interviews as they are plenty within the village.

3.5. Ethical considerations

The participants were informed of the nature of the study, the purpose and the activities to be carried out. Regarding the two families I interviewed, the fathers were contacted and informed about the nature, type of data to be collected, the means of collection and the uses to which data were intended. I made them aware that they had the right to withdraw from the study at their own discretion. I provided a guarantee of privacy and confidentiality to individual participants from whose house data were collected. Names of the participants were not revealed to other people. I cooperated with all the participants, learners and the members of the families involved.

3.6. Quality criteria

A common criticism directed at qualitative research is that it fails to adhere to canons of reliability and validity (LeCompte & Goetz, 1982). Bringing objectivity (reliability and validity) into qualitative research is hampered by things like values, positions, choices and power relations (Adler, 1996). Despite these difficulties, that are characteristic of qualitative research and ethnographic approaches, researchers need to find ways of striving for reliability and validity.

Reliability refers to the consistency of measurement, the extent to which the results are similar over different forms of the same instrument or occasions of data collecting (Schumacher & McMillan, 1993). Reliability involves the extent to which a study can be replicated.

In my study, the responses from the parents collected by both the learners and me yielded the same results. All the responses about the operational procedures and techniques of constructing the circular buildings were the same. As such they were grouped together into one category.

Validity is concerned with whether researchers actually observe or measure what they think they are observing or measuring (LeCompte & Goetz, 1982). It is the extent to which data and subsequent findings present accurate pictures of the events they claim to be describing (Silverman, 1993; Maxwell, 1992).

In my study, I spent enough time in the field observing and interviewing, with the purpose of collecting accurate information. The amount of time spent with the builders as well as the learners as a participant observer was intended to improve on validity.

Qualitative research also depends on two different kinds of validity, namely descriptive and interpretive validity (Adler, 1996). It is critical that there be a clear linkage between the two kinds as both involve accuracy. This may be achieved through careful transcriptions which results in recognisable categories which the other researchers may agree with when making their own analysis on the transcriptions.

In this study, transcriptions on the data had been done accurately. Data had been transcribed carefully and thoroughly, covering builders' responses, learners' responses and parents' responses.

CHAPTER 4

FINDINGS AND INTERPRETATIONS

This chapter is designed to capture my findings and interpretations based on the learners' responses, the parents' responses and the builders' responses. To organize my description of the findings I use the following three categories guided by my initial research questions:

- The actual construction of the traditional circular houses.
- Indigenous knowledge of geometry in the construction and decorations of the traditional circular houses.
- Relating what is observed from the traditional circular houses to what is learned in the classroom situation.

This is then followed by my understanding and interpretation of the responses of the interviewees in the study, and recommendations related to teaching and learning of ethnomathematical concepts and drawing on ethnomathematical concepts to influence the teaching and learning of school mathematics.

4.1. The actual construction of the traditional circular houses

From the responses I got from interviewing the builders and the responses obtained by the learners from interviewing the builders and people who knew how to construct these types of houses, I observed that the builders' operational procedures and techniques followed in the construction of traditional circular buildings were similar. They were similar in the sense that both the Tsongas and the Pedis followed the same operational procedures and techniques; they only differed in how they decorated the floor, wall and roof.

In this category, my findings and interpretations are based on the following:

- Construction of the foundation.

- Construction of the wall.
- Construction of the roof.
- Patterning through wall decorations.
- Patterning through roof decorations.

4.1.1. Operational procedures and techniques followed in the construction of the traditional circular buildings with special reference to the foundation, wall and roof

Construction of a foundation

Like any building, an indigenous circular house has a foundation. The type of material used in the construction of traditional circular house plays a significant role in determining the type of foundation and a wall. I learned about the following two ways of constructing a foundation:

- By using mud bricks.
- By using poles and stones.

Foundation for a wall made of mud bricks.

For this form of foundation the builder starts by leveling the surface where the intended house is going to be built. The size of the foundation is the one that determines the size of the house to be built. The builder starts by identifying the centre of the surface and nails down a small stick. Thereafter he tightens a string to the nailed stick at the centre to the second stick that he will use to make a circle. Then he pulls the string and moves around the centre stick making a circle on the ground with the second stick in his hand. That place where the centre stick is nailed down is then identified as the centre of the house. This is followed by digging a foundation around the circular lane where mud bricks are going to be used to build a wall. This method of laying down a foundation of a traditional house is the same regardless of the type of wall to be used in the construction of the house.

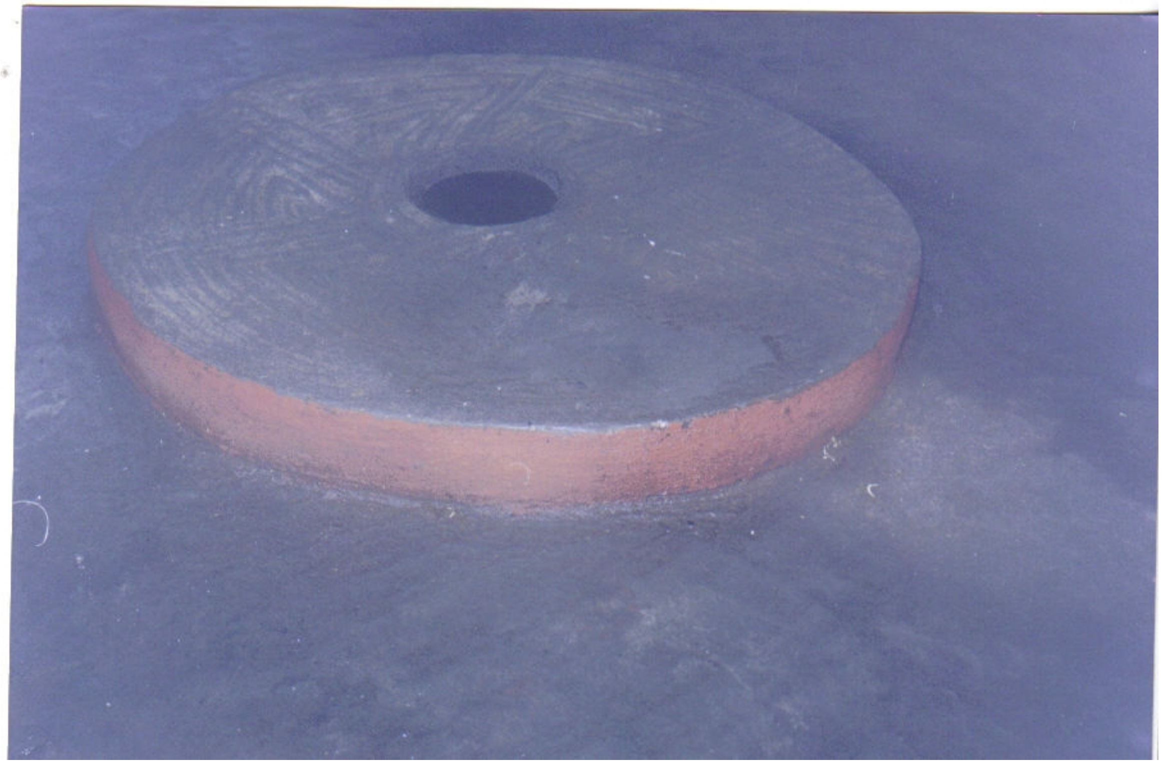


Figure 1: Foundation made up for a wall of mud bricks

Foundation for a wall made of poles and stones.

The procedure of leveling the surface where the house is going to be erected and the technique of drawing the foundation is the same as the foundation for a wall of bricks. However, in this instance, there is no need of digging a foundation round the circle made. Instead several holes following the circular lane are dug in a particular range or distance. Poles made of natural trees (mafate) are fitted into the holes. These poles are bound to each other by means of laths (dipalelo) that run horizontal to the poles with the same space between themselves. The space is filled by arranged stones and mud.

Figure 2: Poles fitted in holes to form a wall structure

After the two builders had explained to me how they constructed the circular foundation, I posed the following questions for clarification:

1. How do you identify the centre of the house?

Mr Malabela: The point where the nail or the stick that has been tightened to the string has been nailed down is identified as the centre of the house.

2. How do you make sure this is a perfect circular foundation?

Mr Malabela: I use the same string that was nailed to the centre through the stick (nail) to rotate around to draw a perfect circular foundation.

3. How do you determine the size of the house?

Mr Nkuna: The size of the house is determined by the length of the string. The longer the string, the bigger the size of the house and the shorter the string, the smaller the house.

4. How do you make sure that the foundation is constructed exactly where you have made your markings?

Mr. Nkuna: Two nails are used. The first nail is to keep in place the identified centre of the circle. The second stick or nail at the end of the string is used to mark the outer line of the foundation.

The following geometric concepts that are part of circle geometry were identified in the construction of the foundation:

- The centre of the circle
- The radius of the circle
- The circumference.

Construction of the wall

For the construction of the wall made of poles and stones, the poles are bound to each other by means of the laths (dipalelo) that are horizontal to the poles but parallel to each other. The laths are round the poles at a specific distance between them. The wall is then built using a combination of stones and mud between the poles.

Figure 3: Wall made up of poles

Construction of the roof

The roof of the house is made up of the following: timber (poles), laths and thatching grass. Just like the foundation, the builders identify the centre of the roof. They dig a hole at the centre of the house. In the hole a long pole is inserted and the pole is put in such a way that it goes straight up to the roof. On top of this pole, they put circular wooden block which has an edge that protrudes to the top of the roof.

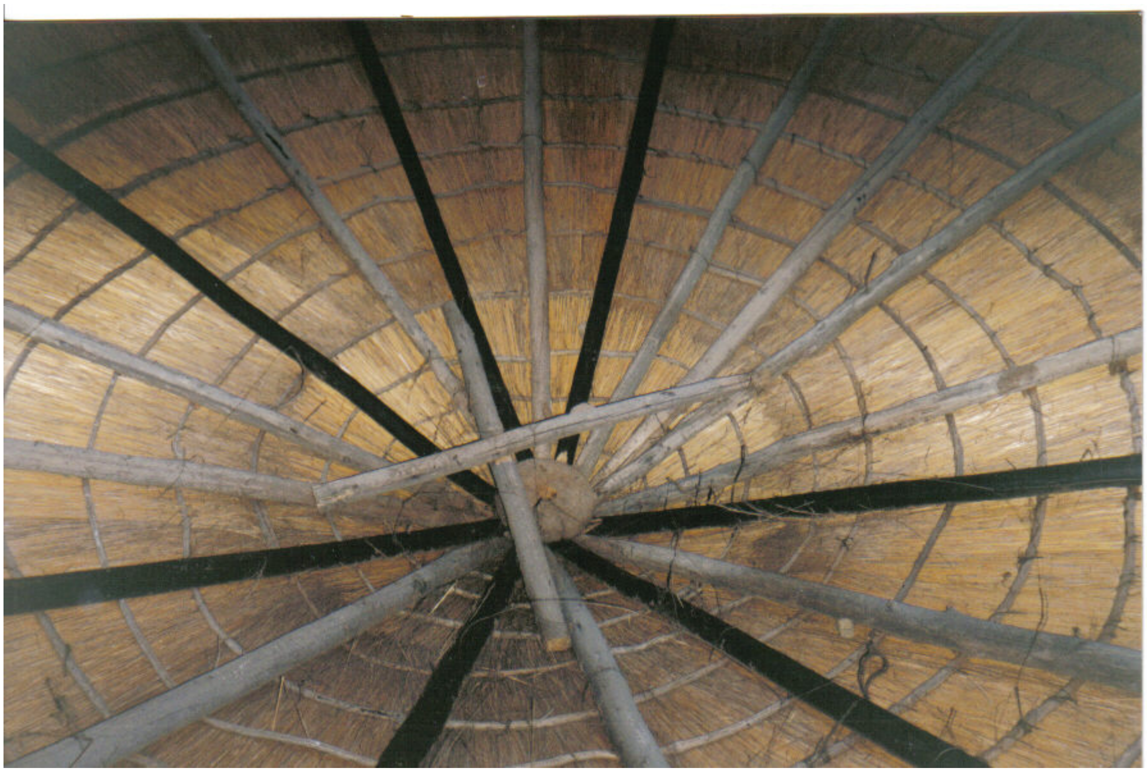


Figure 4: Roof structure

The poles are spread round the wall plates and nailed round the circular wooden block/apex (lenotlo) in an attempt to estimate equal spacing between the poles and the plates. This wooden block (apex) is essential as it holds the major timbers (poles) used to construct the roof. The laths are tightened round the poles to strengthen the roof as well as to lay a base where thatching grass is to be placed.

I asked the following questions to search for clarity:

1. How do you identify the centre of the roof?

Mr. Malabela: The pole that is inserted at the centre of the house is the one that determines the centre of the roof.

2. How do you estimate the space between the poles round the wall plates?

Mr. Nkuna: The spacing left when the poles are nailed round the wooden block is regarded as the right spacing of the poles round the wall plate.

From the interview with the builders, I realised that just like the foundation has the centre, the roof also has a centre. The poles that are nailed on the wooden block serve as radii because they are of equal length from the wall plate to the centre of the roof. On the wall plate the roof is circular shaped but it makes a funnel-shape towards the apex of the roof. The poles round the wall plate leave equal spacing.

4.1.2. Patterning through wall and floor decorations

Mural decoration is displayed on the walls and the floors of the houses. Most of the decorations display different geometrical shapes such as circles; squares, semi-circles, oval, kites, trapezium, rectangles, and combination of various shapes are drawn on the floors and walls.

Figure 5: Different decorations on the wall

Figure 6: More on decorations on the wall

Coloured soil is used to decorate the wall. The floor is decorated by a mixture of soil, water and cow dung.

4.1.3. Patterning through roof decorations

There is a great difference between Bapedi and Vatsonga with respect to the decoration of the roof. Vatsonga do not prefer to decorate their roofs. They make plain roofs without any decorations.

Figure 7: Vatsonga's roofing

Bapedi decorate their roofing by putting the thatch grass to look like ladder or steps around the roof. Bapedi further cover the apex of the roof (lenotlo) from outside by a thatching grass called "Sennasegole".

Figure 8: Bapedi's decorated roofing

4.2. Indigenous knowledge of geometry displayed on the traditional circular houses

4.2.1. The shape of the foundation, the wall and the roof

I realized through observation that the shapes of the foundation and the wall are similar. Both are circular or round in shape. The foundation has the centre and the circumference which is similar to the circle taught in the classroom situation. The distance from the centre of the foundation to its circumference is the same. These are the same as the radii of a circle. These circular shapes of the foundation and the wall have all the characteristics of a circle. The roof is cone – shaped. It has a circular plane base, tapering to the point called an apex. The inner side of the roof is funnel – shaped. It is like an ice–cream cornet. The shape of the roof appears to be symmetrical.

4.3. Relating what is observed to what is learned in the classroom situation

In this category, I analyzed the learners' responses on the geometrical concepts observed from the traditional circular buildings and how they related them to what they had learnt in the classroom situation. The learners were given a project to observe the following:

- Geometrical shapes found on the floor, wall and roof which are similar to the ones they have learnt in grade 11 classes.
- Geometrical shapes found on the floor, wall and roof decorations which are related to the ones they have learnt from grade 11 textbook.
- How they relate the identified geometrical shapes on the buildings to the classroom learning situation in grade 11 classes?

The first question on the project was aimed at highlighting the learners about the geometrical concepts learnt on circle geometry in grade 11 classes. From the learner's responses, I observed and identified that learners did not concentrate only on what they had learnt in circle geometry from grade 11 textbook as highlighted in question 1 of the project. They went beyond circle geometry and mentioned shapes which they had learnt either in grade 8, 9 or 10 such as trapezium, kite, pentagon, hexagon and rhombus.

The process of analyzing the emerging data went through with the aim of organizing data into coherent development account. I went through the learners' responses several times in an attempt to make sense and coded the responses according to which question the data responded to more adequately. I searched for the emerging themes and patterns within the learners' responses as an attempt to organize the data into a coherent developmental account.

During my analysis of the learners' responses, I realized that the learners approached the given questions in different ways. I went through the learners' responses again to try to search for the emerging themes and concepts. I listed down all the answers for a particular question. The whole list of answers was carefully read through to establish the emerging themes or concepts. All the answers that I thought belonged together were grouped into one category.

The project was given to the learners with the purpose of exposing them to the geometrical concepts in the traditional circular buildings and to find out whether these buildings can be used in the teaching and learning of circle geometry. I expected the learners to identify, to define and to describe the geometrical concepts, and thereafter to relate them to the classroom learning situation. To my surprise, some learners did not answer my questions according to my expectation.

It was at this stage that I realized that all the learners' responses appeared to fall into three main categories: learners who listed the identified geometrical concepts found on the traditional circular buildings without defining or describing and relating them to the classroom situation; learners who tried to show their knowledge and understanding of geometrical concepts in context, but did not define or describe the identified shapes exactly the way they are defined in the textbooks; and learners who tried to relate the identified shapes to the classroom situation. From these three categories I decided to organize my analysis using the following themes from the learners' responses.

- Identification or listing of geometrical concepts.
- Questioning as a problem.

- Knowledge and understanding of geometrical concepts in context. (contextualization)
- Relating what is observed to the classroom learning situation.

4.3.1. Identification or listing of geometrical concepts

For the learners to be able to learn and understand circle geometry in context, they should be able to identify geometrical shapes in the real life- world and relate them to the classroom situation. Twenty one out of twenty five learners simply listed different types of geometrical concepts without defining or describing them. They never tried to relate their identified concepts to the classroom learning situation even though they were asked to do that. It seemed they did not know how to relate and apply the knowledge they have learnt in context. The examples of the geometrical concepts identified by the learners were: circle, diameter, radius, rectangle, square, triangle, parallelogram, parallel lines, and centre of the circle.

Initially I thought the given activity was straight forward. I became stuck when I realized that learners did not answer the questions as expected. I realized that my questions were not well phrased. I did not ask the learners to define or to describe their identified geometrical concepts. If I managed to offer learners the opportunity to identify and to describe geometrical concepts such as the centre of the circle, radius, diameter, circumference, etc. from the traditional circular buildings and to relate them to the classroom learning, it would have been easier for them to learn circle geometry in context. They would have been able to calculate the radii of the whole house, the diameter, the distance between the two chords, the angle at the centre of the house and the angle subtended by the diameter.

4.3.2. Questioning as a problem

Questioning emerged as one of the issues that needed special attention. I realized that it was important to pose questions in a way that it will not be ambiguous to learners.

That implied I was supposed to have checked the questions before they were given to the learners to answer.

After I realized that my questions did not address the core concerns, I randomly selected five learners out of twenty five for an unstructured interview. I posed follow-up questions to seek clarity on aspects that were not clear and on those aspects that I thought were not properly answered.

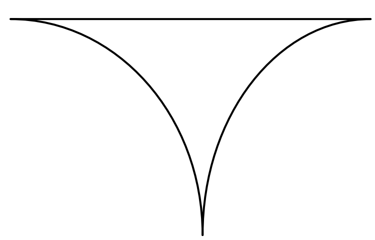
4.3.3. Knowledge and understanding of geometrical concepts in context (contextualisation)

In this particular grade 11 class I expected the learners to know how to define and describe the geometrical concepts they had learnt from grade 8. From my assessment, I realized that almost all the learners did not define and describe the identified concepts exactly as they were defined in the textbooks they referred into. Only one out of the twenty five learners attempted to give careful thought of definitions.

What follows captures the learners' attempts:

Triangle

Isaac defined triangle as a "figure with three sides and three angles". This definition accommodated a shape such as:



According to Isaac's definition, the above figure is a triangle because it has three sides and three angles, which is not true. A triangle could be defined as three non-circular points (that is points which do not lie on the same straight line) joined by three straight lines. A triangle will have vertices and the sides that are straight. The sum of the angles in a triangle should always be equal to 180 degrees.

Rectangle

Isaac identified a rectangle to have only one property: “two opposite sides are equal”. According to him as long as two opposite sides are equal, the geometrical shape is a rectangle, which is not necessarily true. I expected Isaac to include the following properties in his response:

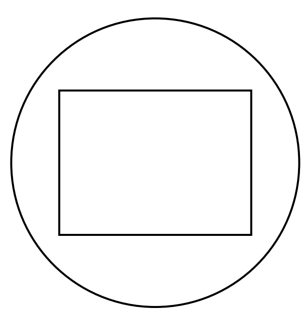
- The opposite sides of a rectangle are equal in length.
- All four angles are 90°.
- The diagonals are equal in length.
- The diagonals bisect each other.

Parallelogram

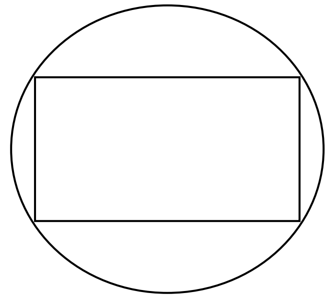
Isaac defined a parallelogram as a figure which has equal pair of opposite sides and opposite angles. Other properties of a parallelogram were not considered, for example, both pairs of opposite sides of a parallelogram are parallel and the diagonals bisect each other.

Cyclic quadrilateral

Learners also identified cyclic quadrilateral as one of the geometrical shapes they observed. For example, Maria and Isaac defined it as a circle which has four sided figure inside. They did not mention anything about the vertices. Thus, according to their description, the following figure explains a cyclic quadrilateral:



They appeared not to know that the vertices of a quadrilateral inside should lie on a circle as in the following:



The learners failed to argue out that if the vertices of a quadrilateral do not lie on a circle, then it is not a cyclic quadrilateral. I expected the learners at that stage, in a grade 11 class, to adequately define or describe concepts such as the radius, diameter, secant, tangent, mid-point and other geometrical concepts learned in grade 8. That knowledge would then assist me to expose my learners in solving real-life problems such as:

- Calculate the area of a circular house with the radius of 7 metres?
- Find the circumference of a bicycle wheel with the diameter of 14 metres?
- A circular table with height 70 cm and diameter 50 cm needs a circular tablecloth that will drape to the floor. What is the diameter of the tablecloth?

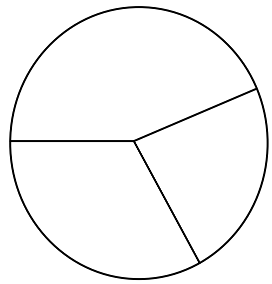
Challenging learners with the type of questions that relate to their real-life experiences appears promising to enhance the teaching and learning of circle geometry in this particular case.

4.3.4. Relating what is observed to the classroom learning situation

One of the questions I asked the learners was to relate the geometrical shapes they were able to identify from the traditional circular buildings to their classroom learning situation. That was my attempt to facilitate learning from a practical perspective, teaching circle geometry in context. Only four out of twenty five learners tried to relate what they had observed to the classroom learning situation. The geometrical concepts that were identified and related to the classroom learning situation were:

Circle

According to their understanding, all the points on the circle are the same distance away from the centre.

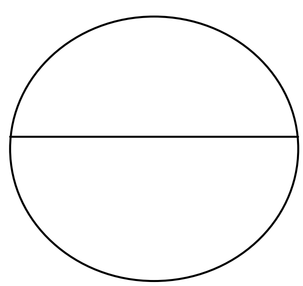


If O is the centre and A, B and C lie on the circumference of the circle then OA = OB = OC. The lines OA, OB and OC are called radii of the circle (singular radius).

Isaac identified circles which appeared on the roof of the circular buildings called “sebalelwana” in Sepedi. He concluded that they looked similar to the ones they learned about in grade 11 class.

Semi-circle

The learners identified what they thought represented a chord appearing on the roof (see figure 4), a pole that passes through the centre of the roof. They were able to refer to that as a diameter of a circle, a conquest chord of a circle.



They went further to explain that a diameter divides a circle into two equal halves called semi-circles. As put by Daphney (one of the learners) “a semi-circle is half of a circle figure divided by diameter”. She tried to relate half of a diameter that is a radius, with the string that was nailed at the centre of the house and used to draw the circular or round foundation.

Square

Square shapes were identified from the decorations on the wall and the floor of the house. Alfred defined a square as a figure which has four equal sides and four equal angles.

Parallel lines

Using their definition that parallel lines are lines that will never meet, learners identified parallel lines on the roof, what they referred to as “mabalelo”. Learners also identified parallel lines on the wall and on the floor appeared as decorations.

4.4. Conclusion

From my interpretations and findings, I realized that learners learn better when learning is approached from a practical experience. There are geometrical shapes on the traditional circular buildings which are similar to the ones taught in the classroom situation. Thus, to enhance the teaching and learning of circle geometry, we could expose the learners to activities designed in the context of their daily life experiences like on traditional circular buildings. For example, learners could be asked questions like the one below to provoke their thinking:

> Mogale would like to lay a foundation for a circular house. He wants to make a perfect circular foundation. As a builder he is used to using a set of instruments such as protractor, pair of divisors and meter-stick for that purpose. Unfortunately he does not have them. He only has a hammer, strings and nails.
>
> 1. Indicate what he should do with the instruments he has to make a perfect circular foundation?
> 2. Why do you think your plan will be a good plan? Substantiate.
> 3. Produce a good mathematical proof to show that your method is mathematically right.

I

CHAPTER 5

SUMMARY, IMPLICATIONS AND RECOMMENDATIONS

In this section I present a summary of the main findings, the implications of the study and the recommendations. I also reflect on my personal experience gained from undertaking such an investigation.

5.1. Summary

The study addressed two main questions: What geometrical concepts are involved in the design of the traditional circular buildings and mural decorations? And how do the traditional circular buildings relate to the learning of geometrical concepts in grade 11 class?

In pursuing my research questions, it emerged from the data that mathematics can be taught effectively and meaningfully by relating it to daily life experiences of the learners. For example, in the construction of the foundation, the geometric concepts identified were: the centre of the circle, the radius of the circle, the diameter, the circumference and the semi-circle. It was realized that just like the foundation had the centre, the roof also had a centre. The poles that were nailed on the wooden block at the centre of the roof serve as radii because they looked to be of equal length from the wall plate to the centre of the roof. On the wall plate the roof was circular shaped but it made a funnel-shape towards the apex of the roof. From the mural decorations displayed on the walls and the floors of the houses, the geometrical shapes such as circles; squares, semi-circles, oval, kites, trapezium, rectangles, and combination of various shapes were also observed.

The circular shapes of the foundation and the wall revealed all the characteristics of a circle. Learners learned that the roof appeared to be cone in shape, tapering to the point called an apex. The inner side of the roof looked funnel shaped. The shape of the roof appeared to be symmetrical.

Traditionally, classroom mathematics has been presented as absolute, abstract, pure and universally the same. The teaching of mathematics was devoid of social, cultural, and political connotations. The rise of the new perspectives has led to the perception that mathematics is a human endeavor, and therefore it is fallible and context-bound. In this study, it appeared that in order to make mathematics more relevant and more useful the abstract world should be related to the real world. When mathematics is taught in a way detached from cultural aspects, and in a purely abstract, symbolic and meaningless way, it is not only useless, but also very harmful to the learners, to society, to mathematics itself and to future generation (Fasheh, 1982). Although most of the learners during this study did not respond in writing how they related what they observed with what they read from their textbooks regarding circle geometry concepts, meaningful learning appeared to be emerging.

It was evident that the builders of the traditional circular houses used geometry in their construction. Although the builders who participated in this study could not explain using the mathematics language how they constructed, learners were able to learn from their explanations. The geometrical knowledge was observed intertwined with art and craft embedded in the traditional buildings (rondavels).

5.2. Implications

Many teachers had a general understanding that mathematics can be taught effectively and meaningfully without relating it to culture and history. Mathematics was perceived as a pure isolated knowledge, which is superhuman, ahistorical, value free, culture-free, abstract, remote and universal (Ernest, 1991; 1996; 1999). It became evident that mathematics is a cultural product as all people of the world practice some form of mathematics, as it was a case with the builders. The builders of the traditional circular houses used geometry in their construction. Although the builders who participated in this study could not explain using the mathematical language how they constructed, learners were able to learn from their explanations. The geometry knowledge was observed intertwined with art and craft embedded in the traditional circular buildings. Everywhere and throughout time, human beings use geometry in their everyday life. The frozen geometry of circular buildings could be used to enhance the teaching and learning of circle geometry.

The new South African curriculum, for example, encourages that learner's critical thinking powers and problem-solving abilities be developed. To achieve these sorts of skills, contextualization appears to be the appropriate strategy in the teaching and learning of mathematics. There is also an expectation that teaching should contribute towards the wider development of different cultures. The use of culture in teaching is thus included, for it influences the way people see things, perceive things and understand concepts as observed by Fasheh (1982). It became evident from this study that learners become more interested and learn better when learning is approached from a practical experience. Thus, to enhance the teaching and learning of circle geometry, teachers should expose learners to the activities designed in the context of their daily life experiences. Traditional circular buildings promise to be one of the resources that could be used in the teaching and learning of circle geometry.

In our mathematics teaching, we should assist learners to access mathematical knowledge through the use of the social and cultural contexts and those contexts should be maximally exploited to the benefit of the learners. Although most of the learners during this study did not respond in writing how they related what they observed with what they read from their textbooks regarding circle geometry concepts, meaningful learning appeared to have emerged.

It appeared that to teach mathematics more meaningfully and more relevantly, learners, teachers, their experiences, and their cultural backgrounds should be seen as extremely important factors to contribute towards creating conducive learning environments. Learners should be assisted to construct their own meaning and understanding within created learning environments. Thus, mathematics cannot be taught effectively and meaningfully without relating it to daily life experiences of the learners. Mathematics cannot be divorced from social and cultural influences.

5.3. Recommendations

I recommend that:

- Mathematics educators should be sensitive enough and acknowledge learners' cultural diversity in their classrooms.
- Contextualized learning activities should be designed to encourage learning mathematics concepts for understanding.
- In our mathematics teaching we should assist learners to access mathematical knowledge through the use of their social and cultural contexts and those contexts should be maximally exploited to the benefit of the learners.

5.4. Reflections

In this study, I explored the ethno-mathematics embedded in traditional circular buildings. I identified various geometrical concepts and exposed the learners to the geometrical concepts which are similar to the ones taught in the classroom learning. All the properties of a circle were identified on the traditional circular buildings. The circular shape of the foundation and the wall revealed all the characteristics of a circle such as: the centre of the circle, the radius of the circle, the diameter, the circumference and the semi-circle. It was also realized that just like the foundation has the centre, the roof also has a centre. The poles that were nailed on the wooden block at the centre of the roof serve as radii because they looked to be of equal length from the wall plate to the centre of the roof. The inner side of the roof appeared to be symmetrical. From the mural decorations displayed on the walls and the floors of the houses, the geometrical shapes such as circles, squares, rectangles, oval, and combination of various shapes were also observed. I further discovered that these traditional circular buildings can be used by both educators and learners to enhance the teaching and learning of circle geometry.

Being a novice researcher I found the whole exercise demanding, challenging and the toughest in my learning. I struggled with finding literature that focuses on research on ethno-mathematics. I had to travel more than 150 km to access the library. It was really frustrating. I never thought that I would be able to complete the dissertation. At one stage I thought of jumping out of the boat, but through the assistance, inputs, and encouragements from my supervisors, I managed to arrive where I am today.

When collecting data, I encountered some problems with the heads of the families I intended to involve. They wanted detailed explanation of the nature and the type of the data to be collected, the means of data collection, and the intended uses of the study before they could allow me in their homes. From this I learned that ethical considerations are important in the research process. The rights of information, permission, privacy, and confidentiality should be considered.

During the analysis of data, questioning emerged as one of the issues that needed special attention. It appeared learners did not interpret the questions as I expected. I learned that the questions were not well structured and not straightforward to assist me in digging deeper into core circle geometry concepts. That resulted in learners not giving detailed and rich responses.

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APPENDIX A

LEARNERS' QUESTIONS AFTER OBSERVING HOUSES

1. Draw a circle and indicate the following terms:

Centre of the circle, Diameter, Radius, Secant, Chord, Semi-circle and Tangent.

2. Which geometrical shapes found on the foundation, wall and roof are similar to the ones you have learned in the classroom situation?

3. Which geometrical shapes found on the floor, wall and roof decorations are similar to the ones you have learned in the classroom?

4. How do you relate the identified geometry concepts found on the traditional circular buildings to classroom learning in grade 11 classes?

The first question was aimed at reminding learners the concepts in dealing with circle geometry.

APPENDIX B
BUILDERS' INTERVIEW QUESTIONS

- How do you construct a foundation for a wall made of mud-bricks?
- How do you construct a foundation for a wall made of poles, stones and mud?
- What do you use to level the floor?
- What do you use to decorate the floor?
- How do you decorate the floor?
- How do you make a wall made of mud bricks?
- How do you make a wall made of poles, stones and mud?
- What do you use to decorate the wall?
- How do you decorate the wall?
- How do you make the roof?
- How do you decorate the roof?
- What do you use to decorate the roof?

APPENDIX C

LEARNERS' QUESTIONS TO INTERACT WITH PARENTS

- Ask your parents or the builders or the people who know how to build a traditional circular building how is it constructed from the foundation up to the roof?
- How do they make different types of geometrical shapes on the: Foundation, Floor and Roof?
- What do they use to make various geometrical shapes on the: Foundation, Wall and Roof?
- Ask your parents or the builders of these traditional circular buildings if they were aware that they were making geometrical shapes or not?

APPENDIX D

LEARNERS' INTERVIEW QUESTIONS AFTER INTERACTING WITH PARENTS

- According to your observations and analysis, is the house truly or really circular in shape?
- Does it has a centre, where you can say this is the centre of the circle?
- How is the distance from the centre of the house to the circumference around the house?
- Can you really say these are similar to the radii of a circle?
- Have you identified the diameter of the house?
- Is the length of the diameter of the house twice the length of its radius?
- Can you easily identify the semi-circle of the house using a diameter of the house?
- Does the house has all the characteristics of a circle as you have learned them in a classroom situation?