Mathematical Concepts of the Traditional Buildings of the Limpopo Province that Can be Used to Teach High School Mathematics

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Thesis submitted for the degree

of

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at the

Mafikeng Campus of the North- West University

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DECLARATION

I declare that ***Mathematical Concepts of the Traditional Buildings of the Limpopo Province that Can be Used to Teach High School Mathematics*** is my own work and that all the sources that I have used or quoted have been indicated and acknowledged by means of complete references.

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N.M. SEROTO DATE

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DEDICATION

This study is dedicated to my late grandmothers, Mabu "MaaNkhelemane", Seroto, for enlightening and instilling enquiring mind of cultural life, and Mmakgobane "Maanapsadi", Masila for instilling in me values that continued to shape my life: seriousness, hard work, respect and self discipline.

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ABSTRACT

There are several factors in our environment such as cultural artefacts, murals, our tradition, buildings and language that can be used to teach mathematics in context or used as examples to the learners but which we are unaware of or which we do not consider as appropriate. People interact with the world and attempt to comprehend, interpret, and explain it using numbers, logic and spatial configuration which are culturally shaped. These are the ways in which we produce mathematical knowledge. This has helped to stimulate other mathematicians on the African continent to Africanise mathematics teaching. Mathematics is viewed as a human activity as all people of the world practice some form of mathematics. In teaching mathematics meaningfully and relevantly, the teacher, the learner, their experiences, and their cultural backgrounds become extremely important factors to create conducive learning environments.

This study was set out to explore the mathematical concepts of the traditional buildings of the Limpopo Province, South Africa and the teaching of high school mathematics. The rationale for the study was to explore the extent to which mathematical shapes or concepts of the traditional buildings of the Limpopo Province could be used to enhance the teaching and learning of mathematics in context. The research questions that guided the exploration were:

1. Which mathematical concepts embedded in the traditional buildings of the Limpopo Province can be used to teach high school mathematics?
2. What challenges do high school mathematics educators face in contextualising their teaching?
3. Which suggestions can be made to assist mathematics educators to contextualise their teaching?

The population for the study was made up of the builders of the circular houses from the Vhembe (Tshivenda), Mopani (Xitsonga) and Sekhukhune (Sepedi) people of the Limpopo Province and Grade 12 mathematics teachers of the

Limpopo Province. The total population was 255, (68 circular houses builders and 187 Grade 12 mathematics teachers.) The three districts were chosen because they are classified as largely rural as compared to other districts in the Limpopo Province. They also have many indigenous buildings which were used to collect data for this study.

The data were gathered through observations, interviews with the builders and questionnaire for the educators. For analysis, descriptive statistical analysis, narrative, and inductive analysis were used to analyse the data.

Although the builders who participated in this study could not explain using the mathematical language how they constructed the buildings, various mathematical concepts and symbols such as triangles, squares, parallelograms, kites, circles, rhombi, rectangles, trapeziums, translations, reflections, rotations, similarities, congruency, tessellations were discovered. These mathematical concepts can be used by both educators and learners to enhance the teaching and learning of mathematics.

Further evidence emerged that teaching mathematics with meaning and relating it to the real world makes mathematics more relevant and meaningful. It was suggested that teacher training courses and programmes should include also courses on culture, society, the relationship between mathematics and culture, and the history of evolution of mathematical concepts. Contextualised learning activities should be designed to encourage learning mathematics concepts for understanding.

In-service courses at Colleges of Education and Universities should include the application of ethnomathematics and indigenous knowledge systems in their teacher training programmes.

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LIST OF ACRONYMS AND ABBREVIATIONS

AAMT	Australian Association of Mathematics Teachers
AMESA	Association for Mathematics Educators of South Africa
ANC	African National Congress
ANCNCC	African National Congress National Coordinating Committee
AS	Assessment Standard
C2005	Curriculum 2005
CAPS	Curriculum and Assessment Policy Statement
CHAT	Cultural Historical Activity Theory
D o E	Department of Education
ICME	International Congress on Mathematical Education
ICTF	Inter-Commission Task Force
IKS	Indigenous Knowledge System
IVCN	International Voice Communication Network
LCHC	Laboratory of Comparative Human Cognition
LEPEIST	Learner Performance Improvement Strategy
LO	Learning Outcome
LPG	Learning Programme Guidelines
MKO	More Knowledgeable Other
NCS	National Curriculum Statement
NCTM	National Council of Teachers of Mathematics
OBE	Outcomes-Based Education
PDME	Political Dimensions of Mathematics Education
RNCS	Revised National Curriculum Statement
SAG	Subject Assessment Guidelines

SARDC	South African Research and Documentation Centre
SCT	Socio-Cultural Theory
SCP	Socio-Cultural Perspective
SDT	Social Development Theory
STS	Science, Technology and Society
LTSM	Learning and Teaching Support Materials
TIMSS	Third International Mathematics and Science Study
ZPD	Zone of Proximal Development

LIST OF MATHEMATICAL SYMBOLS AND FORMULAE THAT APPEAR IN THE RESEARCH

A	Area
Area of Circle	$A = \pi r^2$
C	Circumference
Circumference of Circle	$C = 2\pi r$ or πd
d	Diameter
h	Height
r	radius
SA	Surface Area
Surface area of Cone	$A = \pi r^2 + \pi rs$ where s is the slant height of the cone and $s = \sqrt{r^2 + h^2}$
V	Volume
Volume of Cone	$V = \frac{1}{3}Ah$ or $V = \frac{1}{3}\pi r^2 h$
Volume of Cylinder	$V = \pi r^2 h$ or Ah
Π	Pie

CHAPTER ONE

RESEARCH ORIENTATION

1.1 Introduction

This chapter provides a general overview of the study. It starts by providing a view of mathematics and culture. This is followed by a brief explanation about what prompted the researcher to undertake this study. The chapter also contains the background to the problem and the research questions. It continues to indicate the purpose and the significance of this study. It also includes the limitations and delimitations of the study. The discussion in the chapter then continues to clarify the concepts or the key words in the research study. The chapter concludes by outlining the chapter division of the whole research.

1.2. Mathematics and Culture

There are several factors in our environment such as cultural artefacts, murals, our tradition, buildings and language, that can be used to teach mathematics in context or used as examples to the learners but which we are unaware of or which we do not consider as appropriate. People interact with the world and attempt to comprehend, interpret and explain it using numbers, logic and spatial configuration which are culturally shaped (Powel, 2002). These are the ways in which we produce mathematical knowledge.

Gerdes (1997), Cherinda (2002), Mosimege (2000), Mogari (2001) and other mathematicians examined culturally shaped products of mathematical knowledge expressed in African material culture and discovered various mathematical concepts and structures such as square, rectangle, symmetry and Pythagoras theorem. This has helped to stimulate some mathematicians on the African continent to Africanise mathematics teaching.

Human beings everywhere and throughout time have used mathematics in their everyday life activities (Bishop et al., 2003). The school curriculum should accommodate mathematical knowledge practised by diverse cultures, not only from one community (Barwell, 2004). In some African countries, such as South Africa, the old curriculum did not accommodate mathematical knowledge practised by the African community (Barwell, 2005a). Cultural diversity was not fully acknowledged (Barwell, 2005b). Ethno-mathematics was not fully integrated into mainstream classroom mathematics (Davison & Williams, 2001).

The relationship between mathematics and culture has been of concern to the researchers for the past few decades (Bishop, 1991). The importance of culture for mathematics education in general has been brought to our attention by ethno-mathematicians such as Bishop (1991) and D'Ambrosio (1999). According to Bishop (1991), in Britain for example, children from minority cultural groups experienced problems 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). Mathematics was taught without relating it to learners' background, culture and social experiences (Bishop, 1991).

Bishop (1998) contends that such children did not only have to be bilingual but bicultural as well, as they had to cope with both their home and school cultures. Bishop et al. (2003) further appealed to mathematics teachers to be sensitive to this by acknowledging such diversity in their classrooms.

This conflict is also present in South Africa with 11 official languages where mathematics has to be learned through the medium of English (Setati, 2005). Learners of English as an additional language develop a different understanding of particular concepts as compared with monolingual students (Adler, 2001; Gorgorio & Planas, 2001). The complexity of such multilingual issues is also an important aspect in many ethno-mathematical studies (Setati, Adler, Reed, & Bapoo, 2002). The use of cultural artefacts in the teaching of mathematics seems to be a challenge to most educators in Limpopo and also in other parts of South

Africa. The situation is made worse by the fact that mathematics educators lack the use of appropriate strategies for using cultural artefacts in the teaching of mathematics.

This scenario has significantly contributed to South Africa's poor performance in overall mathematics results (Brombacher, 2000). 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. This has led the former Minister of Education, Prof. Kader Asmal, to declare mathematics as the 'priority of priorities' (Brombacher, 2000).

This study focused on mathematical concepts of the traditional buildings of Limpopo Province and the teaching of high school mathematics. The topic is relevant to the teaching of mathematics and addresses Learning Outcomes (LO) 3 of the NCS: Space, Shape and Measurement. The learning outcomes come from the National Curriculum Statement which is underpinned by Outcomes-Based Education. The focus was to develop learners' understanding and appreciation of the pattern, precision, achievement and beauty in natural and cultural forms.

Assessment is the process of gathering evidence of a learner's progress towards achieving the stated outcomes on an ongoing basis. Assessment Standard 2 says learners should be able to interpret, understand, classify, appreciate and describe the world through 2D and 3D objects, their location, movement and relationship. The topic is also relevant to the assessment standard.

According to the Third International Mathematics and Science Study (TIMSS) Video Mathematics Research Group (2003) results, South African pupils performed poorly when compared to other participating countries. South Africa obtained an average score of 275 points out of 800 points which was well below the international average of 487 points (TIMSS Video Mathematics Research Group, 2003).

In the TIMMS study, 225 schools were randomly selected from all 9 provinces of the Republic of South Africa. Ultimately 194 schools and 8147 pupils were included in the data set for analysis. South African pupils' performance was relatively low in every mathematics topic (from 37% for Algebra to 45% for data representation, analysis and probability) (TIMSS Video Mathematics Research Group, 2003).

In Limpopo Province 1166 pupils entered and obtained a minimum score of 6.5, a maximum score of 485 and the mean scale score of 226 out of 800 which is relatively below the average score of 275 for South Africa (TIMMS Video Mathematics Research Group, 2003). The situation in Limpopo Province as compared to the rest of South Africa is disturbing and needs to be thoroughly addressed.

Although contextualisation is not the main contributory factor to low performance in mathematics, addressing it may be one of the most appropriate solutions to the problem. Amongst the various recommendations that have been suggested by researchers, contextualisation is advocated as one of the appropriate strategies in addressing the issue of alienation (Bishop et al., 2003). The argument raised is that mathematics is a cultural product as all people of the world practise some form of mathematics. In helping learners to access mathematical knowledge, their social and cultural context should be acknowledged and be maximally exploited to their benefit. In this study, the researcher aimed to explore mathematical concepts of the traditional buildings of the Limpopo Province and their integration into high school mathematics.

1.3. Background to the problem

Since South Africa became a democratic country in 1994, there have been some changes in the education system. The South African education system has changed from NATED 550 to using the National Curriculum Statement which is underpinned by Outcomes-Based Education and endorses the principle of the learner-centred approach (Department of Education, 2001). According to

Alexander (2005), education changes in South Africa were required to provide equity in terms of educational provisions and to develop learners' critical thinking powers and problem solving skills and abilities.

To improve implementation, the National Curriculum Statement was amended, with the amendments coming into effect in January 2012. A single comprehensive Curriculum and Assessment Policy document (CAPS) was developed for each subject to replace Subject Statements, Learning Programme Guidelines and Subject Assessment Guidelines in Grade R – 12 (Department of Basic Education, 2011).

The National Curriculum Statement Grade R – 12 (January, 2012) replaces the two current National Curriculum Statements, namely:

- Revised National Curriculum Statement Grade R – 9, Government Gazette N0 23406 of 31 May 2002, and
- National Curriculum Statement Grade 10 – 12 Government Gazette N0 25545 of 6 October 2003 and N0 27594 of 17 May 2005.

The curriculum aims to ensure that children acquire and apply knowledge and skills in ways that are meaningful to their own lives. In other words, the curriculum promotes knowledge in local contexts, while being sensitive to global imperatives (Department of Basic Education, 2011). The curriculum supports the Social Constructivism Theory which is based on authentic and real-world situations.

Presmeg (2007) argues that culture influences the way people see things and understand concepts. Thus, it seems that mathematics cannot be divorced from social and cultural influences. All people of the world practise some form of mathematics. Mogari (2001) contends that mathematical knowledge does not originate from only one community, to be imposed upon other communities. Instead, it is developed by all communities.

Fasheh (1997) further argues that 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.

Mathematics can be observed in the following universal behaviours: Locating, measuring, designing, etc. (Bishop et al., 2003). Bishop et al. (2003) further contend that human beings everywhere and throughout time have used mathematics in their everyday lives. This mathematical knowledge is intertwined with art, craft, weaving, beadwork and traditional buildings, such as granaries, for maize storage. Learners are expected to learn all sections of mathematics in context because it is considered useful in their everyday lives. They have to learn, for example, the properties of space in context so that they can make better connections between in-and-out of school with regard to mathematics concepts.

During the old Bantu Education System (before 1994), mathematics teaching was mostly divorced from social and cultural influences (Bantu Education Act, 1953). Learning largely took place through memorisation without understanding. Learners' critical thinking powers and problem solving abilities were not developed. Teaching of mathematics in context was not emphasised and seldom used. Contextualisation was seen as time-consuming and prevented teachers from completing the syllabus.

In contrast, the design of the National Curriculum Statement Grade R – 12 (January, 2012) is influenced by the philosophy of progressive learner-centred education, outcomes-based education (Outcomes Based Education) and an integrated approach of what is to be learned (Department of Basic Education, 2011). It encourages the development of learners' critical thinking and problem-solving abilities. Learners should be assisted to construct their own meaning and understanding within created learning environments. Contextualisation is advocated as an appropriate strategy in designing teaching and learning activities (Bishop et al., 2003). The National Curriculum Statement encourages

teachers to teach content in context so that learners can see the usefulness of mathematics in real-life situations. Mathematics is therefore relevant to living and must be learned by all of us. This is because cognisance of learners' background experiences is considered crucial for meaningful learning to take place (Bishop et al., 2003).

The use of cultural artefacts in the teaching and learning of mathematics is supported by the views of Mogari (2001) who sees mathematics as a cultural product, as all people of the world practise some form of mathematics. Mogari (2001) further stresses that mathematics should not be taught within one culture separated from other cultures. Presmeg (2007) and Fasheh (1997) emphasise that it is acceptable to import ideas and this should be encouraged, but the meaning and the implications of these should be "locally made". Culture influences the way people see things and understand context in mathematics teaching. The role of the teacher in the curriculum is to facilitate the learning process and to assist the learners to construct their own meaning and understanding within "locally" created learning environments.

For example, there are many traditional buildings in the Limpopo Province of South Africa. Most mathematics teachers and learners are exposed to them, they see these traditional buildings on a daily basis and some sleep inside these types of houses. There are many mathematical concepts or shapes on the traditional buildings that seem to be similar to the ones taught in high school mathematics curriculum. It seems these mathematical concepts or shapes can be used by both educators and learners to enhance the teaching and learning of high school mathematics in context.

It is of concern to the researcher that most mathematics educators lack the use of appropriate strategies for using cultural artefacts in the teaching of mathematics in Limpopo Province of South Africa. Contextualisation is seldom used in teaching. According to Rakgokong (1993), lack of confidence, due to limited mathematical knowledge or to appalling conditions in the classroom (e.g. lack of proper resources and overcrowding), is one of the reasons.

Rakgokong (1993) further argues that most teachers are conditioned by the way they have been "trained" during their training as teachers which they then translate into an authoritarian teaching style in the classroom. They view activity-based teaching as time-consuming which prevents them from "covering the prescribed syllabus".

By changing the system, the Department of Education hoped that there would be some improvement in the learners' performance (DoE, 2001). However, the performance of learners in mathematics at high schools was not improving as expected. Naledi Pandor, the former Minister of Education in South Africa, acknowledged that the education system is underperforming and fails to support learners to acquire key skills for learning (DoE, 2007). The use of context is a problem for most mathematics educators in their teaching.

After realising that the performance of learners in mathematics and science was not improving, the National Ministry of Education introduced a project for mathematics and science called the Dinaledi schools (DoE, 2007). The project aimed at improving the performance of learners in mathematics and science. Some high schools were identified as Dinaledi schools throughout South Africa and in Limpopo Province, 51 high schools were identified as Dinaledi schools for the project. The feeder schools (primary schools) of Dinaledi schools were identified as Dinaletsana so that the performance of learners in mathematics and science could improve from the primary level.

Beside Dinaledi schools in Limpopo Province another project called LEPEIST (Learner Performance Improvement Strategy) was also introduced with the aim of improving the performance of learners in mathematics and science (DoE, 2003). Some high schools were identified throughout the province for Saturday lessons and only the best teachers were appointed to teach mathematics and science. Unfortunately, the project concentrates only on grade 12 mathematics and science learners.

Valuing indigenous knowledge is one of the principles of the National Curriculum Statement. The National Curriculum Statement has infused indigenous knowledge systems into the Subject Statements and it acknowledges the rich history and heritage of this country as being important contributors to nurturing the values contained in the Constitution (Department of Education, 2003). People recognise the wide diversity of knowledge through which people make sense of and attach meaning to the world in which they live.

Indigenous Knowledge Systems in the South African context refer to a body of knowledge embedded in African philosophical thinking and social practices that have evolved over thousands of years (Department of Education, 2003). The use of cultural artefacts in teaching mathematics is encouraged so that learners can learn mathematics in context.

Indigenous Knowledge has contributed significantly to mathematics education. Ethno-mathematics may be regarded as one component of indigenous knowledge, focusing on the mathematical aspects of those systems (that is, mathematics which is practised among identifiable cultural groups such as labour groups, children of certain age group and rural communities). Everyday mathematics (that arises out of the socio–cultural context of living) is integrated into academic or classroom mathematics. The National Curriculum Statement allows and encourages academic mathematics to accommodate the lived culture of the people (Department of Education, 2003).

This type of mathematics practised among identifiable cultural groups, such as tribal societies, is called ethno-mathematics. D'Ambrosio (2001) defines ethno-mathematics as mathematics practiced among identifiable cultural groups, such as tribal societies, labour groups and professional classes. His definition supports the views of Mogari (2001) that mathematics is commonly used in various communities. Teachers are encouraged to create learning activities within the learners' immediate environment and use it to teach mathematics in context.

There are many mathematical aspects that are embodied in socio-cultural activities or everyday practices. These mathematical concepts and shapes should be maximally exploited and used in the teaching of mathematics within the "locally" created learning environment. The following mathematicians examined culturally shaped products of mathematical knowledge expressed in African material culture and discovered various mathematical concepts and structures such as square, rectangle, symmetry and Pythagoras theorem.

Mogari (2001) explored the geometrical thinking embedded in the construction of a kite. Mosimege (2000) indicated that there are mathematical ideas and principles involved in *malepa* (string figure games). Cherinda (2002) identified the mathematical aspects embodied in the activity of weaving by basket makers in Mozambique. Santos and Matos (2002) investigated the mathematical practices of the young boys between ages 12 and 17 that sell newspapers in the street of Praia, the capital of the Republic of Cabo Verde. Duarte (2003) explored the mathematics used in the mixing of mortar (sand, cement, and water) and, depending on the particular use, some crushed stones. Giongo (2001) analysed the mathematical practices of shoemakers.

Evidently, the above studies conducted by various mathematicians throughout the African continent, show that indigenous people have used mathematical knowledge and ideas to carry out their activities accordingly without knowing that mathematics is involved. However, it would appear that not much has been done in terms of exposing the mathematical aspects that are embodied in the socio-cultural activities or every day practices of the people in and around the Limpopo Province. Mathematical concepts or shapes found in the African material cultures are similar to the ones taught in high school mathematics.

However, from the literature review conducted, it was noticed that the study of the mathematical concepts of the traditional buildings of the Limpopo Province, can be used to illustrate mathematical concepts and also used to explain mathematical problems.

It is for these reasons that the researcher was prompted to explore how the mathematical concepts of the traditional buildings of the Limpopo Province and decorations found on them could be integrated into high school mathematics curriculum. It seems there are many mathematical aspects, such as *circle, circumference*, *cone*, *radius, cylinder, symmetry, square and rectangle* which are embedded in the construction and decorations of these structures. All these mathematical concepts are part of the high school mathematics curriculum. In my opinion, it seems the mathematical concepts and shapes found on the traditional buildings can be used to contextualise the teaching and learning of mathematics.

The ultimate goal in this context is to use the learners' environment to enhance the teaching and learning of mathematics. This is supported by the National Curriculum Statement which emphasises the development of learners' critical thinking powers and problem solving skills. This is because it encourages educators to contextualise what they teach (Department of Education, 2001).

1.4. Statement of the problem

Rakgokong (1993) argues that most teachers are conditioned by the way they have been "trained" during their teacher education which they then translate into an authoritarian teaching style in the classroom. They view an activity-based teaching as time-consuming which prevents them from covering the prescribed syllabus. Contextualisation in the teaching of mathematics is seldom used.

This study explored the mathematical concepts of the traditional buildings of the Limpopo Province that could be used to enhance the teaching and learning of mathematics in context. Therefore, the problem researched was:

> *The extent to which mathematical shapes and concepts of the traditional buildings of the Limpopo Province could be used by the mathematics educators to contextualise the teaching and learning of mathematics.*

1.5. Research questions

Based on the problem established, the questions that guided the research study were:

- Which mathematical concepts embedded in the traditional buildings of the Limpopo Province can be used to teach high school mathematics?
- What challenges do high school mathematics educators face in contextualising their teaching?
- Which suggestions can be made to assist mathematics educators to contextualise their teaching?

1.6. Purpose of the study

The use of cultural artefacts could be one of the appropriate strategies that can be used to contextualise the teaching of mathematics. Teachers need to take into consideration the fact that learners learn better when teaching is approached from their familiar backgrounds and social experiences. Therefore, the purpose of the study was to investigate:

- Mathematical aspects or shapes of the traditional circular buildings of Limpopo Province that could be used in the teaching of mathematics.
- Challenges or problems that mathematics educators faced in contextualising their teaching.
- Suggestions that could be made to assist mathematics educators to make use of cultural artefacts to contextualise their teaching.

1.7. Significance of the study

The National Curriculum Statement acknowledges the body of knowledge embedded in African philosophical thinking and social practices that have evolved over thousands of years (DoE, 2003). It acknowledges the rich history

and heritage of this country as important contributors to nurturing the values contained in the Constitution.

Based on the above research questions, the research study is significant for the following reasons:

- The study indicates that to teach mathematics in context, the examples from learners' environment and socio-cultural shapes or structures in the artefacts such as beads, mats, kraal and traditional buildings should be used.
- The study provides suggestions that can assist mathematics educators to make use of cultural artefacts to contextualize their teaching.
- The study also indicates that mathematical knowledge does not originate from one community only, but it is developed by all communities so mathematical concepts of the traditional circular buildings of Limpopo Province should be explored.

1.8. Delimitation of the field of study

The Limpopo Province was formed by the three previous homelands and people were grouped together according to their culture and the language they speak. These were Lebowa (Sepedi), Gazankulu (Xitsonga) and Venda (Tshivenda).

The study was restricted to the Limpopo Province where traditional buildings and their builders are found. Therefore, the delimitation of the research was the Limpopo Province of South Africa. However, only the builders and the Grade 12 mathematics educators within the following districts or cultural groups, with their spoken languages given in brackets participated in the research: Vhembe (Tshivenda), Mopani (Xitsonga) and Sekhukhune (Sepedi). The three districts were chosen because they were classified as largely rural compared to other districts in the Limpopo Province (Refer to Figure 1). They also had many indigenous circular buildings that were the source of data for this study.

Figure 1 shows the map of the Limpopo Province, South Africa with the five districts demarcated while Table 1 indicates the municipalities chosen for the research within the three districts, that is, Mopani, Vhembe and Sekhukhune.

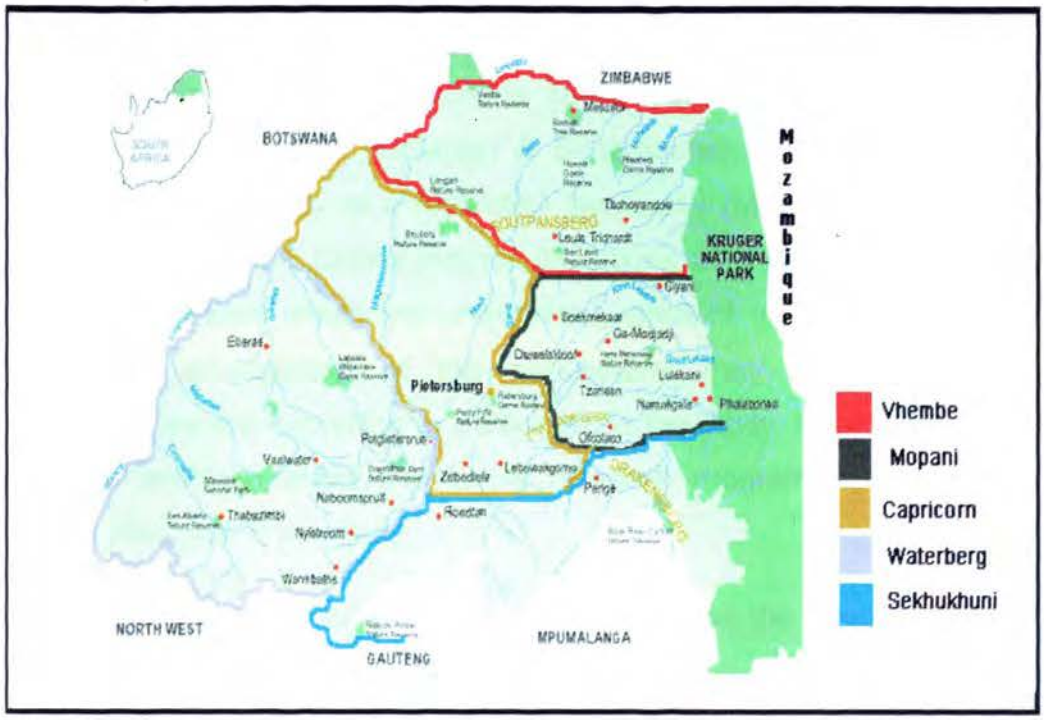

Figure 1: Map of Limpopo Province, South Africa. Source: Maps google.co.za

Table 1: Districts of Limpopo Province, South Africa.

Waterberg District	Capricorn District	Vhembe District	Mopani District	Sekhukhune District
Belabela	Polokwane	Makhado	Tzaneen	Tubatse
Lephalale	Lepelle-Nkumpi	Thulamela	Letaba	Fetakgomo
Modimolle	Aganang	Musina	Giyane	Groblesdaal
Mogalakwena	Blouberg	Mutale	Maruleng	Makhuduthamaga
Mookgopong	Molemole		Baphalaborwa	Marble Hall
Thabazimbi				

The following municipalities were chosen for the study, in Vhembe: Thulamela and Makhado, in Mopani: Tzaneen and Giyani and in Sekhukhune: Tubatse and Fetakgomo. Refer to Table 1.

1.9. Research Limitations

Research limitations refer to conditions outside the researcher's control that affect the collection of data (McMillan & Schumacher, 2006). It also refers to short-comings in the study or a restrictive weakness (McMillan & Schumacher, 2001). Punch (2006: 69) further defines limitations as the limiting conditions or restrictive weaknesses which are unavoidably present in the research. Mental discomfort or unhappiness of the participants may affect the research programme if they are not willing to participate in the study. If the participants are not properly informed about the whole research programme, they might be reluctant to take part in the study.

In this study, some of the educators did not answer all the questions or did not understand the questions or mathematical concepts. Some educators were reluctant to participate in the study and they left some of the questions blank on the questionnaires. Some of the builders were not willing to participate in this research. They refused to be interviewed due to privacy and confidentiality. They did not want to be exposed or to be known.

1.10. Definition of key words or concepts

In this study, the following concepts associated with the topic were defined to ensure that there was a common understanding of their use and application in the study:

- **African** refers to a person of African descent or related to Africa (Thompson, 1995). In this research, Africans are referred to Bapedi, Va-Tsonga and Vha-Venda because they are the native or inhabitants of Limpopo, South Africa. They are also referred to as Africans because they were born and bred in South Africa.

- **Cultural artefacts** refer to material objects made by various cultural groups for use when dealing with reality and challenges encountered in everyday life (Laridon, 2000). Mosimege (2000) further defines artefacts as a product of human art and workmanship.

  In this research, cultural artefacts were used to refer to material objects that are culturally conditioned such as beads, granaries for maize, pots and weaving made by Bapedi, Va-Tsonga and Vha-Venda and that emphasise the cultural identity of their cultural groups.

- **Culture** refers to the way 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). Mosimege (2001) also perceives culture as a set of shared experiences among a particular group of people. 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 a group's members both formally and informally (McConatha & Schnell, 1995). Bishop et al. (2003) further perceive culture as a set of beliefs and understanding, which serve as a basis for communication within a community of people. Mogari (2001) and Encyclopedia Americana (1992)

define culture as an organised set of beliefs and understanding that manifest itself in acts and artefacts.

Reuter in Ezewu (2005) gives a more comprehensive definition of culture as the sum total of human creation such as tools, weapons, shelter and other material goods, all that have emerged from the experience of groups of people throughout the ages to the present time including attitudes and beliefs, ideas and judgment, arts and Sciences as well as philosophy and social organisation. In this research, culture is used to refer to an organised set of beliefs and understandings that manifest themselves in acts and artefacts.

- **Cultural diversity** refers to the different traits of behaviour as aspects of broad cultural differences that distinguish societies from one another (Giddens, 2001). In this study, cultural diversity refers to Sepedi culture, Xi-Tsonga culture, Tshi- Venda culture and Ndebele culture within Limpopo Province. Multicultural means consisting of many cultures or more than one culture. In Limpopo Province, it refers to all the four cultures mentioned above.

- **Ethno-Mathematics** is defined as mathematics which is practised among identifiable cultural groups such as tribal societies (D'Ambrosio, 2001). Gerdes (1999) further defines ethno-mathematics as the cultural anthropology of mathematics and mathematics education. In this study, ethno-mathematics means a "field of research that tries to study mathematics (mathematical ideas) in its (their) relationship to the whole of cultural and societal life" in the Limpopo Province.

In this context, ethno-mathematics is used to refer to mathematics which is practiced among Bapedi, Ndebeles, Tsongas and Vendas, (that is, by the builders of the traditional circular houses).

- **Indigenous Knowledge Systems** refers to local or community based system of knowledge that is unique to every culture and society (Warren, 2005). Makgopa (2007) further defines indigenous knowledge systems as the local knowledge that is unique to every culture and society. In this study, indigenous knowledge systems are used to refer to a body of knowledge embedded in African philosophical thinking and social practices that have evolved over thousands of years.

  The traditional people of Limpopo Province, that is, Bapedi, Va-Tsonga, Vha-Venda and Ma-Ndebele, have their own specific Indigenous Knowledge Systems. They have their own specific system of knowledge that is unique to each cultural group.

- **Tradition** refers to custom, opinion or belief handed down to posterity especially orally or by practice (Free Online Dictionary, 2010). In this study, tradition means the passing down of elements of cultures from generation to generation, especially by oral communication.

  In this research, this term tradition is also used to refer to an inherited pattern of thoughts or actions that are used in the construction and decorations of the traditional circular buildings. The builders of the traditional houses did not undergo any formal training on how to construct the buildings. The knowledge is passed from one generation to another, orally or by practice.

- **Traditional** means based on or obtained by tradition (Free Online Dictionary, 2010). In this study, traditional means something consisting of tradition or derived from tradition. This is related to tradition because it is obtained by passing down elements of culture from generation to generation, especially orally or by practice. In this research, traditional builders use the knowledge gained either orally or by practice to build traditional houses.

- **Traditional circular building or house** is defined as a circular building for housing (Thompson, 1995). Makgopa (2007) further defines traditional circular house as a house built from natural materials in an African context. In this study, traditional circular building is used to refer to a building in Limpopo Province with a circular ground plan especially one with a dome, built with natural materials and thatching grass.

1.11. Outline of chapters

This thesis is organised into the following five chapters:

CHAPTER ONE: RESEARCH ORIENTATION

The first chapter provides a general overview of the study. It contains an introduction, background to the problem, the statement of the problem, research questions, purpose of the study, significance of the study, delimitations and limitations of the study, clarification of the concepts and the outline of the chapters.

CHAPTER TWO: LITERATURE REVIEW

This chapter outlines the theoretical underpinnings of the study, previous research conducted on indigenous knowledge systems, ethno-mathematics and cultural artefacts, reference to the National Curriculum Statement, principles of Outcomes-Based Education and how these relate to the teaching and learning of mathematics in context.

CHAPTER THREE: RESEARCH DESIGN AND METHODOLOGY

The third chapter describes all the research processes in depth, including the research design, population, sample selection, ethical statement, instruments used; qualitative and quantitative research methods followed in the collection and analysis of data, and the administration of instruments. The chapter continues to provide an in-depth discussion of the methods used in data collection, data analysis and the interpretations of the findings of the study.

CHAPTER FOUR: PRESENTATION, ANALYSIS AND INTERPRETATION OF DATA.

In this chapter raw data is presented. The chapter presents data in two different forms, that is, from the quantitative collection research methods (questionnaire) and from the ones collected through qualitative research methods (interviews and observations). This chapter continuous to presents the analysis and interpretations the data. This is followed by a detailed presentation of the main findings of the study, grouped according to the main research questions.

CHAPTER FIVE: DISCUSSIONS, CONCLUSIONS AND RECOMMENDATIONS

In chapter five, the researcher discusses the main findings of the study and presents the conclusions drawn from the study. Recommendations for addressing issues raised in the findings are also provided in this chapter.

1.12. Summary

This chapter provided a structure for an exploration of the mathematical concepts embedded in the traditional circular buildings and their integration into high school mathematics. The chapter provided a general overview of the study, followed by a brief explanation of what prompted the researcher to undertake the study, the background to the problem, research questions, purpose and significance of this study. Limitations and delimitations of the research, various concepts and key words were clarified. The next chapter presents the review of literature.

CHAPTER TWO

REVIEW OF LITERATURE

2.1. Introduction

In this chapter, a review of literature in the field of ethno-mathematics is done to set the scene for a detailed analysis of the subject of inquiry. The chapter begins by first presenting the theory underpinning the study, followed by perceptions of the teachers about the mathematics curriculum and then the examination of mathematics and its various types of connections. Thereafter, it continues to examine these two themes: Indigenous knowledge systems and mathematics teaching and learning, and ethno-mathematics. Then, it addresses the question of how to teach mathematics effectively through constructivism, followed by geometry and culture, and traditional buildings and decorations. The chapter concludes by drawing together the arguments to guide thinking and analysis for the rest of the thesis.

2.2. The theory underpinning the study

There is need to move away from the traditional activities of the mathematics classroom –such as teacher-centred exposition and individual seatwork- towards activities that help learners to develop mathematical powerful forms of thinking (National Council of Teachers of Mathematics (NCTM), 2000; Australian Association of Mathematics Teachers (AAMT), 2002). This study is underpinned by Social Constructivism Theory that encourages learners to construct their own meaning and understanding of the world they live in. The theory is supported by fallibilist philosophy that views mathematics as subject to change, with new mathematics truths being invented, or emerging as the by-product of investigations, rather than being discovered (Ernest, 1996). Ernest (1999) further argues that no definitions or proofs in mathematics are ever absolutely final and beyond revision. He further contends that mathematics can be revised and created by a group of people who must formulate and critique new knowledge in a formal conversation before it can be accepted (Ernest, 2010).

In Constructivist Theory learners themselves construct their own new ideas and knowledge, and discover correct answers by themselves. Social Constructivism is a theory where learners learn by constructing meaning and thought by-interpretative interactions with and experiences in the environment (Threlfall, 1996). Vygotsky in Ernest (1996) argues that the Social Constructivism model stresses the importance of learning in context- constructing understanding through interactions with others in the social environments in which knowledge is to be applied.

Vygotsky's (1978) argues that social interaction precedes development; and that consciousness and cognition are the end products of socialisation and social behaviour. Vygotsky's theory is one of the foundations of Constructivism. It asserts the following three major themes:

- Social interaction plays a fundamental role in the process of cognitive development. In contrast to Jean Piaget's understanding of child development (in which development necessarily precedes learning), Vygotsky (1978) felt social learning precedes development. He states that every function in the child's cultural development appears twice: first, on the social level, and later, on the individual level; first, between people (interpsychological) and then inside the child (intrapsychological) (Vygotsky, 1978).

- The More Knowledgeable Other (MKO). The MKO refers to anyone who has a better understanding or a higher ability level than the learner, with respect to a particular task, process, or concept. The MKO is normally thought of as being a teacher, coach, or older adult, but the MKO could also be a peer, a younger person, or even a computer (Vygotsky, 1978).

- The Zone of Proximal Development (ZPD). The ZPD is the distance between a student's ability to perform a task under adult guidance

and/or with peer collaboration and the student's ability to solve the problem independently (Vygotsky, 1978). According to Vygotsky (1978), learning occurs in this zone.

Vygotsky focused on the connections between people and the socio-cultural context in which they act and interact in shared experiences (Crawford, 1996). According to Vygotsky (1978), humans use tools that develop from a culture, such as speech and writing, to mediate their social environments. Initially, children develop these tools to serve solely as social functions, ways to communicate needs. Vygotsky believed that the internalization of these tools led to higher thinking skills (Crawford, 1996).

Contributions of the Vygotsky's Social Development Theory(SDT) to teaching

Many schools have traditionally held a transmissionist or instructionist model in which a teacher or lecturer "transmits" information to students. In contrast, Vygotsky's theory promotes learning contexts in which students play an active role in learning (Crawford, 1996). Roles of the teacher and student are therefore shifted, as a teacher should collaborate with his or her students in order to help facilitate the construction of meaning in students (Crawford, 1996). Learning therefore becomes a reciprocal experience for the students and teacher (Crawford, 1996).

Vygotsky's SDT is supported by Social-Cultural Perspective (SCP) and Cultural Historical Activity Theory (CHAT) (Cole, 2005). The SCP draws heavily on the work of Vygotsky (1986) as well as Wertsch (1991, 1998), and has the profound implications for teaching, schooling, and education. A key feature of this theory in the human development is that higher order functions develop out of social interaction (Vygotsky, 1986). A child's higher order functions develop through the participation in the activities that require cognitive and communicative functions (McRobbie & Tobin, 1997). Children are drawn into the use of these functions in ways that nurture and 'scaffold' them (Vygotsky, 1986: 6-7).

Kublin et al. (1998) succinctly stated that Vygotsky (1986) described learning as being embedded within social events and occurring as a child interacts with people, objects, and events in the environment. Here, the influence of the social environment on the individual's learning activities is essential. For this to happen, the teaching of mathematics should move away from the traditional emphasis of facts and skills, and include activities that help learners to develop mathematical reasoning, communication and decision making (Goos, 2004).

Cultural Historical Activity Theory (CHAT) refers to an interdisciplinary approach to studying human learning and development (Laboratory of Comparative Human Cognition (LCHC), 2009). It offers a broad approach to analysing the learning and the contexts of learning. A critical issue in approaches to education is the relationship between learning and development (Vygotsky, 1986). In CHAT the focus is on how we develop understanding of the real world, draw meaning from the understanding, create learning from those meanings and are motivated to respond to those learnings (LCHC, 2009).

CHAT based inquiry combines these three components (LCHC, 2009):

- A system's component that helps learners to construct meaning from situations;
- A learning component which is the method of learning from those meanings; and
- A developmental component that allows learners to expand those meanings towards actions.

Constructivism is described as a learning theory based on authentic and real-world situations (Ernest, 1996). Learners internalise and construct new knowledge based on past experience. The Constructivist Theory is learner-centred and encourages higher level processing skills for learners to apply their knowledge in solving real- life mathematical problems. Cole (2005) further contends that the socio-cultural approach of learning deals with the interconnections between the individual and the (social) environment.

The educational impact of constructivism is positive, in that instruction is based on students' prior knowledge, allowing them to make significant connections and solve complex problems. Students use higher level processing skills such as evaluating, analysing and synthesising to apply newly constructed knowledge to problems or situations (Threlfall, 1996).

According to the theory of constructivism, students' responsibility for their own learning is greater, as they discover how new knowledge connects with prior knowledge (Threlfall, 1996). Learners continuously ask questions and guide their own learning process. Students learn that there is not just one way to solve problems, but rather multiple ways to find answers. The teacher's role is to anticipate and address student misconceptions while presenting authentic questions and real-world problems or situations (Threlfall, 1996). The teacher does not provide clear answers on how to solve these problems or questions, but guides students to make sense of how things work according to what their past experiences were and how it applies to the new knowledge they are constructing (Threlfall, 1996). Overall, the constructivist approach to teaching allows students to be actively involved in decision-making and problem-solving scenarios.

In Constructivism, the focus of teaching is on empowerment of the learners (Ernest, 1996). The teachers' role is to engage learners in the discovery of knowledge and provide them with opportunities to reflect upon and test theories through real-world applications of knowledge (Threlfall, 1996).

Fallibilist theory is viewed as Post-Modernist because of its rejection of absolutism, foundationalism and the associated logical meta-narratives of certainty (Bishop, 1991). Mathematical knowledge is understood to be fallible and eternally open to revision, both in terms of its proof and its concepts. Post-Modernism is committed to a multi-disciplinary account of mathematics as a set of socially distributed practices (Ernest, 1991). It embraces the practices of mathematicians, the history and the implications of mathematics, and the place of mathematics in human culture, including issues of value and education. It no

longer views mathematics as a body of pure and abstract knowledge which exists in a superhuman and objective realm. Instead, mathematics is associated with sets of social practices, each with its history, persons, social locations, symbolic form, and so on (Ernest, 1991).

Likewise, both ethno-mathematics and school mathematics are distinct sets of such practices. They are intimately bound together because the symbol production of one practice may be reconceptualised and reproduced in another. This study might assist learners to discover the connections between mathematical concepts and the indigenous practices within their "locally" created learning environments. Learning and understanding of mathematics should be constructed within the created learning environment.

2.3. Perceptions about the Mathematics curriculum

The majority of teachers have a general understanding that mathematics can be taught effectively and meaningfully without relating it to culture and history (Fasheh, 1997). They perceive the mathematics curriculum as being academic, and contexts beyond the formal "word sum" are seldom used. Teachers are driven by a content-based syllabus. The ultimate goal of many teachers is to 'cover the syllabus' and to drill learners to pass the examination. Activity-based teaching is seen as time-consuming and preventing teachers from completing the syllabus in time. The ethos of mathematics teaching revolves around the syllabus and the matriculation examination.

The National Curriculum Statement encourages the teaching of mathematics in ways that are seen to be meaningful to learners, and linked with their everyday realities (DoE, 2011). Learners should be assisted to construct their own meaning and understanding of mathematics within created learning environments. Teachers should acknowledge learners' background experiences and their cultural backgrounds. Recognition of these will help to create more conducive learning environments and the lesson becomes more meaningful and more relevant.

When mathematics is taught in a way detached from social and cultural aspects, and in a meaningless way, it is not only useless, but also very harmful to the learners (Presmeg, 2007). The learners' background experiences and culture are considered crucial for meaningful learning to take place. They are extremely important factors to create more conducive learning environments in which it is easy for the learners to create their own meaning and understanding. The design of the National Curriculum Statement 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).

The National Curriculum Statement provides opportunities for educators and researchers to see mathematics in ways that present mathematics as a discipline that has connections with everyday realities (Department of Education, 2001). It also urges teachers to make explicit links between mathematics and other school curriculum areas, and again between mathematics and social and cultural aspects (Department of Education, 2001).

It also allows for the development of teaching strategies that help educators and teachers see teaching from new perspectives. The vision in the curriculum also helps to conceptualise assessments in ways that recognise that all learners can learn, and succeed in mathematics when learners are exposed to activities designed in the context of their daily life experiences.

In this study the focus was on mathematical concepts of the traditional buildings of the Limpopo Province and the teaching of high school mathematics. The topic is relevant to mathematics teaching and addresses Learning Outcome (LO) 3 of the NCS: Space, Shape and Measurement. The focus was to develop learners' understanding and appreciation of the pattern, precision, achievement and beauty in natural and cultural forms.

Assessment is the process of gathering evidence of a learner's progress towards achieving the stated outcomes on an ongoing basis. Assessment Standard 2 says learners should be able to interpret, understand, classify, appreciate and describe the world through 2D and 3D objects, their location, movement and relationship. The topic is also relevant to the assessment standard.

2.4. Connections in Mathematics

Mwakapenda (2008) argues that mathematics is a discipline that has connections or links with first, *itself* and second, *with other disciplines.* Connections are the underlying principle of mathematics (Mwakapenda, 2008).

According to the Department of Education (2003: 9):

> Mathematics enables creative and logical reasoning about problems in the physical and social world and in the context of mathematics itself. It is a distinctly human activity practised by cultures. Knowledge in the mathematical sciences is constructed through the establishment of descriptive, numerical and symbolic relationship. Mathematics is based on observing patterns, with rigorous logical thinking, this leads to theories of abstract relations. Mathematics problem solving enables us to understand the world and make use of that understanding in our daily lives. Mathematics is developed and contested over time through both language and symbols by social interaction and is thus open to change.

The Department of Education (2003: 54) states that there are ``opportunities for making connections'' across various mathematical content involved within and across learning outcomes. According to the DoE (2003: 54), these opportunities ``should be sought in requiring the solution to standard as well as non-routine unseen problems''. However, the following statement regarding the ``purpose'' of mathematics suggests that some kinds of connections are more highly valued than others:

> An important purpose of mathematics in the Further Education and Training band is the establishment of proper connections between mathematics as a discipline and the applications of mathematics in real-world context (DoE, 2003: 10).

When people interact with the world, they encounter some problems or challenges. Mathematical knowledge is used to address or to solve some of the challenges or problems of daily life. Mathematical problem solving enables people to understand the world and to make use of this understanding in their daily lives.

Connections are at the heart of the definition of mathematics for Mwakapenda (2008). These connections are concerned with what mathematics is: where it comes from – human activity, a construction, a development and contestation that is time dependent and socially dependent- and what it does: problem–solving and understanding the world and daily living (Mwakapenda, 2008). Mathematics is not about reasoning for its own sake, but it is concerned with reasoning, symbolizing and thinking processes that are connected to activities and problems of the social, physical and mathematical world involving human practices in all cultures (Mwakapenda, 2008).

From the definitions of mathematics (Mwakapenda, 2008), there is a conceptual and social dimension in the essence and use of mathematics. In mathematics, both social and conceptual connections are important. Mathematics is a highly conceptual domain, a field of knowledge consisting of concepts that are structured in a specialised way. This entails that the processes of knowing and understanding mathematics are also specialised. The ability to do mathematics well, to represent and communicate mathematics effectively depends on individuals having achieved a conceptual understanding of mathematical concepts and procedures, and the relations between concepts and procedures (Kilpatrick, Swafford, & Findell, 2001). In particular, the "powerful conceptual tools" that are made available by mathematics enable learners to "analyse

situations and arguments; make and justify critical decisions; and take transformative action" (DoE, 2007: 7).

Adler, Pournara, and Graven (2000) identified three levels of integration:

- First, integration of the various components of mathematics;
- Second, integration between mathematics and everyday real world knowledge; and
- Thirdly, integration across learning areas.

In this study, the research focus was on the integration or connections between classroom mathematics and everyday real world mathematical knowledge. The focus was on the integration between mathematics as practised by the indigenous people of the Limpopo Province and the classroom mathematics.

Mathematical concepts of the traditional buildings of the Limpopo Province are explored and integrated into high school mathematics teaching. Warren (2005: 134) points out that educators and community developers have frequently operated in isolation both professionally and institutionally. He argues that it is difficult to "teach children well if teachers lack an understanding of their students' culture and lives".

2.5. Indigenous Knowledge Systems and Mathematics teaching and learning

Indigenous Knowledge Systems (IKS) is viewed as local knowledge that is unique to every culture and society (Makgopa, 2007). Makgopa (2007) further argues that IKS serve as the basis for local decisions about different aspects of life, such as agriculture, management of natural resources and infrastructure. IKS in this country demonstrate how indigenous Africans were able to survive, display their knowledge and skills prior to colonialism. Unfortunately, this knowledge was not written down but was transmitted from one generation to the next by word of mouth. Oral communication was the only means of preserving knowledge and

skills. Its information may change overtime due to incorrect hearing, personal interpretations and improper teaching.

Makgopa (2007) further states that the South African Research and Documentation Centre (SARDC), defines Indigenous Knowledge Systems as:

> ... a body of knowledge and beliefs built by a group of people, and handed down through oral tradition, about the relationship between living beings and their environment. It includes a system of organization, a set of empirical observations about the local environment, and a system of self-management that governs resource use (Makgopa, 2007: 26).

In this context, mathematical knowledge is transmitted from one generation to another, either orally or by means of practices. However, the advent of modern technology that brought about writing, reading, urbanization and globalization also increased channels of learning through formal schooling.

The Inter-Commission Task Force (ICTF) on Indigenous People has provided one of the most elaborate definitions of indigenous knowledge:

> Indigenous Knowledge Systems are local, community-based systems of knowledge which are unique to a given culture or society and have developed as that culture has evolved over many generations of inhabiting particular ecosystems. Indigenous Knowledge Systems is a general term that refers broadly to the collective knowledge of an Indigenous People about relationships between people, habitat and nature. It encompasses knowledge commonly known within a community or a people, as well as knowledge which may be known only to a shaman, tribal leaders, a lineage group, or a gender group (IVCN, 1997: 46).

Numerous studies have illustrated the role that indigenous knowledge and indigenous people play in the sustainable development of their natural environment and communities (Van der Vlist, 1994). Warren, Slikkerveer, and Broker (1995) define indigenous knowledge as the local knowledge that is unique to a given culture or society. Most definitions of indigenous knowledge also encapsulate or include the accumulation of experience and the passing of information from one generation to another in a particular cultural context. This knowledge is often preserved in people's minds. Mundy and Compton (1995: 113 – 114) illustrate the importance of understanding indigenous communication system.

As Warren and Rajasekaran (1993: 8) assert, indigenous knowledge is:

> The information basis for a society which facilitates communication and decision-making. Indigenous knowledge is the systematic body of knowledge acquired by local people through the accumulation of experiences, informal experiments, and intimate understanding of the environment in a given culture.

When people interact with the world, they attempt to contend with and give meaning to what they encounter and perceive. They try to comprehend, interpret, and explain the aspects and challenges that reality presents, using numbers, logic, and spatial configurations that are culturally shaped. These are the ways in which people produce mathematical knowledge (Gamsen & Appleton, 1995).

In this research, practical mathematics, as practised by a group of people within a particular environment (that is, indigenous builders in Limpopo Province) were explored and integrated or connected to high school mathematics teaching and learning. Mathematical concepts of the traditional buildings of the Limpopo Province were explored and integrated into classroom mathematics to enhance the teaching and learning of mathematics in context.

Embracing and asserting indigenous knowledge is the key to self-determination. The importance of self-determination, according to Dodson (1994: 23) is:

> At the most fundamental level, self-determination is deeply rooted in the ultimate goal of human dignity. It is an inherent right of people which is indivisible, non-negotiable and cannot be raised through non-recognition. At the more pragmatic or instrumental level, the enjoyment of the right to self-determination is essential to our survival as people. It is the pillar which supports all other rights; a right of such a profound nature that the integrity of all other rights depend on its observance.

According to Dodson (1994), some of the reasons for focusing on Indigenous Knowledge Systems include the following:

- It encourages sustainable livelihood strategies that are based on existing know-how and can lead to income-generating opportunities.
- It builds local and institutional capacity among disadvantaged communities.
- It focuses on the sustainable use of cheap natural resources.
- It contributes towards improving the quality of lives.
- Utilising Indigenous Knowledge Systems is a cost-effective means of building on existing resources that promote sustainability and enhance capacity-building.

Indigenous Knowledge (IK) and mathematical development as an area of focus in research has implied that there needs to be a common understanding about how it is defined and interpreted (Mosimege, 2001). Some of the ethno-mathematicians have done considerable work on indigenous knowledge and mathematical development, and also contributed immensely to the establishment of indigenous knowledge systems centres in a number of countries. Warren (1996) is one of the people who has done considerable work on indigenous knowledge development and also contributed immensely to the development and establishment of the indigenous knowledge systems.

Warren (1996) defines Indigenous Knowledge Systems as a systematic body of knowledge acquired by local people through the accumulation of experiences, informal experiments and intimate understanding of their environment in a given culture. This means that the experiences of the local people are largely affected by the environment in which they live. Experiences are one of the central components of culture, and make the knowledge acquired by local people special. Therefore, the mathematical knowledge acquired and practised by local people should be the central component in the mainstream (classroom) mathematics (Warren, 2005). The mathematical knowledge practised locally should play a central role in the teaching and learning of mathematics.

Expressing the same idea about the importance of this knowledge to the local people, Deliwe (1998: 7), in the *Prolegomena to a Policy Framework on Indigenous Knowledge Systems in South Africa*, argues that what makes this knowledge 'indigenous' is its inalienable link to the native people or aborigines of a particular locality-knowledge particular to the cultural system of such communities in a given locale. Therefore, mathematical knowledge acquired and practised by local people should be used in the teaching and learning of mathematics. For mathematics teachers to teach children well, they need to know and understand their students' cultural and social lives.

IKS are valuable to all in South Africa in the 21st century. In this phase of world history, when globalisation is pursued as the "ideology" of the Western world, which is dominating other peoples of the world, including Africans, IKS can serve us in a noteworthy or remarkable manner (Leeuw, 2004). Leeuw (2004) further contends that IKS are our point of anchorage for withstanding any global efforts to create an inferiority complex among us, with the aim of making us feel like people who are devoid of knowledge that ever did, or ever could, sustain humanity materially, intellectually and spiritually.

Leeuw (2004) argues that Africans ought to acknowledge that the prevailing systems of knowledge, couched in Western modes of thought and technology, are valuable if one is mindful of their cultural relativity. Leeuw (2004) further

contends that Africans ought to march forward together with other people of the world, fully aware of the fact that we are straddling ancient heritages and those of the 21st century when it comes to the endowment of knowledge, values, our humanity and our identity. It is the responsibility of indigenous people of Africa to be ever aware that their position among modern societies of the world is unique. Therefore, the unique mathematical knowledge practised by indigenous builders of the Limpopo Province should be acknowledged, maximally exploited, and integrated into high school mathematics teaching.

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2.6. Ethno-Mathematics

Ethno-mathematics can be defined as the mathematics which is practised among identifiable cultural groups such as national - tribal societies, labour groups, children of a certain age bracket, professional class (D'Ambrosio, 1999). D'Ambrosio (2001) has interpreted the notion of ethno-mathematics by considering its three conceptual elements: ethno-mathema-tics. 'Ethno' refers to people; 'mathema' to understanding; while 'tics' refers to techniques. Thus, ethno-mathema-tics refers to culturally embedded techniques for understanding (Skovsmose, 2005). It must be noted that the notion of 'mathema' is broader than 'mathematics' as we normally consider it, and that 'ethno' has to be understood as people/culture, and that it does not include any reference to 'ethnicity' (Skovsmose, 2006; Ribeiro & Ferreira, 2004).

Gerdes (1996: 909) further defines ethno-mathematics as "the field of research that tries to study mathematics or mathematical ideas in their relationship to the whole of culture and social life". Culture, in this context, is viewed as going beyond the traditional perspective of confining it only to ethnicity or geographical location. It includes builders, designers, etc. These social groups develop their own jargon, code of behaviour, symbols and expectations as well as their own way of doing mathematics. Setati (2002: 31) defines ethno-mathematics as the mathematics practised by a cultural group defined by philosophical and ideological perspective.

Borba (1990) argues that mathematics education should be thought of as a process in which the starting point would be the ethno-mathematics of a given group and the goal would be for the learners to develop a multi-cultural approach to mathematics. The indigenous people of Limpopo Province practise some form of ethno-mathematics in their normal way of living. Their knowledge of mathematics is intertwined with art and craft and cultural artefacts. Therefore, ethno-mathematics of Limpopo Province should be integrated into classroom mathematics. Seepe (2000) supports this argument by stating that indigenous knowledge systems would encourage learners to draw on their cultural practices and daily experiences as they negotiate and grapple with new situations and unfamiliar terrain.

Interest in ethno-mathematics was prominent in the thinking of curriculum developers in South Africa in the late 1980s and early 1990s (Mosimege, 2000). According to Laridon (2000), this interest was largely stimulated by the writings of other mathematicians such as Paul Gerdes (1994), Ubrinaton D'Ambrosio (1991) and Allan Bishop (1991).

During the second Political Dimensions of Mathematics Education Conference (PDMEC), which was organised under the auspices of the African National Congress' National Co-ordinating Committee (ANCNCC), in Broederstroom in April 1993, 13 papers with connections to ethno-mathematics were presented (Laridon, Mosimege, & Mogari, 2005). An ethno-mathematics interest group became active within the Association for Mathematics Educators of South Africa (AMESA) and they had a direct influence on the shaping of the new curriculum for the South African Curriculum 2005 (Laridon, Mosimege, & Mogari, 2005).

In ethno-mathematics, the mathematical concepts practised by cohesive social groups are studied with the emphasis on indigenous cultures.

According to Eglash (1997: 79), ethno-mathematics is divided into the following five sub-fields:

- Non-Western mathematics: this consists primarily of historical studies, with a cultural focus on empire states such as the ancient Chinese, Hindu and Muslim civilizations.
- Mathematics anthropology: this uses mathematical modelling in ethnographic and archaeological studies to describe material and cognitive patterns, generally without attributing conscious intent to the population under study.
- Sociology of mathematics: here the methodologies most closely associated with Science, Technology and Society (STS) that of the social construction of Science are applied to the work and community of professional mathematicians.
- Vernacular mathematics: this is the informal mathematics, non-standard mathematics or folk mathematics used by a particular group of people such as weavers, carpenters, adults, etc.
- Indigenous mathematics: cultural locations of research that emphasize small-scale (indigenous, traditional) societies.

Ethno-mathematics requires attention to the intentions and conscious aspects of knowledge systems of a particular group (Gerdes, 1999). In this study the attention was on the indigenous mathematical concepts in the traditional circular buildings of the Limpopo Province, practised by the following cultural groups: Bapedi, Va-Tsonga and Vha-Venda cultural groups.

2.6.1. Ethno-Mathematics and indigenous knowledge system

Warren, Slikkerveer, and Broker (1995) define indigenous knowledge as the local knowledge that is unique to a given culture or society. Most definitions of indigenous knowledge also encapsulate or include the accumulation of experience and the passing on of information from one generation to another in a

particular cultural context. Therefore, local mathematical knowledge practised by cultural groups of Limpopo Province can be viewed as Indigenous Knowledge.

Gerdes (1996: 909) defines ethno-mathematics as "the field of research that tries to study mathematics or mathematical ideas in their relationship to the whole of culture and social life". Culture, in this context, is viewed as going beyond the traditional perspective of confining it only to ethnicity or geographical location. It includes builders, designers, etc. These social groups develop their own jargon, code of behaviour, symbols and expectations as well as their own way of doing mathematics. In ethno-mathematics, mathematical concepts are studied by cohesive social groups, with the emphasis on indigenous cultures.

Given the above definitions of ethno-mathematics and indigenous knowledge systems, it follows that ethno-mathematics may be regarded as one component of an indigenous knowledge system, focusing on the mathematical aspect of those systems (i.e. mathematics which is practised among identifiable cultural groups such as labour groups, children of certain age group, national-tribal societies, professional class and rural communities).

Various mathematical structures or concepts are embedded in the traditional buildings of the Limpopo Province, South Africa. These concepts need to be explored and integrated or connected to high school mathematics.

2.6.2. Focus of ethnomathematical research

Gerdes (1997:343) goes on to indicate that as a research field, ethno-mathematics may be defined as the "cultural anthropology of mathematics and mathematical education". Although Gerdes provides this definition, he also stresses the importance of seeing ethno-mathematics as a movement and he provides a framework for understanding this notion of an ethno-mathematical movement and the ethno-mathematicians or researchers involved in the movement (Gerdes, 1996:917), as follows:

(i) Ethno-mathematicians adopt a broad concept of mathematics, including, in particular, counting, locating, measuring, designing, playing, and explaining;

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

(iii) Ethno-mathematicians 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) Ethno-mathematicians emphasise that the school mathematics of the transplanted, imported 'curriculum' is apparently alien to the cultural traditions of Africa, Asia and South America;

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

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

Mathematical concepts of the traditional buildings of the Limpopo Province that have been practised by various cultural groups, have survived colonisation. They could be incorporated into the school curriculum. These mathematical concepts might assist mathematics educators to contextualise the teaching of mathematics. The concepts may also serve as a starting point for doing and elaborating mathematics in the classroom situation. This will help learners to reflect on the realities in which they live, and empower them to develop and use mathematics freely.

Mathematics educators working in the area of ethno-mathematics have explored either one specific aspect mentioned above or a component thereof (Mogari, 2000). For instance, Mosimege (2000) investigated how indigenous games may be used in the mathematics classroom. Other projects have explored mathematical knowledge in various cultural artefacts (e.g. beadwork, weaving etc) and indigenous practices (e.g. string figure games, moruba, etc).

Vithal and Skovsmose (1997: 134-135) identify four research strands that have emerged in the 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.
- 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. For example, 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. Gerdes (1996) wanted to formalize ethno-mathematics into the main-stream mathematics curriculum. According

to Vithal and Skovsmose (1997), this strand is however, relatively under-researched.

- The fourth strand is that which looks for mathematical connections in traditional cultures, which although colonized, continued with their indigenous practices. These include activities such as those found in weaving, buildings and beading artefacts. Several studies conducted show a link between mathematical concepts and indigenous practices.

This study explored the mathematical concepts embodied in the indigenous practices or socio-cultural activities (traditional circular structures of Mopani, Vhembe, and Sekhukhune districts of the Limpopo Province, South Africa) and their integration into mainstream mathematics (high school mathematics).

2.6.3. Ethno-Mathematics and Culture

"Ethno-mathematics is the mathematics practised by any socio-cultural group such as labour communities, traditional religious groups, professional classes, etc. (Horsthenke, 2004). It is the study of mathematics or mathematical ideas in their relation to the whole culture and social life. As a new field of interest, Barton (1996:3) notes that the first use of the term "ethno-mathematics" 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 recent and less than 30 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 ethno-mathematics: these definitions differ but largely identify culture as a central tenet.

One of the earlier definitions of Ethno-Mathematics by D'Ambrosio (1999: 16) 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.

Here, D'Ambrosio looks at the cultural elements such as language, codes, symbols, values, and attitudes which characterise a particular practice. Culture in this context is viewed beyond the traditional perspective of confining it only to ethnicity or geographical location. It includes builders, designers, *etcetera*. These social groups develop their own jargon, code of behaviour, symbols and expectations as well as their own way of doing mathematics.

Culture is defined as the interconnection between the individuals and the objects in the environment through their usage in a specific and socially legitimate way. Giddens (2001) further defines culture as the way 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. Mosimege (2001) also perceives culture as a set of shared experiences among a particular group of people. 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".

Cole (2005) further states that culture is necessary to participate in the social environment. Because of that, culture is both a contextual and a cognitive phenomenon: the context influences and creates human cognitive structures and vice versa (Cole, 2005).

Culture is also defined as an organised system of values that are transmitted to a group's members both formally and informally (McConatha & Schnell, 1995). Thus, the emphasis is on the context of his work which includes cultural and social life. In this case the definition of ethno-mathematics relates closely to that of D'Ambrosio (2001).

The concept "culture" is defined in various ways and debated in many areas of the social Sciences. According to Ezewu (2005), culture consists of a body of shaped ideas and knowledge which serves as a medium through which individuals interact with each other. Also, there are aspects that are common in the descriptions of culture such as behaviours, practices, physical objects, ideas and knowledge.

Various identifiable groups of people or communities have distinctive ways of giving expression to these elements (Mosimege, 2000). Each community has a unique culture. The importance of culture for mathematics education in general has been brought to our attention by Bishop (1991). Bishop (1991) contend that mathematics is embedded in cultural practices such as counting, measuring, comparing, classifying, playing, locating and designing. Nickson (1992) further concurs with Bishop et al.'s ideas and brought the special significance of culture for the micro level of the classroom to the forefront. Nickson (1992) further defines the culture of the classroom as the invisible and apparently shared meaning that teachers and pupils bring to the mathematics classroom and that govern their interaction in it. Values, beliefs and meanings are implicated in these "shared invisible" meanings (De Corte & Verschaffel, 2007: 247).

The central thesis of Bruner's (1996) seminal book, *The Culture of Education* is that culture shapes minds, that it provides us with the toolkit by which we construct not only our words, but our very conceptions of ourselves and our powers. Bruner (1996) describes education as a complex pursuit of fitting a culture to the needs of its members, and of fitting its members and their ways of knowing to the needs of the culture.

Ethno-mathematics is a relatively new field of theory and research. D'Ambrosio (2001) sees ethno-mathematics as mathematics which is practised among identifiable cultural groups engaged in the process of addressing problems encountered in their environments. This mathematics is embedded in cultural practices such as counting, measuring, comparing, classifying, playing, locating, designing, exploring (Bishop et al., 2003; D'Ambrosio, 1999). Through ethnographic research the mathematics embedded in cultural practices and artefacts can be made explicit, it can be seen as a manifestation of cognition (Nickson, 1992) and as developed through a cultural psychology (Abreu, 1998), the mathematics can be 'unfrozen' (Gerdes, 1999).

By bringing these aspects of mathematics to the fore in the curriculum through an appropriate pedagogy, cultural reaffirmation can be brought about, so as to counter the suppression of indigenous cultures under colonisation and in Eurocentric accounts of the history of the development of mathematics.

In the Limpopo Province there are various mathematical concepts in the traditional buildings. Mathematical concepts or shapes such as circle, circumference, centre of the circle, triangle, rotation, tessellation and symmetry are displayed on the traditional buildings. Some of these mathematical concepts are displayed in the mural decorations.

2.6.4. Ethno-Mathematics versus Academic Mathematics

The discipline that has become known as ethno-mathematics involves a study of mathematics that takes into account the social and cultural context in which mathematical reasoning is employed (Horsthenke, 2004). It is used specifically with regard to the thinking and practices in small-scale indigenous societies.

In a broader sense, the prefix "ethno" has been used to refer to any socio-cultural group such as labour communities, traditional religious groups, professional classes, *etcetera* (Horsthenke, 2004). It is clear, then, that ethno-mathematics is a discipline that has emerged with multi-cultural and post-colonial discourse. Borba (1990) points out that mathematics refers not only to symbolic systems but also to concrete physical practices or activities such as measuring, ordering, modelling, classifying, ciphering and inferring. Ethno-mathematics challenges this Euro centrism thinking: that the academic mathematics taught in schools world-wide was created solely by the Europeans and Americans, and that mathematical knowledge exists outside of, and unaffected by culture.

Contrasts are often made between everyday mathematics (that arise out of the socio–cultural context of living), and academic or mainstream mathematics (classroom mathematics). Academic or mainstream mathematics generally remains driven by absolutist philosophy (Ernest, 1996) while ethno-mathematics looks to fallibilist quasi – empiricism (Tymoczko, 1994) for its epistemology. For quasi–empiricism, mathematics is not founded solely on logic in an *"apriori"* manner, but takes the empirical and historical into account in the development of mathematical knowledge (Barton, 2004). Ethno-mathematics is embedded in culture and can be made explicit. The assumption of the empirical and the fallible allows for the differences in mathematical cognition, which are currently evident in different cultures to be accommodated (Barton, 1998).

2.6.5. Some challenges facing ethno-mathematical teaching in South Africa

The proposal to introduce ethno-mathematics does not signify rejection of or ignoring academic mathematics. It implies that academic mathematics should accommodate the daily lived culture of people as multi-culturalism is becoming the most notable characteristic of education today. With the great mobility of people and families, inter-cultural relations are becoming more intense. Therefore, intercultural encounters will generate conflicts that can only be resolved based on ethics that result from the individual knowing himself and knowing his culture, and respecting the culture of others.

In South Africa it is still very difficult for academic mathematics to accommodate the daily lived culture of people within its philosophical framework – that culture in which embedded mathematics can be found and made explicit. A Palestinian mathematician Munir Fasheh, takes the objective of mathematics teaching to be to discover new acts about one self, society, and culture, to be able to make better judgment and decisions; and to build the links or connections or integrations between mathematical concepts and concrete situations and personal experience (Fasheh, 1997).

Most educators in South Africa seem to be using academic teaching in their mathematics classes, rather than ethno-mathematical teaching. They are reluctant to use ethno-mathematical teaching for some of the following reasons:

- Teachers are under pressure to "cover the syllabus" and to drill learners on rote examination procedures;
- They are driven by the syllabus which is content based. Contexts are seldom used in their classroom situations;
- The ultimate goal for many teachers is to get their learners to pass examinations; and
- The ethos of mathematics teaching revolves around the syllabus and examinations.

According to Rakgokong (1993), lack of confidence due to limited mathematical knowledge or to appalling conditions in the classroom (e.g. lack of proper resources and overcrowding) is one of the reasons why teachers are reluctant to use ethno-mathematical teaching. Rakgokong (1993) further argues that most teachers are conditioned by the way they have been "trained" during their teacher education which they then translate into an authoritarian teaching style in their own classroom. They view activity-based teaching as time-consuming and preventing them "covering the prescribed syllabus".

In ethno-mathematical teaching, educators choose activities that provide a familiar context to the learners. Learners are attracted to mathematics classes and enjoy mathematical lessons that are presented in their familiar contexts. Such contexts stimulate positive attitude and some enjoyment, thus they invite interest in the mathematics embedded in each context. Mathematics is not confined within classroom walls only but it is practiced by all communities. Learners are assisted to construct their own meaning and understanding within the created learning environment. They are also helped through resources to perform to their full potential in mathematics. This approach encourages learners to develop critical thinking powers and problem-solving abilities.

It seems some teachers and learners in rural areas of Limpopo Province of South Africa experience difficulties in appreciating mathematics behind the cultural practices they are engaged in, despite having been exposed to these situations. It would appear that only through direct mentoring, which is human resource intensive and financially demanding, can substantial progress be made in this regard.

2.6.6. Cultural artefacts and Ethno-Mathematics

Thompson (2005) defines an artefact as a product of human art and workmanship. A key aspect of an artefact is the context in which it is made (Mosimege, 2000). This implies that artefacts are linked to a particular culture. Artefacts are also referred to as the material objects of culture. They are made by various cultural groups for use when dealing with the reality and challenges encountered in everyday life.

These artefacts emphasise the cultural identity of a particular cultural group. Therefore, such artefacts are said to be culturally conditioned and are referred to as cultural artefacts (Mosimege, 2000).

Cultural artefacts are often made of available low cost material, e.g. grass, strings, poles and seeds or the materials found locally without the need to buy them, e.g. sticks, woods, soil, reeds and tins. The construction of cultural artefacts does not necessarily involve the use of modern tools such as rulers, measuring tapes, pliers and protractors. Instead, the makers of cultural artefacts often use improvised equipment. It should also be noted that the techniques and procedures followed when constructing cultural artefacts are not necessarily learned at school but can be learned informally, by first observing the more skilled artefact makers and then engaging in 'hands on' activity in accordance with observed procedures and techniques.

The knowledge and skills involved are then perfected over time as more artefacts are constructed. However, there is a possibility that technical knowledge of constructing artefacts might be lost with time when more skilled makers become less involved in these activities through a loss of interest or for other reasons.

A number of studies involving cultural artefacts have been carried out in southern Africa (Mosimege, 2000). These studies contain examples of activities that can be used in making mathematics accessible to learners. If the notion of teaching mathematics in a familiar context is to be followed, more activities that are practised in specific cultural groups should be identified and explored.

From the literature study, the researcher identified the following activities explored by various ethnomathematicians that were practised by various cultural groups:

- Purkey (1998) used six groups of activities, three of which were based on cultural artefacts, namely the South African flag, South African architecture, and Ndebele mural art (Loridon, 2000). Each of these activities uses some mathematical concepts and principles that are related to the mathematical syllabus in various grades.

- Purkey (1998) explored the mathematical concepts with respect to the South African flag that included measurement of angles and lines in the reproduction of the flag, proportions, tessellations, symmetry, reflections and geometrical shapes. With respect to South African architecture the activities involved different types of huts designed by various cultural groups. One of the activities involved measurement, the construction of geometrical shapes and the determination of area.

- In considering the rectangular houses of the Basotho, right angles using Pythagorean triples, the Theorem of Pythagoras and the distance formula were demonstrated (Purkey, 1998). The colourful Ndebele mural art was explored in activities which considered aspects of translation, reflection and symmetry. Purkey (1998) also demonstrates that mathematics is also embedded in "Ma-dice" (a game involving the use of dice).

- Mogari (2001) conducted a study involving the construction of a kite. The activity required the use of thick cotton, a newspaper page of tabloid size, and the stem of a blackjack plant or a tall grass. The commonly preferred shapes for kites are quadrilaterals and hexagons. The activity of constructing a kite

involves mathematical concepts such as angles, orthogonality, congruency, parallelism, area, shapes, and the properties of triangle quadrilateral and hexagons.

- Gerdes (1999) provides many examples of the mathematics embedded in the artefacts of African culture. For example, in the Republic of Mali, Gerdes (1999) identified horizontal and vertical threads crossing each other one over, one under weaving. He further explored the basket bowl in Mozambique and identified properties of a circle such as centre of circle, tangent, radius, diameter and circumference.

- Cherinda (2002) used twill weaving in Mozambique basketry to identify mathematical ideas such as sequence and series, symmetry, combinatorics and aspects of group theory. Getz, Becker and Martinson (2001) explored symmetry, translation, reflection and rotation in frieze pattern of Zulu beadwork and in Northern Sotho beaded – aspron panels. The patterns have motifs repeated at regular intervals along straight lines. Getz's (1998, 1999) work on Zulu *izimbenge* basketry relates the patterns involved to fractal geometry and is an example of how ethno-mathematics goes beyond basic mathematics.

- Santos and Matos (2002), Mwakapenda (1995), Millroy (1992) and Mogari (1998, 2001) conducted various studies that looked at the use of mathematical practices in-and-out of school situations. The studies provide yet further evidence that aspects of mathematics can be made identifiable in most of our everyday practices. Santos and Matos (2002) investigated the mathematical practices of the *ordinas*, who are described as young boys between 12 and 17 who sell newspapers in the streets of Praira, the capital of the Republic of Cabo Verde

Ardinas and discovered that mathematical concepts were used during the sale of the stock.

- The study by Mogari (2002) on wire cars, illustrates in detail how the construction of cultural artefacts such a wire car can be related to mathematics. The construction of such cars requires a feel for the embedded geometry. Millroy (1992) explored the mathematical ideas used by a group of carpenters when they curve their furniture. A study by Mwakapenda (1995) reveals that mathematical concepts are used by street vendors when making packages of the items they sell and also during the sale of their stock.

- Mosimege (2000) indicates that there are mathematical ideas and principles involved in "malepa" (string games), "morabaraba" and "moruba". The following mathematical concepts were found during the analysis of "malepa" or String Figure Games (Mosimege, 2000: 382-389):

  - Triangles, quadrilaterals (square and rectangle), symmetry and the relationships between various figures and generalisations drawn from these relationships. For example, the number of triangles (y) is related to the number of quadrilaterals (x) by formula $y = 2x + 2$; quadrilaterals and intersection points: $y = 3x + 1$; quadrilaterals and the number of spaces: $y = 3x + 2$.
  - In the analysis of morabaraba, Mosimege (2000) identified the following geometrical concepts: quadrilaterals (square), ratio and proportion, symmetry, counting and logical deductions in the execution of the various steps in the game.

- Mosimege (2000: 382-389) further identified the following mathematical concepts in the analysis of moruba: counting, symmetry and probability.

- Gibbs and Sihlabela (1996: 26) also explored the geometrical figures identified from String Figure Games and suggested that the loop of a piece of string can be manipulated further to create a variety of geometrical shapes. For instance, they discussed the ways in which the loop can be manipulated to create an isosceles and an equilateral triangle out of the existing loop. In the same way, the string can be manipulated to create a kite or a rhombus from the identifiable square and rectangle.

- Ethno-mathematical research programmes have proliferated worldwide. Abreu (1993) and Regnier (1994) conducted the studies that dealt with mathematical ideas or aspects such as parallel lines etc used in the sugar cane farming. Duarte (2003) addressed the "world of construction", for instance the mathematical knowledge used in mixing of mortar (sand, cement and water) and, depending on the particular use, some crushed stones. Giongo (2001) analyses the practice of mathematics in designing various sizes and shapes of shoes at the shoemakers. The perspective of street children has been addressed by Mesquite (2004) by investigating the notion of space.

Wedege (2003, 2004) presents *socio-mathematics* as addressing the relationship between people, mathematics and society. Socio-mathematical problems concern:

- Peoples' relationship with mathematics and mathematics education in society;

- The functions of mathematics and mathematics education in society as well as society's influence on mathematics and mathematics education; and
- Learning, knowing and teaching mathematics in society.

According to the conceptual delineation of ethno-mathematics, one could talk about the mathematics of bakers, carpenters, street children, vendors, bank assistants, tele-engineers, system developers, dentists, statisticians, and the ethno-mathematics of pure mathematicians (Skovsmose, 2006).

However, it seems that the ethno-mathematics programme itself has incorporated a priority in focusing on the ethno-mathematics only of certain cultural groups (Skovsmose, 2005). There is not much research within the ethno-mathematical programme that addresses, for example, engineering mathematics (Skovsmose, 2006). This conceptual expression suggestion may help to establish further relationships between the ethno-mathematical programme and studies which share a number of the same concerns, which may be awkward to operate within the notion of ethno-mathematics (Skovsmose, 2006).

Based on the information provided by Gibbs and Sihlabela (1996) and other mathematicians on mathematics and culture, it is not relevant to teach mathematics without relating it to culture and history. The social and cultural background and experiences of the learners are the starting point in teaching mathematics more relevantly and meaningfully. The cultural artefacts should be used in the teaching and learning of mathematics in context. Mathematics educators should choose activities that provide a familiar context to the learners. Learners are attracted to mathematics classes and enjoy mathematical lessons that are presented in their familiar contexts (Mosimege, 2000).

2.7. Effective teaching of Mathematics through Constructivism

The National Curriculum Statement (NCS) encourages the development of learners' critical thinking powers and problem-solving abilities. The National Curriculum Statement has been amended, with the amendments coming into

effect in January 2012. A single comprehensive Curriculum and Assessment Policy document (CAPS) was developed for each subject to replace Subject Statements, Learning Programme Guidelines and Subject Assessment Guidelines in Grade R – 12 (Department of Basic Education, 2011).

The curriculum aims to ensure that children acquire and apply knowledge and skills in ways that are meaningful to their own lives. In other words, the curriculum promotes knowledge in local contexts, while being sensitive to global imperatives (Department of Basic Education, 2011). The curriculum supports the Social Constructivism Theory which is based on authentic and real-world situations. In this regard, learners are to be assisted to construct their own meaning and understanding by using a context which is familiar to them.

Teachers are encouraged to teach content in context so that learners can see the usefulness of mathematics in real-life situations. Taking cognizance of and recognizing learners' background experiences are considered crucial for meaningful learning to take place (Ernest, 1996; Bishop et al., 2003). Contextualization is advocated as an appropriate strategy in designing teaching and learning activities (Shirley, 1995).

Fasheh (1997) also sees mathematics as a cultural product as all people of the world practise some form of mathematics. As Fasheh (1997: 6) states:

> 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 mathematics 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 (Fasheh, 1997: 6).

Fasheh (1997) stresses that it should be understood that mathematics should not or could not be taught within one culture separate from other cultures. Advances in thought in one culture, should be understood and welcomed by other cultures. But these advances should be "translated" to fit the "borrowing" culture (Fasheh, 1997). In other words, what Fasheh is emphasizing here is that it is acceptable to import mathematical ideas from other communities and that they should be encouraged, but they should also be presented to the learners in a familiar setting.

He also pointed out that not only local and cultural meanings should be encouraged, but also personal feelings and interpretations (Fasheh, 1997). Here he emphasises the role of context in mathematics teaching. Culture influences the way people see things and understand concepts (Fasheh, 1982). Thus, 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.

2.8. Geometry and culture

Geometry and culture are examples of ethno-mathematics associated with a system of products in response to the principle need of an organized society to cater for the needs and aspirations of its people (D'Ambrosio, 2001). "Geometry" in its origin and in its name is related to measurements of land, while "calendar" is associated with counting and recording of time, which is arithmetic (D'Ambrosio, 2001). Geometry was learned from the Egyptians, and arithmetic originated from the Ancient Greeks. Geometry [geo = land, metry = measure] is the result of the Pharaohs' practice that made it possible to feed the population in years of low productivity, distribute productive lands along the banks of the Nile River, and measure the production following floods to collect the part intended or destined for storage, a form of taxation (D'Ambrosio, 2001).

It is very important to know where (space) and when (time) to plant, harvest and store. Calendars synthesize the knowledge and behaviour necessary for the success of the stages of planting, harvest and storage, which guaranteed the survival of the community.

In Egypt, geometry was more than a mere measurement of land; it had everything to do with the system of taxation of productive areas. Behind this development, there is an entire system of production and an economic, social and political structure that require measurement of land and, at the same time, arithmetic to deal with the economy and with counting time (D'Ambrosio, 2001). According to Thompson (1995), geometry is a branch of mathematics that deals with the properties and relations of points, lines, surface, space and solids. Culture can be defined as a set of shared knowledge and behaviour. Culture influences the way people see things and understand concepts (Fasheh, 1982). Human beings everywhere and throughout time have used mathematics in their everyday lives.

Mathematics 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 et al., 2003). Traditional objects such as baskets, mats, pots and rondavels seem to possess the geometrical forms that clearly indicate that geometrical knowledge was used during weaving or construction and decorations.

Studies analysing the geometry of the traditional cultures of indigenous people who may have been colonized, but have continued with their original practices have been undertaken (Bishop et al., 2003). These studies explored the ethno-mathematics of the traditional cultures of basket and mat weaving and plaiting; beadwork; house decorations and mural painting; geometrical knowledge of carpenters; indigenous games; wire artefacts; geometrical knowledge applied in the construction of traditional houses and granaries for maize and beans to name a few.

The role of technology and activity in the early development of geometrical thinking was analysed in Gerdes' doctoral thesis (English version: 2003). The following studies analysing the mathematical patterns and designs around the entire African continent investigating various traditional buildings and objects were explored. These studies explored the connections between mathematical concepts and the indigenous practices or socio-cultural activities. Some explored the relationships between mainstream mathematics (classroom mathematics) and ethno-mathematics (everyday mathematics).

- Gerdes (2005) explored the weaving of a nonahedral musical instrument weaved with cardboard strips and discovered other polyhedral in space. Gerdes (1996) also identified the mathematical aspects embodied in the activity of weaving by basket makers in Mozambique. Purkey (1998) demonstrated that there was mathematics embedded in the Basotho huts.

- Crowe in Gerdes (1999) analysed the Bakuba clothes and woodcarving in the Democratic Republic of Congo, and identified the geometrical patterns. Gerdes (1999) conducted numerous studies in the Sub-Saharan 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 of Begho, southern Ghana and eastern Cote d'Ivoire. Square and rectangular shapes were identified on the clothes.

- In Lesotho, symmetrical patterns in Sotho wall decorations (*litema*) were noticed (Gerdes, 1994). Properties of a circle, such as the centre of the circle, tangent, radius, diameter and circumference of a circle were identified on a basket bowl in Mozambique.

- Gerdes (1998) further identified regular hexagonal patterns on the light transportation basket called "litenga" in Mozambique. He also discovered attractive geometrical designs with axial, two-fold or four-fold symmetries. The global form of the design is that of a toothed square- a square with adjacent congruent teeth on its sides. The sides form angles of 45 degrees with the sides of the rectangular mats. He further analyzed and noticed diameter, radius, area and circumference on the circular mats in the north of Mozambique.

Major outcomes of these studies indicate that the classroom culture has an impact on students' learning and performance in mathematics (Nunes, 1992). The learners' social background and experiences play a very significant role. The investigations also show that this classroom culture is a complex phenomenon, that the processes that mediate its dynamic impact on learning and performance are not yet very well understood, and that the study of these processes can profit from the theoretical and methodological ideas that are connected to the anthropologist's perspective (Clarke, 2003; Presmeg, 2007).

All the above mentioned studies are relevant to this research project because the study explored the mathematical concepts that are embedded in the indigenous practices (traditional circular buildings) and their integration into the academic mathematics (high school mathematics). Evidently, in the above studies, the indigenous people used mathematical knowledge and ideas in their activities.

2.9. Examples of murals

Mural is a general term for the art of ornamenting a wall surface. This is one of numerous scarce branches of decorative art which has been applied to the ornamenting of wall surfaces. Various methods of mural decorations have been identified from the literature studies (Encyclopaedia Britannica, 2005, 2006, 2009):

- Relief Sculptured in Marble or Stone

This is the oldest method of all wall-decorations, of which numerous examples still exist. The tombs and temples of Egypt are rich in this kind of mural ornament.

- Marble Veneer

This is another widely-used method of mural decoration that applies thin marble linings to wall-surface, the decorative effect being produced by the natural beauty of the marble itself and not by sculptured relief.

- Wall-Linings of Glazed Bricks or Tiles

This is a hard kind of stucco made and possessed by the Greeks and Romans, creamy in colour, and a polish like finish to stand exposure to various weather conditions.

- Sgraffito

This is a variety of stucco work used chiefly in Italy, and employed only for exterior of buildings, especially the palaces of Tuscany and Northern Italy.

- Stamped Leather

This was a magnificent and expensive form of wall decoration by using the skins of goats or calves, which were tanned and cut into rectangular shapes.

- Painted Cloth

This is another form of wall-hanging where canvas is painted to imitate tapestry.

- Printed Hangings and Wall-papers

This is one of the most ancient arts whereby various textiles are printed with dye-colours and mordents.

- Painting

This is naturally the most important and the most widely used of all forms of wall-decorations, as well as perhaps the earliest (e.g. Egyptian, Roman, English painting, etc.).

In this study, the murals of the traditional buildings of the Limpopo Province, South Africa, were produced by painting with coloured soil on the wall and smearing cow dung on the floor. The murals were mathematically interesting because transformations such as translation, reflection, rotation, tessellation, and other shapes such as *rectangle, triangle, trapezium, oval, square, parallelogram and rhombus* were displayed in the decorations of these traditional circular structures. These geometrical concepts appear in the high school mathematics curriculum and could be used in the study of *fractions, percentages, circle geometry, angles, triangles, quadrilaterals, etc.*

It is important to indicate that these mathematical shapes or concepts were not the only ones to be found in the design or structure and mural decorations of traditional buildings. It is also possible that other mathematical concepts may be found through further analysis of the mathematical shapes and literature on mural decorations.

2.10. Acquisition and transmission of indigenous knowledge (Source of knowledge)

Locally based knowledge systems are transmitted in different ways from the elders. Although some indigenous knowledge is recorded in texts, most is orally based and is often revealed in stories and legends, as well as through actual practice (Bob, 2001). IKS depend on living people as sources. Actions and spoken words are used. In the case of traditional circular houses, skills are passed from one generation to the next by the act of teaching-by-doing. Knowledge is acquired through accumulation of experience and informal experiments. Novices observe the expert and practice until they acquire

knowledge. There is no formal schooling or training. Knowledge is acquired and transmitted to the next generation by the act of teaching -by-doing.

The fact that the knowledge of mathematics used in the construction and decorations of the indigenous circular houses had not been formally learned at school, suggests that it is not only those who have attended formal school who can develop mathematical knowledge. One can learn mathematics by interacting with one's immediate environment, and one uses aspects of mathematics in daily life (Mogari, 2001).

Mathematical knowledge is a component of culture, since aspects of mathematics manifest themselves in daily activities (Encyclopaedia Americana, 2010). According to Mogari (2001), mathematical knowledge does not originate from one community only, but it is developed by all communities.

2.11. Symbolism

In this study, the focus was on the mathematical concepts of the traditional circular buildings and their integration into high school mathematics, but due to the prevailing circumstances the following social significances of mural decorations were also captured. From the literature study, the researcher realised that murals had deeper significance other than merely beautifying or decorating the homes for aesthetic purposes (Encyclopaedia Britannica, 2009).

- Decorations are a form of religious art relating the beliefs concerning the ancestors. Historically mural decorations brought homage to the ancestors and in more recent times, they represent aspects of celebration, ritual and initiation.

- Colours of the decorations themselves have strong symbolic and religious relevance; in some instances even making feminist and political statements.

- In the African culture, murals around windows and doors sometimes prohibit evil spirits or people supposed to have dealing with the devil from entering into the house.

- White colours symbolise happiness and peace while black and dark colours symbollise negative emotions such as grief or sadness.

From the literature study, the researcher realised that everywhere and throughout time, human beings use mathematics in their everyday lives. There are plenty of mathematical concepts embodied in the structure and mural decorations of the traditional circular buildings. The concepts are similar to the ones taught in the high school mathematics and can be used to teach mathematics in context.

Learners can learn better when learning is approached from a practical angle. Thus, to enhance the teaching and learning of mathematics in context, learners should be exposed to the practical activities. The purpose of this research was to explore the mathematical concepts of the traditional buildings of Limpopo Province and integrate them into the teaching and learning of high school mathematics.

2.12. Summary

In the National Curriculum Statement of South Africa, there is an expectation that teaching should contribute towards the wider development of different cultures (DoE, 2001). The use of culture in teaching is thus included, for it influences the way people see and 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 (DoE, 2001). Mathematics is thus cultural knowledge, like the rest of human knowledge. 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. The next chapter outlines details of the research design and methodology.

CHAPTER THREE

RESEARCH DESIGN AND METHODOLOGY

3.1. Introduction

This chapter outlines the processes that were engaged in, in the collection of data for this research. It starts with a detailed discussion of the research design and research methods that were employed in the study. The chapter discusses the population, sample selection and sampling procedures. It also includes a statement about the ethical considerations and quality assurance which are central in qualitative studies. The discussion in this chapter indicates the instruments used to generate data, data collection procedures and the administration of instruments. The in-depth discussion on the data analysis methods chosen for the research and how quality assurance was addressed are included in this chapter.

3.2. Research design

Punch (2006: 66) describes research design as the overall approach to be taken in a research study. A research design refers to the plan and structure of the investigation used to obtain evidence to answer the research question (McMillan & Schumacher, 2006).

Mouton (2003) further defines a research design as a set of guidelines to be followed and instruments to be used in addressing the research problem. The main function of a research design is to enable the researcher to anticipate what the appropriate research decisions should be so as to maximize the validity of the eventual results (Mouton, 2003). Le Roux (2000: 36) further states that all studies require an outline of the research methods in which the issues of research methodology are discussed, described, planned and determined on the basis of the nature of the particular study. Methods can be either qualitative or quantitative, or both.

A research method is a description of how information is generated and the methodology for dealing with this information (Schulze, 2002: 11). According to Leedy and Ormrod (2001), the nature of the data required and the questions asked, determine the research methodology that is used. The choice between quantitative and qualitative research is influenced by particular assumptions about the nature of reality (ontology) and the nature of knowledge (epistemology). The research methods adopted in the study had to include a number of activities which helped to explore the mathematical concepts of the traditional circular buildings in the Limpopo Province.

De Vos (1998) regards the choice of methods as being one of the most crucial decisions the researcher has to make in research. He distinguishes between nomothetic strategy, which focuses on general trends or patterns, and an idiographic strategy, which focuses on unique qualitative and quantitative methods or characteristics.

In this study, the choice of methods for the research was focused on both the general trends or patterns and the unique characteristics of shapes or structures. The study was conducted through a combination of qualitative and quantitative research methods. This combination of research methods is called a triangulation (De Vos et al., 2005).

Triangulation is the combination of two or more data-collection methods, and reference to multiple sources of information to obtain data (Du Plooy, 2009). Mixed methods research is relatively new and builds on both quantitative and qualitative approaches.

Creswell (2005) defines mixed methods as a procedure for collecting, analysing and "mixing" both quantitative and qualitative data at some stage of the research process within a single study to understand a research problem more completely.

Creswell (2005) provides the following four main reasons for combining quantitative and qualitative methods within one study. These are:

- Explaining or elaborating on quantitative results with subsequent qualitative data.
- Using qualitative data to develop a new measurement instrument or theory that is subsequently tested.
- Comparing quantitative and qualitative data sets to produce well-validated conclusions.
- Enhancing a study with a supplemental data set, either quantitative or qualitative.

In this study, the researcher collected both numerical information on the survey instrument (questionnaire) and text information (interviews or observations) to answer the study's research questions.

De Vos et al. (2005) argue that in addition to the use of two or more methods and multiple sources of data, triangulation also applies to:

- The collection of data using different types of sampling.
- The analysis of the same data from two or more theoretical and conceptual perspectives (theory triangulation).
- The conduct of observations or analysis of data using more than one investigation (investigation triangulation).

Both qualitative and quantitative research approaches were used because the use of only one research method could compromise the internal validity of data collected, and ultimately the reliability of the research findings (Maree, 2007).

The use of multiple sources of data collection in a single research project increases the reliability of the results, and also compensates for the limitations of each method (Maree, 2007). The combination of research methods strengthens the rigour of the research design (Maree, 2007). Observation and interview methods are qualitative in nature while a questionnaire is used in the quantitative

research method. A camera was used to take photos in the research study. Ethnographic research design and survey research design were used to capture, analyse, interpret and explain specific mathematical concepts or structures.

3.2.1. Qualitative research methods

Qualitative research is a naturalistic inquiry, the use of non-interfering data collecting strategies to discover the natural flow of events and processes, and how participants interpret them (McMillan & Schumacher, 2006). Mouton (2007) defines qualitative research as the approach in which the procedures are formulated and explicated in a less 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. White (2005: 80) further states that the qualitative research method deals with data that are principally verbal.

In the qualitative research method, the point of departure is to study the object, namely man, within unique and meaningful human situations or interactions. In this approach it is often observation and interviews that generate the investigation or data.

According to Gall, Borg, and Gall (2003), man is the primary data-collecting instrument in this qualitative research. Denzin and Lincoln (2005) define qualitative research as multi-method in focus, involving an interpretive, naturalistic approach to its subject matter. This means that qualitative researchers study objects 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 (2005), qualitative researchers deploy a wide range of interconnected methods such as a 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 wide range of situations for a wider range of purposes. The essential purposes of qualitative research are to document in detail the conduct of everyday events and to identify the meaning that those events have for those who participated in them and for those who witness them. The emphasis is on discovering kinds of things that make a difference in social life.

According to Leedy and Ormrod (2001), a qualitative approach:

- Reveals the nature of situations, settings, processes, relationships, systems or people; and
- Enables the researcher to gain insights into a particular phenomenon and develop new concepts about a phenomenon.

Qualitative research attempts to discover the depths and complexity of a phenomenon (Bell, 2005). Human, social actions and opinions are locally distinct and situationally contingent. The qualitative researcher's emphasis is to study human action in its natural setting and through the eyes of the participants themselves (Babbie & Mouton, 2001).

Maree (2007: 74) identified the following qualitative research designs:

- **Ethnographic research design**: In this research design the researcher spends a significant amount of time in the field so that he can study the lives of the people within their natural setting.
- **Case study design**: This is a systematic inquiry into an event or a set of related events which aims to describe or explain the phenomenon of interest.
- **Action research design**: This is the process through which practitioners study their own practice to solve their own personal problems.

- **Grounded theory**: This is the theory that is inductively derived from the study of the phenomenon it represents.
- **Survey research design:** In this research design, an investigator selects a sample of subjects and administers a questionnaire or conducts interviews to collect data.

In this study, ethnographic research and survey research were used to capture, analyze, interpret and explain specific aspects of mathematical aspects or structures embodied in the traditional buildings. Data were generated through the researcher's observation of the mathematical aspects or structures embedded in the construction and mural decorations of the traditional buildings of Mopani, Vhembe and Sekhukhune districts of the Limpopo Province, South Africa. Builders were interviewed by the researcher to get first hand information on mathematical aspects found on the traditional buildings.

3.2.2. Quantitative research method

Schulze (2002: 11) defines quantitative research as a statistical calculation of figures (numbers) for analyzing and interpreting results. Maree (2007) also defines quantitative research as a process that is systematic and objective in its ways of using numerical data from only a selected subgroup of a population to generate the findings to the population that is being studied. Quantitative research is the approach that is more structured or formal in nature as well as explicitly controlled, with more carefully defined scope (Mouton, 2001). Quantitative research presents statistical results with numbers (McMillan & Schumacher, 2006).

Quantitative research concerns things that can be counted. One of its most common disciplines is the use of statistics to process and explain data and to summarize findings (Fox & Bayat, 2007). In general, quantitative research is concerned with systematic measurement, statistical analysis and methods of experimentation.

Fox and Bayat (2007: 87) present the following characteristics of quantitative research:

- Data is in the form of numbers.
- The focus is concise and narrow.
- Data is collected by means of structured instruments such as questionnaires.
- Results are less detailed as far as behaviour, attitudes and motivation are concerned.
- Results are based on larger sample sizes representative of the population.
- Given its high reliability, the research can be represented or replicated.
- Analysis of results is more objective.
- Hypotheses may be tested.
- Concepts are in the form of distinct variables.
- Standardized measures are systematically created before data is collected.
- Reasoning is logically deducted, going from the general to the specific.
- Knowledge is based on the relationship between cause and effect.
- Analysis progresses by way of charts, statistics and tables and then discussion on what they reveal in relationship to the hypothesis.

According to Fox and Bayat (2007: 88), the following are some of the advantages of quantitative research:

- The use of numbers allows greater precision in reporting results.
- Powerful methods of mathematical analysis can be used in the form of computer software packages.

In this study, a questionnaire about mathematical structures or concepts of indigenous buildings was given to Grade 12 educators to answer.

3.2.3. Ethnographic research design

Ethnography comes from cultural anthropology (Neuman, 2006). "Ethno" means people or folk and "graphy" means writing about or representing something. Thus, "ethnography" refers to describing different cultures from the viewpoint of an insider in the culture to facilitate understanding. Ethnographic research, which is an interactive research that requires relatively extensive time in a site to systematically observe, interview, and record the processes as they occur at the selected location (McMillan & Schumacher, 2006), was used.

Bogdan and Biklen (2003) 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 (McMillan & Schumacher, 2006).

Ethnography can also be described as an essential descriptive design which is used in investigations amongst individuals or groups within a given group, community or organisation (Welman, Kruger, & Mitchell, 2005). The ethnographer systematically works at deriving the meaning of events. He does not immediately decide the meaning of, for example, one student hitting another.

Ethnographers spend a significant amount of time in the field so that they can study the lives of the people from within their naturalistic settings (Maree, 2007). The aim is to describe a culture or a way of life from the perspective of people by making sense of the inherent meaning of gestures, displays, symbols, songs, sayings, and everything else that has some implicit or tacit meaning in the culture (Maree, 2007). Ethnography can be described as the data of cultural anthropology that is derived from the direct observation of behaviour in a particular society (Babbie & Mouton, 2001).

The researcher is very often not a member of the group. He or she needs to spend time living in a community observing and doing in-depth interviews, reading and researching source materials, and observing the lives of the people he or she wishes to study. An ethnographer seeks to understand people's construction, what are their thoughts and meanings, feelings, beliefs, and actions, as they occur in their natural context. Research reports are in a narrative format. Participant observations and semi-structured interviews are the most common methods used in ethnographic research to fulfil the criterion of validity.

3.2.4. Survey research design

McMillan and Schumacher (2001: 602) define a survey research as "the assessment of the current status, opinions, beliefs, and attitudes by questionnaires or interviews from a known population". In survey research, an investigator selects a sample of subjects and administers a questionnaire or conducts interviews to collect data (McMillan & Schumacher, 2006). The data gathered are used to describe the characteristics of a certain population.

Maree (2007) uses the word "design" to describe the degree of control the researcher manages to exert over her or his environment. Cohen, Manion, and Morrison (2001: 169) assert that surveys "set out to describe and to interpret what is". Surveys are used frequently in educational research to learn about people's attitudes, beliefs, values, opinions, behaviour, habits, desires, ideas, and other types of information (McMillan & Schumacher, 2006).

In a survey research, the research is usually designed so that information about a large group of people (population) can be inferred from the responses obtained from a smaller group of people (sample). It is used frequently in business, politics, government, sociology, public health, psychology, and education because accurate information can be obtained for large numbers of people with a small sample (McMillan & Schumacher, 2006).

Most surveys describe the incidence, frequency, and distribution of the characteristics of an identified population (McMillan & Schumacher, 2006). McMillan and Schumacher (2006) further state that in addition to being descriptive, surveys can also be used to explore relationships between variables, or used in an explanatory way. The Department of Education uses surveys to determine levels of knowledge and to ascertain needs in order to plan programmes (Department of Education, 2007). Schools use surveys to evaluate aspects of the curriculum; government agencies use surveys to form public policy and universities use surveys to evaluate their courses and programmes (Department of Education, 2007).

In conducting survey research, the selection of the population, choosing and developing a technique for data gathering and the sampling procedures are crucial (McMillan & Schumacher, 2006). More complex factors include the positioning of questions and their wording (McMillan & Schumacher, 2006).

Maree (2007: 156-158) identifies the following different ways of conducting a survey research:

- Group administration of questionnaires where a whole group of respondents complete questionnaires.
- Postal survey where questionnaires are mailed to respondents who have to read instructions and answer the questions.
- Telephone survey where the respondents are phoned by interviewers, who ask the questions and record the answers.
- Face-to-face survey where well-trained interviewers visit the respondent, ask the questions and record the answers.
- Questionnaires delivered by hand so that the respondents can complete them on their own time, and then the researcher collects them later.

In this study, a self-completion questionnaire was given to eighteen Grade 12 mathematics educators within Mopani, Vhembe and Sekhukhune to answer. Teachers were given two weeks to complete them and the researcher collected them at a later stage.

Pilot Study

A pilot study was conducted with a small group of mathematics educators who did not participate in the main study. This was done to test the validity and reliability of the research instruments and to adapt them where necessary. A pilot study can be defined as the process whereby the research design for a prospective survey is tested (De Vos et al., 2005). Bless and Higson-Smith (2000: 155) provide what is perhaps the most encompassing definition of the pilot study:

> A small study conducted prior to a larger piece of research to determine whether the methodology, sampling, instruments and analysis are adequate and appropriate (Bless & Higson-Smith, 2000: 155).

Mitchel and Jolley (2001: 13-14) add that a pilot study helps the researcher to fine-tune the study for the main inquiry. It is one way in which the prospective researcher can orientate himself to the project he has in mind (De Vos et al, 2005:205). Mouton (2001:103) further says that one of the most common errors in doing research is that no piloting or pre-testing is done. Prospective researchers are often over-hasty to get to the main investigation, and are therefore inclined to neglect the pilot study.

McBurney (2001: 228-229) says the temptation to skip the pilot phase should be restricted because a little effort can greatly increase the precision of the study. Researchers should never start the main inquiry unless they are confident that the chosen procedures are suitable, valid, reliable, effective and free from problems and errors, or at least that they have taken all possible precautious measures to avoid any problems that might arise during the study (Sarantakos, 2000:291).

The pilot study forms an integral part of the research process. It is indeed a prerequisite for the successful execution and completion of a research project. A pilot study has the following values for the research study (De Vos et al., 2005):

- Suitability for the interview schedule or questionnaire;
- Testing and adapting the measuring instruments or apparatus;
- Suitability of the procedures of data collection;
- Suitability of the sampling frame; and
- Variability of population (De Vos et al., 2005: 296).

Using a pilot study is always a good idea to test whether the respondents interpret the questions correctly and whether the response categories provided for the questions are suitable. The feedback from the respondents in the pilot study may lead to some adjustments being made to the instrument.

In this study a pilot was conducted on the three (3) selected Grade 12 educators. The pilot study conducted on the selected participants exposed the following problems and errors from the research instruments: (See attached questionnaire as Appendix E on Annexure).

- Questions posed a problem

Questioning emerged as one of the issues that needed special attention. The questions were not relevant and sufficient to provide useful answers to the research questions. There were no questions on the preparation and presentation of mathematics lessons, teaching and assessment strategies in mathematics, mathematics teacher support materials, and mathematics teacher support and development. Also questions on the use of cultural artefacts to contextualize the teaching of mathematics, and problems or challenges faced by mathematics educators when teaching mathematics in context were not raised. Participants provided answers that were not useful to the research.

It was then realised that it was important to pose questions so that the respondents did not find them ambiguous. Questions should be thoroughly checked before they are given to participants to avoid double-barreled questions, i.e., questions which have two parts to them.

- Participants' understanding of questions

Initially, it was thought that the respondents were not competent to answer the questionnaires, but later the researcher realised that the educators did not understand the questions. Questions were not straight forward and also not clear. Questions were too long and not easy to understand. They needed to be changed completely. With the help of the supervisors the questions were changed and re-formulated.

- Number of participants

It was through this pilot study that the researcher realised that the number of participants should not be three but should be more. The three educators compromised the validity and reliability of the results. With the help of the supervisors of the research, the number was increased from three to eighteen.

3.3. Population for the research

Babbie (2007: 190) defines a population as the aggregation of elements from which a sample is actually selected. Population is a group of elements or causes, whether individual objects or events that conform to specific criteria and to which the researcher intends to generalize the results of the research (McMillan & Schumacher, 2001: 169). Population also refers to a large group of subjects or participants. Wayne and Stuart (2001) further define population as any group that is the subject of research interest.

The accessible population or target group for this study was the builders and the Grade 12 mathematics educators from the Vhembe (Tshivenda), Mopani (Xitsonga) and Sekhukhune (Sepedi) districts of the Limpopo Province. The three districts were chosen because they are classified largely as rural compared to

other districts in the Province. They also have many indigenous buildings which formed the basis for the collection of data.

Vhembe consists of five municipalities and only two, that is, Thulamela and Makhado were chosen for the research. Mopani is made up of five municipalities and only Tzaneen and Giyani were considered. Sekhukhune consists of five municipalities and only Tubatse and Fetakgomo were chosen for the research. Besides being classified largely as rural compared to other municipalities in the districts, the above mentioned municipalities were chosen due to the following reasons: (1). they represent the cultural diversity within the province, and (2). they also have many indigenous buildings which formed the basis for the collection of data.

According to the DoE EMIS Report (2011) from each Municipality, Greater Tzaneen has 32 Grade 12 Mathematics educators, Greater Giyane 28, Thulamela 29, Makhado 30, Tubatse 35 and Fetakgomo 33. The total population of Grade 12 educators was 187.

The number of builders was made up of 13 builders of traditional houses in Greater Tzaneen, 12 in Greater Giyane, 10 in Thulamela, 11 in Makhado, 12 in Tubatse and 10 in Fetakgomo (Municipality Data Base, 2011). The total population of the builders was 68. The total population of educators and builders eligible to participate in the research study was 255.

3.4. Sample selection and Sampling procedure

White (2005: 114) describes a sample as a portion of the elements in a population. It is a smaller group or subset of the total population where the data is obtained in such a way that the total population is represented (Cohen, Manion, & Morrison, 2007: 100). A sample consists of individuals selected from a population (McMillan & Schumacher, 2001). The sample must be representative of the population being studied otherwise no general observations about the population can be made from studying the sample.

Sampling is defined as the process used to select a portion of the population for a study (Maree, 2007). Mouton (2007) further defines sampling as the process of selecting things or objects when it is impossible to have knowledge about a large collection of those objects. Du Plooy (2009) also defines sampling as the process of following rigorous procedures when selecting individual units from a large population.

The main aim of sampling is to produce a representative selection of population elements. Qualitative research method is generally based on non-probability and purposive sampling while quantitative research is based on probability or random sampling approaches. White (2005: 115) further explains that if the population is relatively small, the sample should comprise a reasonably large percentage of the population.

In this study, the following sampling techniques were used and the sample size was determined by percentage, accessibility and convenience.

3.4.1. Selection of builders

A purposive non-probability sampling technique was used to select the sample of the traditional builders. Purposive sampling was used because it involves selecting information-rich cases for study in-depth when one wants to understand something about those cases. Du Plooy (2001: 164) argues that "when drawing a purposive sample...previous knowledge of the population and/or the objective of the study can result in the researcher using his or her judgment to select a sample". Purposeful sampling requires that information be obtained about variations among the sub units before the sample is chosen (McMillan & Schumacher, 2001). White (2005: 119) further explains that non-probability sampling is the most common type in educational research.

Purposeful sampling is a qualitative sampling strategy whereby the researcher selects individuals and sites for study because they can purposefully inform an understanding of the research problems and central phenomenon in the study (Creswell, 2007: 125). Purposive sampling simply means that participants are selected because of some defining characteristics that make them the holders of

the data needed for the study. Accessibility and convenience can result in the researcher using his or her judgment to select a sample. In this study, sampling was flexible and often continued until no new theme emerges from the data collection process – this is called data saturation (Maree, 2007).

White (2005: 115) explains that a qualitative sample size must be suitable for specific situations and that a purposeful sample size can range from 1 to 40 or more. In this study, the population consisted of sixty eight builders from all six municipalities. Given the vastness of the target population, accessibility and convenience, a sample size of six builders, one from each of the six chosen municipalities was selected and participated in the study. Builders who were accessible and convenient to reach were chosen. The percentage size was approximately ten percent from each municipality. The builders with expertise in building the traditional houses were selected from each cultural group to accommodate their cultural diversity. The builders were interviewed by the researcher to get first hand information.

3.4.2. Selection of educators

The number of mathematics educators was 187. Given the vastness of the area, ten percent of the total population from each municipality was selected. A sample size of eighteen Grade 12 mathematics educators, three from each of the above mentioned municipalities, was chosen for the study. Three schools from each municipality were chosen to participate in the research and only one Grade 12 mathematics educator per school was selected. Taking into consideration that some chosen schools had only one Grade 12 mathematics educator, in such instances that educator was automatically selected for the study.

In the case where a chosen school had more than one Grade 12 mathematics educators, simple random sampling was used so that every member (Grade 12 mathematics educators) of the population had an equal chance of being chosen to be in the sample. In simple random sampling, all subjects selected from the

population have the same chance of being selected (McMillan & Schumacher, 2006). In such instances only one educator per school was chosen to participate.

Schools that were within the municipalities involved in the research and which were situated in an area where there were plenty of traditional circular houses were chosen for the research project. This made it possible to undertake a study of traditional houses in a familiar setting. Three schools from each municipality were chosen for the project. A total of eighteen schools were chosen to participate in the research study.

3.5. Research assumptions

The research was based on the following assumptions:

- The builders selected for the study within the Limpopo Province had the expertise in building the traditional circular buildings and also had their own cultural values which they upheld either as individuals or as a collective.
- Some mathematics educators faced challenges in contextualising their teaching.
- Mathematics educators needed suggestions that could assist them on how to make use of cultural artefacts to contextualise their teaching.
- All the participants, i.e., the builders and the educators gave a true reflection on behalf of the whole population of the research in their responses.

3.6. Ethical statement

Ethics are the norms or morals of conduct that distinguish between acceptable and unacceptable behaviour or between right or wrong, proper or improper, good or bad. David and Resnik (2007) define ethics as a method, procedure, or perspective for deciding whether to act and for analyzing complex problems and issues. Since research often involves a great deal of cooperation and

coordination amongst many different people in different disciplines and institutions, many of these ethical standards promote the values that are essential to collaborative work.

Schulze (2002: 17) advises that whether the researcher uses a quantitative or qualitative research approach, it is important that the researcher does his/her research in an ethically responsible way. Researchers are ethically obliged to anticipate what will be done in data collection, analysis and reporting, and to explain to the subjects or participants why it will be done in a specific way.

The primary ethical obligation of the research is to do no harm. Since qualitative research requires active participation in and commitment to the research by those who are studied, the best way to achieve trust with participants in the research relationship is by being trustworthy as a researcher.

In this study, the researcher was given permission to proceed with the research by the Faculty of Education Higher Degrees Research Committee. This was in compliance with the North West University's Ethic requirements. The Limpopo Department of Education also granted permission to conduct research using Grade 12 mathematics educators within Mopani, Sekhukhune and Vhembe districts.

The participants were informed about their involvement in the research. The researcher discussed the proposed research activities, the nature of the project, the nature and the type of data to be collected, the means of collection and the purpose of the research with all the participants. Participants, i.e., the builders and the educators were given the right to withdraw from the study if they wished. The researcher was also given permission by the owners of the buildings before any research was conducted on their buildings.

Privacy and confidentiality of all the participants were guaranteed. No other person had the opportunity to access data obtained from the builders or the educators. Names of the participants were not revealed to other people, organisation or institution. Participants were given the right to remain anonymous

or to use pseudonyms so that they could not be identified. Data was not linked to the individual subjects by name and no one had access to the real names of the participants.

The researcher co-operated fully with all participants in the study. The co-operation and contributions of all the participants were acknowledged in such a way that confidentiality was retained. The researcher was very open and honest with the builders and the educators. The issue of intellectual property rights was fully considered in the research study by acknowledging the knowledge and expertise of all the contributors in this study.

3.7. Instrumentation

Another way to classify research besides research design is to examine the technique used in the study to collect data. The researcher indicates how the data was generated. According to McMillan and Schumacher (2006), there are basically six ways to collect data: Observations, questionnaires, interviews, documents, tests, and unobtrusive measures.

In this study, the following instruments and data collection methods were used:

(a). An observation schedule was used to observe and study the mathematical concepts and shapes on the traditional building. See appendix C.

(b). An interview schedule was used to interview the builders about mathematical shapes or concepts used in the traditional circular buildings. See appendix A.

(c). A questionnaire about mathematical concepts on the traditional buildings was given to the Grade 12 educators to answer. See appendix B.

(d). A camera was used to photograph mathematical concepts shown on the traditional buildings.

3.7.1. The use of observation in the research

Esterberg (2002) 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. McMillan and Schumacher (2001) define observation as a technique for gathering data which relies on a researcher seeing and hearing things and recording these observations rather than relying on subjects' self reported responses to questions or statements. Maree (2007) further defines observation as the systematic process of recording the behavioural pattern of participants, objects and occurrences without necessarily questioning or communicating with them. It is an everyday activity whereby their senses (seeing, hearing, touching, smelling and tasting) are used.

As a qualitative data collection technique, observation is used to enable the researcher to gain a deeper insight and understanding of the phenomenon being observed (Patton, 2002). In this study, the researcher spent some time observing different types of mathematical concepts on the traditional buildings. Various mathematical aspects and structures on the mural decorations from the floor, the inner and the outer side of the walls, were observed. The researcher also spent time observing the roof patternings to find out the mathematical concepts or structures. Mathematical concepts or shapes observed were recorded on the observation schedule.

a) Types of observations

Maree (2007: 84) identifies the following types of observation in qualitative research:

- Complete observer;
- Observer as participant;
- Participant as observer; and
- Complete participant.

The researcher used this type of observation:

- Observer as participant

Here the researcher gets into the situation, but focuses mainly on his role as observer in the situation, which was studying aspects of mathematics embodied in the construction and decorations of the traditional buildings (Maree, 2007). A camera was used to take some photographs of the mathematical concepts that were embodied in the traditional buildings. Field notes were taken and a short description of basic actions during observations were recorded (Maree, 2007).

The researcher observed all mathematical concepts and structures on the traditional buildings and recorded them on the observation schedule. Non-verbal observations (cues) were also captured (Maree, 2007). Concepts that were not on the observation schedule, but observed on the traditional buildings, were also written down in the note book.

(b) Observation methods used

In this research, ethnographic observation was used to observe mathematical concepts or structures of the traditional building and to study, in-depth ways of constructing and decorating traditional circular buildings. As ethnographic observations are unstructured, note taking was used to record the findings. Participant observation technique was used 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 and from the group's point of view in their own cultural settings (Charles & Mertler, 2002). When doing ethnographic research, the researcher is interested in the characteristics of a particular setting, and in how people create and share meaning (their custom, habits and behaviours).

(c). Details of observation schedule

The observation schedule contained the following items or themes:

- The shape of the foundation of the house, the wall and the roof of the house.
- Mathematics structures or concepts found on the floor, wall and roof decorations.

(d). How observation was captured and recorded

The most important part of observation is the recording of the data. In recording the observation one should capture two dimensions: (1).The description of what one has observed (i.e. the description of what actually takes place without including any value judgement). (2). One's reflections about what happened (i.e. own thoughts or ideas about the meaning of what was observed).

In this study the following recording techniques were used:

- Structured observations

The researcher identified predetermined categories of actions and patterns to be observed and wrote them on the observation schedule. The mathematical aspects were captured or recorded on the observations schedule.

The following mathematical concepts or structures were also recorded on the observation schedule (see Appendix C):

- The circular shape of the foundation;
- The cylindrical shape of the wall;
- The conical-shape or funnel-shape of the roof;
- Mathematical structures and concepts such as triangle, oval, translations and rotations on the floor and wall mural decorations; and
- Parallel lines on the roof decorations.

- Photography

Mathematics aspects or structures of the traditional buildings were photographed as evidence of their presence on the buildings. A camera was used to photograph mathematical concepts shown on the traditional buildings. It seemed the buildings possessed mathematical shapes and concepts such as *circumference, radius, diameter, loci (centre of the house), rectangle and square* which seemed to be similar to the ones in the high school mathematics curriculum. See various photos in chapter four.

Photography is the art or process of producing images of objects on photosensitive papers or by the action of radiant energy and especially light on a sensitive medium (Free Merriam-Webster Online Dictionary, 2010). Mathematical concepts of the traditional buildings of the Limpopo Province were photographed as evidence of their presence on the buildings.

Photographs could be separated or divided into two categories in qualitative research: Those that others have taken (Found Photographs) and those that the researcher produced by him/herself (Researcher-Produced Photographs). In this study, the researcher used Researcher-Produced Photographs.

3.7.2. Data collection by means of interviews

An interview is a two-way conversation in which the interviewer asks the participants questions to collect data and learn about ideas, beliefs, views, opinions and behaviours of the participants (Maree, 2007: 87). The conversation is initiated by the interviewer for the specific purpose of obtaining research material and focuses on content specified by research objectives of systematic description, prediction, or explanation. The aim of qualitative interviews is to see the world through the eyes of the participant, and to obtain rich descriptive data that help the researcher to understand the participant's construction of knowledge and social reality (Maree, 2007).

According to White (2005: 141), interviews are chosen because they represent the most efficient way of collecting data. It is a technique that involves the gathering of data through direct verbal interaction between individuals. If the interviewees think the topic is important and they trust the researcher, they will provide information that one will not be able to collect in any other way. McMillan and Schumacher (2006) define the interview as a technique in which the researcher poses a series of questions to the respondents in a one-to-one situation. It is a personal conversation through which research information is obtained.

For confidentiality purposes, respondents were assured that their names would not appear anywhere in the thesis and this assurance allowed them to give open and honest responses to the questions posed to them. Berg (2004) defines an interview as a conversation with a purpose. The main purpose of the research interview is to obtain information about a human being, his opinions, attitudes, values and his perceptions towards his environment. The in-depth face-to-face interviews with the builders of the houses were conducted to get first-hand information about the mathematical concepts or shapes of the traditional buildings of the Limpopo Province.

In this study, the purpose of the interview was to investigate mathematical concepts or shapes or symbols used in the construction of traditional buildings of the Limpopo Province and integrate them into the teaching of high school mathematics.

Interviews were conducted with builders of the traditional circular buildings. An interview guide was used to elicit responses from the participants. Interviews are best recorded using tape recorders, but additional notes were taken during the interviews (See attached interview schedule as Annexure A).

(a). Types of interviews

- Open-ended interviews

According to Welman, Kruger and Mitchel (2006: 174), an open-ended interview is the one in which the interviewer asks a question without any prompting with regard to the range of answers expected. Open-ended interviews are normally spread over a period of time and consist of a series of questions.

- Semi-structured interviews

Maree (2007) defines a semi-structured interview as the one in which the participants answer a set of predetermined questions. It does allow for probing and clarification of answers and therefore the researcher needs to be attentive to the responses so that newly emerging ideas, in this case mathematical concepts, can be identified and explored.

(b). Interview techniques used in the research

Semi-structured interviews were used. The predetermined questions about mathematical concepts or structures of the traditional buildings were asked. Open-ended interviews were employed by the researcher with the purpose of obtaining builders' views on the symbols embedded in the buildings. Follow-up questions were posed at the end of the interview in order to assist the researcher to get clarity on aspects that were not clear in the responses or to double-check a previous response.

(c). Construction of the interview schedule

Open ended and semi-structured questions based on the following items or themes were constructed on the interview schedule: See annexure A.

- The shape of the house (foundation, wall and roof);
- Symbols or shapes on the traditional circular buildings;
- The meaning of the symbols to the people;
- The source of the different symbols or shapes on the house;

- Symbolism to the people (cultural identity, cultural structure);
- Measurement of the traditional circular house; and
- Construction of the traditional circular house.

The interview guide helped to elicit responses from the builders of the houses.

(d). How the interview was conducted

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The interviews were conducted following suggestions given by Berg (2004).

The researcher established the duration of the interview and timed it to last for a maximum of 30 minutes. Interviews were conducted with builders of the traditional circular buildings. An interview guide was used to elicit responses from the participants. The predetermined questions about mathematical concepts or structures of the traditional buildings were asked. Open-ended interviews were employed by the researcher with the purpose of obtaining builders' views on the mathematics embedded in the buildings. Interviews were recorded using a tape-recorder and transcribed at a later stage. At the end of the interview, follow-up questions were posed to assist the researcher to get clarity on aspects that were not clear from the previous responses. Notes were taken during the interviews. After the interview, the researcher thanked the respondents for their cooperation.

3.7.3. The use of questionnaire in the research

A questionnaire is a set of appropriate structured questions constructed by the researcher and given to the subjects (participants) to answer (McMillan & Schumacher, 2001). De Vos et al. (2005) define a questionnaire as a set of questions on a form which is completed by the respondent in respect of a research project. It is easy to compile a questionnaire but it is not easy to compile an effective one. An effective questionnaire requires planning before hand to ensure that effective data can be objectively analyzed afterwards (McMillan & Schumacher, 2006).

(a). Structure and composition of the questionnaire

Babbie (2004) suggests the following guidelines for writing effective questions or statements:

- Make items clear;
- Avoid double-barreled questions;
- Respondent must be competent to answer;
- Questions should be relevant;
- Items should be short and simple;
- Avoid negative items; and
- Avoid biased items or terms.

The items developed for this study were short, clear, simple and relevant to the research. The researcher tried to avoid double-barreled questions and biased items. Both closed questions and open-ended questions were used in the questionnaire. The Likert Scale was used for responses to some questions. A questionnaire was developed and given to the teachers to answer.

A questionnaire about mathematical concepts on the traditional buildings was given to the Grade 12 mathematics educators to answer. Questions asked from section A to section G were closed questions based on effective teaching and learning of mathematics. From question five to question nine on section H needed Likert scale responses. The questions were about mathematical concepts of the traditional circular buildings and their integration into the high school mathematics. In section H, open-ended questions were asked. The questions were based on problems or challenges faced by mathematics educators in teaching of mathematics in context, and possible solutions to the problems.

(b). Administration of questionnaires

The questionnaires were delivered by hand to the chosen 18 Grade 12 mathematics educators to answer (See Annexure B). Teachers were given 15 days to complete the questionnaires and they were collected at a later stage. All mathematics educators selected for the research study responded positively and submitted their completed questionnaires on the 15th April 2011.

3.8. Methods of data analysis

Analysis means categorising, ordering, manipulating and summarising data to obtain answers to research questions (De Vos et al., 2005). The purpose of analysis is to reduce data to an intelligible and interpretable form so that the researcher can study and test the relations of research problems and draw conclusions. Interpreting data means making sense of data. To interpret is to explain and to find meaning or making sense of data. In interpreting the analysed data, emerging patterns, associates, concepts and explanations in the data are searched.

Analysis and interpretations develop over time in an identifiable direction that is similar to an upwards spiral (Collins, Lasch. Eaton, Khattatov, Lamarque, & Zende, 2000). This process is known as successive approximation. Although the process of interpreting begins during data collection, it intensifies once the researcher has collected data (Davies, 1999). The researcher is 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 of the findings (Terre Blanche & Durrheim, 2004). 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). As soon as the researcher begins to gather data, he also begins the process of sifting data in search of relevant information to the research itself.

Ritchie and Lewis (2003) suggest that during data analysis, qualitative research may be engaged in defining concepts, mapping the range and nature of phenomenon, creating typology, finding associations within the data, providing explanations or developing strategies. In other words, the researcher constructs new meaning and understanding from the emerging themes. During the analysis of data, the researcher tried to investigate and extract some form of explanation, understanding or interpretation from the qualitative and quantitative data collected from the traditional buildings.

According to Mouton (2001), data analysis involves reducing it to manageable proportions of wealth of the collected data and identifying patterns or themes in the data.

Creswell (2003: 192) identified the following steps to be followed by a researcher in the analysis of data:

- *Organise and prepare the data for analysis:* This involves transcribing interviews, optically scanning material, sorting and arranging the data into different types depending on the sources of information.
- *Read through all the data:* Obtain general sense of the information and reflect on its general meaning.
- *Begin detailed analysis with a coding process:* Coding is a process of organising material into "chunks" before bringing meaning to those chunks.
- Use the coding process to generate a description of the setting or people as well as categories or themes for analysing: Description involves a detailed rendering of information about people, places or events in a setting.
- Advance how the description and themes were represented in the qualitative narrative.
- Make an interpretation or meaning of the data: What lessons were learned from the data.

In this study, data was recorded, transcribed and arranged, and the main themes or categories were established from the data. The researcher used both quantitative (descriptive statistics) and qualitative (narrative and inductive) data analysis methods to analyse the data. Quantitative data are based on meaning derived from numbers, collected results are in numerical or standardised data and analysis is conducted through the use of diagrams and statistics (Saunders et al., 2000). Saunders et al. (2000) further state that qualitative data are based on meaning expressed on words, collected results are in non-standardised data requiring classification into categories and analysis is conducted through the use of conceptualisation.

3.8.1. Quantitative data analysis

Data analysis (in the quantitative paradigm) does not in itself provide the answers to research questions (De Vos et al., 2005). Answers are found by interpretation of data and the results. In research, quantitative data can either be analysed manually or by computer. In this study data was analysed manually. If the sample is relatively small, some statistical analysis can be performed manually with calculators. If the sample is relatively large, software programmes for personal computers can be used to analyse data (De Vos et al., 2005). Descriptive statistical analysis was also used to analyse the data.

- Descriptive statistical analysis

The term descriptive statistics is a collective name for a number of statistical methods that are used to organise and summarise data in a meaningful way (Maree, 2007). This serves to enhance the understanding of the properties of the data. Descriptive statistics can be divided into two ways of representing or describing data, that is, graphical ways or numerical ways. In this case, the percentages and frequency counts were used to describe the data (De Vos et al., 2005). In this study, both graphical and numerical ways were used to represent data. Tables and various types of graphs and percentages were also used.

A numerical way of summarising this data is by means of frequency distribution (Maree, 2007). In such a distribution the different response categories of the variable are shown together with the frequency (numbers) of respondents, and usually also the frequency expressed as a percentage of the sample size, in each of the different categories (De Vos et al., 2005). Percentages were used to represent different response categories of the variables.

A graphical way of summarising the data is by means of pie chart, bar graph, histogram, frequency polygon and area chart (Maree, 2007). The advantages of these graphs are that one can immediately and easily see the most prominent property of the responses to the question (Maree, 2007). The graphs make it easy to see whether the respondents "agree" or "disagree" with the statement.

3.8.2. Qualitative data analysis

Qualitative data analysis is a systematic process of selecting, categorising, comparing, synthesizing and interpreting data to provide explanation of single phenomenon of interest (White, 2005: 168). Qualitative data analysis tends to be an ongoing and interactive (non-linear) process, implying that data collection, processing, analysing and reporting are intertwined, and not merely a number of successive steps (McMillan & Schumacher, 2006). Barker, Pistrang, and Elliot (2002), define qualitative analysis as an inductive procedure of data analysis which involves the three related processes: Identifying meaning, categorizing and integrating. Data analysis begins as one is negotiating entry to the research sites. Data analysis is usually based on an interpretive philosophy that is aimed at examining meaningful and symbolic content of qualitative data.

Qualitative data analysis is primarily an inductive process of organising the data into categories and identifying patterns or relationships among the categories (McMillan & Schumacher, 2006). Unlike quantitative procedures, most categories and patterns emerge from the data, rather than being imposed on the data prior to data collection. Data reflecting and data gathering are interwoven. Data gathering is the collection of information and data reflection is the analysis of the

information and recording. Neuman (2000) further cautions that, the flexibility of qualitative research should not mislead one to believe that this type of research is an easy option. Although there are no uniformly fixed guidelines, qualitative research requires rigour and dedication.

According to Maree (2007), there are different types of qualitative data analysis strategies such as hermeneutics, content, conversation, discourse, narrative, inductive, deductive, discovery and interim analysis. In this study, the following data analysis strategies were used to analyse the collected data:

- Narrative; and
- Inductive

Narrative analysis

A narrative analysis refers to a variety of procedures for interpreting (making meaning) of the narratives generated in the research (Maree, 2007). Narrative configurations were used to analyse the collected 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.

Maree (2007) makes a distinction between paradigmatic and narrative modes of thought in analyzing data. This distinction was used to identify two types of narrative inquiry, (a) analysis of narratives in which the researcher collects stories as data and analyses 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.

Narrative analysis was used to derive mathematical concepts and shapes inductively from traditional buildings of the Limpopo Province not from the previous theory. The researcher tried to search the narrative threads (major emerging themes) from the collected data. Mathematical concepts and structures used in the construction and decorations of the tradition buildings were analysed and organised into categories.

Inductive analysis

Inductive analysis means that categories and patterns emerge from the data rather than being imposed on the data prior to data collection (McMillan & Schumacher, 2006). 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.

McMillan and Schumacher (2001) 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 (McMillan & Schumacher, 2001:116).

All the answers for the questions were listed down. The whole list of answers was carefully read and the answers which belonged together were grouped into one category. Mathematical concepts observed from the traditional circular buildings were verified and categorised according to their relationships.

During data collection process, new mathematical shapes and concepts such as reflections, rotations, translations, symmetry, arrow-head, parallelogram, rhombus, parallel lines, squares that were not on the observation schedule were also discovered. All these mathematical concepts and shapes are similar to the ones taught in the high school curriculum. All the mathematical concepts and shapes were written down in the observer comments and interview transcripts.

McMillan and Schumacher (2001) identified the following strategies that researchers can employ during the observation and interview process:

- 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

(McMillan & Schumacher, 2001: 599).

In this study, the summaries of observations and interviews were written down to synthesize and to remain focused to the research questions. The process of analysing data or emerging data started immediately when the researcher began to collect data during the observations and interviews stages. Mathematical shapes or concepts found on the observation schedule and interviews transcripts were written down.

3.8.3. Establishing themes

In this study, data collected through observations, interviews and questionnaires were compiled and captured. The answers that belonged to the same thematic ideas were grouped accordingly. Answers or items that were related were organised or combined into themes or categories.

Data was sorted according to the broad themes of the study, in line with the main research questions. In other words, data that belonged to research question 1 were grouped together under the question as such. This helped to ensure that sorting of data was enhanced in advance. The researcher also used descriptive words to mark the segments of data. Concepts that seemed to relate to the same phenomenon were grouped together into categories. Inductive analysis allows the categories to emerge from the data and the researcher does not impose categories prior to data analysis (Seidel & Kelle, 1995).

Once the categorisation was completed, before the next move was taken, the initial transcripts were re-read to check whether all the essential insights that emerged from the data through coding and categorisation were properly captured (Wells, 1995). This also helped in checking whether the ideas were correctly captured and if incorrect ideas or misinterpretation of data did not slip through (Maree, 2007).

3.9. Quality criteria/assurance

In qualitative research, the issue of quality assurance can be addressed by dealing with issues of validity, practicality and effectiveness (Maree, 2007). Although not all researchers agree on the potential adequacy of quality assurance, Ager (in Cohen et al., 2001: 107) for instance, argues that in qualitative data collection "the intensive personal involvement and in-depth responses of individuals" secure a sufficient level of validity and reliability.

(a) Validity and Reliability

A common criticism directed at qualitative research is that it fails to adhere to canons of reliability and validity (Silverman, 2000). It is important that results remain similar (consistent), even when they are obtained on different occasions or by different forms of the same assessment. Bringing objectivity to ensure both reliability and validity into qualitative research is hampered by factors such as values, positions, choices and power relations (Adler, 1996). Replication in qualitative research is, however, not possible, as repeating the same research will not yield the same results because "human nature is never static" (Merriam, 1998: 205). Despite these difficulties, which are characteristic of qualitative research and ethnographic approaches, researchers need to find ways of striving for reliability and validity (Merriam, 2002).

Reliability refers to the consistency of measurement. This refers to the extent to which the results are similar for the same instrument or occasions of data collecting (Schumacher & McMillan, 2001). Reliability involves the extent to which a study can be replicated. Wayne and Stuart (2001) define reliability as consistent measurement, that is, if the same experiment is performed under the same conditions, the same measurements should be obtained. Du Ploy (2009) further defines reliability as the internal consistency of the measure that gives the same answer at different times. Reliability has to do with the consistency or repeatability of a measure or an instrument. High reliability is obtained when a measure or instrument gives the same results if the research is repeated on the same sample.

It is important that results remain similar or consistent even when they are obtained on different occasions or by different forms of the same assessment or measuring mechanism.

Reliability can be divided into internal and external reliability (White, 2005: 200). Internal reliability relies on measures that will limit random errors during qualitative research. External reliability refers to the verification of the findings of

the research, when the same research is conducted by independent researchers under the same circumstances and using the same participants (White, 2005: 201). Denzin and Lincoln (2003) suggest that paying attention to the following dimensions increases reliability in a qualitative research study, namely, credibility, transferability, dependability and conformability.

In this study, it was discovered that all the answers or responses were consistent; even when they were obtained on different occasions or by different forms of the same assessment or measuring mechanism, it means that they yielded the same results. For example, on the question of the shape of the foundation, the builders together with the teachers agreed with the researcher's observations that the foundation was circular in shape.

Validity means that the measurements are correct, that is, the instrument measures what it is intended to measure correctly (Wayne & Stuart, 2001). Du Plooy (2009) defines validity as the degree to which a test or measuring instrument actually tests or measures what it is supposed to test or measure. Validity is concerned with whether researchers actually observe or measure what they think they are observing or measuring (Silverman, 2000). It is the extent to which data and subsequent findings present accurate pictures of the events they claim to be describing (Silverman, 2000). Maxwell (1992: 284) contends that "validity is not an inherent property of a particular method, but pertains to the data, accounts, or conclusions reached by using that method in a particular context for a particular purpose".

Data itself "cannot be valid or invalid", only the conclusions or inferences drawn from the data can be regarded as valid or invalid (Hammersley & Atkinson, 1993: 191). Hammersley and Silverman (in Cohen et al., 2001: 107) argue that the validity of a qualitative design includes the degree to which the interpretations and concepts used have mutual meaning for both the participant and the researcher. Qualitative research also depends on two different kinds of validity, namely descriptive and interpretive validity (Adler & Adler, 1996). It is critical that there is a clear linkage between the two kinds as both involve accuracy. This

may be achieved through careful transcriptions which resulted in recognisable categories with which other researchers may agree when making their own analysis of the transcriptions.

White (2005: 154) emphasizes that researchers and research students should understand that the inclusion of the transcribed text in the final document is very important and very useful during the analysis of data.

Triangulation is critical in facilitating interpretive validity and establishing data trustworthiness (Terre Blanche & Durrheim, 2004). It requires researchers to check the extent to which conclusions based on qualitative sources are supported by quantitative perspective, and *vice versa*.

Merriam (1998: 204 - 205) classifies the following six strategies to ensure internal validity in qualitative research:

- ***Crystallization:*** Where several investigators, sources and methods are used to compare the findings with one another.
- ***Member Checks:*** Where the data and findings are verified by respondents other than those originally involved.
- ***Long-term observation:*** To gather data over an extended period in order to increase reliability.
- ***Peer examination:*** To solicit the opinions of colleagues and co-workers.
- ***Collaborative research:*** To involve participants in the research process.
- ***Clearing research bias:*** By clarifying the research assumptions, views and theoretical orientation before starting the research.

The researcher checked the extent to which conclusions based on qualitative sources are supported by the quantitative perspective, and vice versa, to ensure that the instrument (that is the questionnaire) measured what it was intended to measure correctly.

3.10. Summary

In this chapter, details of the research design and methodology were outlined. The chapter started with the introduction to the chapter, followed by the research design. The population, sample selection and the sampling procedures and techniques were discussed. Furthermore, the research assumptions and ethical considerations were presented in this chapter. This chapter also outlined the instrumentation and how the instruments were administered, and the methods and procedures used to collect and to analyse data. The chapter concluded by outlining how quality assurance was addressed. The next chapter will present the analysis and interpretation of data in line with the research questions and the methods used to collect data.

CHAPTER FOUR

DATA ANALYSIS AND INTERPRETATION

4.1. Introduction

In this chapter analysis and interpretation of data are presented. Analysis and interpretations of data collected by means of observations, interviews and questionnaires are presented. The chapter represents data in two ways, graphical and numerical. Tables, various types of graphs, frequency counts and percentages are used to represent, to analyse and to interpret data. This is followed by presentation of the main findings of the study, grouped according to the main research questions and data collection methods.

A numerical way of summarising the variables is by means of a frequency distribution. In such a distribution the different response categories of the variables are shown together with the frequency (numbers) of respondents, and usually also the frequency is expressed as a percentage of the sample size, in each of the different categories. In this study, frequency and percentages were used to represent different response categories of the variables.

Graphical ways of summarising the variable are by means of a pie chart, bar graph, histogram, frequency polygon or area chart. The advantage of these graphs is that one can immediately see the most prominent property of the responses to the questions. In this study, data were represented and described using frequency counts, tables, graphs and percentages.

4.2. Analysis and interpretation of observation data

The researcher observed the shapes of the foundation, the wall and the roof and, mathematical concepts, symbols and structures found on the traditional buildings of the Limpopo Province. (See Annexure C). Various mathematical shapes, concepts and symbols observed on the six traditional buildings were recorded on the observation schedule and are reported in tables below. The following Figures came from the three ethnic groups, i.e., Xitsonga, Sepedi, and Tshivenda.

The observation guide contained the following items:

- Shape of the foundation, the wall and the roof;
- Mathematical shapes or concepts on the floor mural decorations;
- Mathematical shapes or concepts on the wall mural decorations; and
- Mathematical shapes or concepts on the roof decorations or patterning.

4.2.1. Foundation of the house

- **Structure of the foundation.**

It was noticed that the foundations for all six buildings in Mopani, Vhembe, and Sekhukhune districts of the Limpopo Province were circular in shape.

Figure 2: How a circular foundation is measured and constructed

Figure 2 was photographed during the data collection process and shows how the circular foundation is constructed. It shows that the foundation is circular in shape. The builder constructed the foundation with sticks and a string. The nailed

stick at the centre marks the centre of the house. A rope is then attached to the stick at the centre and a second stick which is used to draw a circle. The size of the circle indicates the size of the hut (house).

The circumference, diameter and radius of the circular hut (house) can thus be determined. The area of the foundation can be calculated by using the area of a circle formula ($A = \pi r^2$). The circumference of the hut could be calculated by using two pie radius (C = 2πr) where radius is the length of the rope. Figure 3 is a photograph of the foundation of the building.

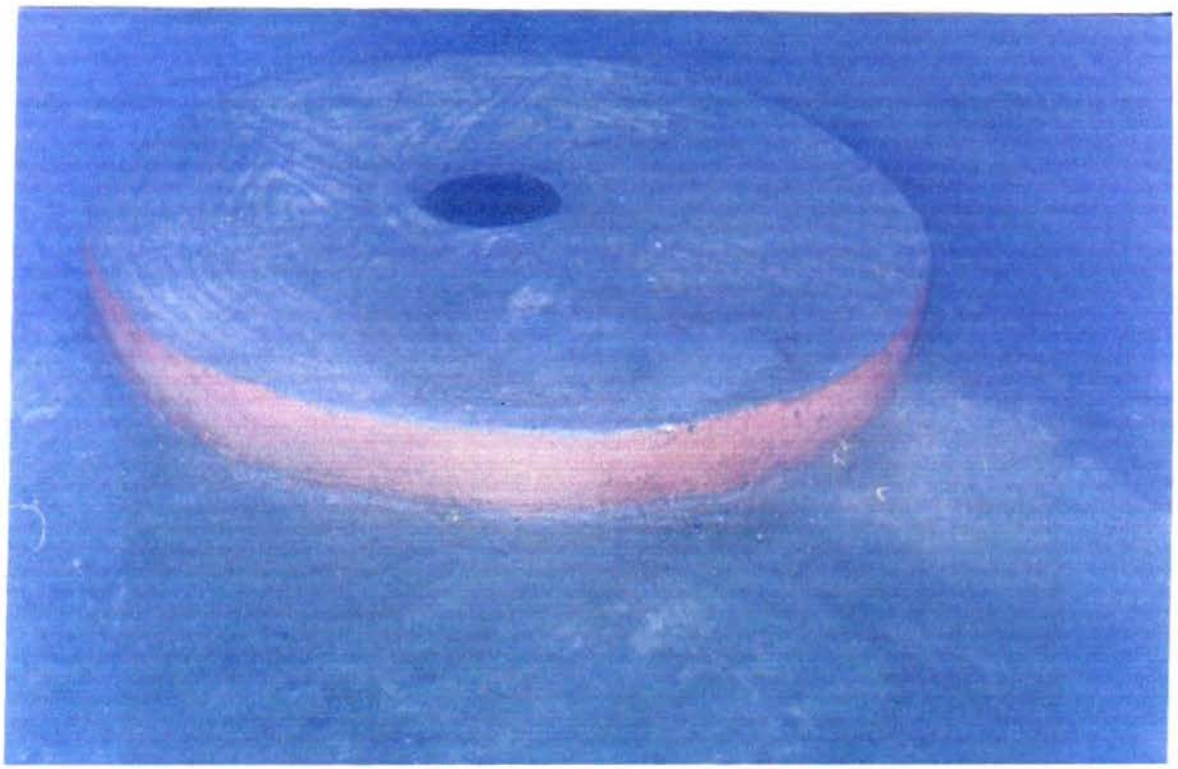

Figure 3: Complete circular foundation without a wall

Therefore, Figure 1 and 2 could be used to teach *circle geometry. The area, circumference, radius and diameter of the circle* can be taught using Figure 1 and Figure 2.

4.2.2. Floor of the house

Murals found on the traditional buildings are painted by the builders. The murals are mathematically interesting because mathematical shapes and concepts such as oval, circle, triangle, parallelogram, reflection, symmetry and rectangle are found on the floor and the wall.

Table 2: Mathematical shapes or concepts observed on the floor of the house

	Cone	Triangle	Oval	Circle	Parallel lines	Square
Floor	None	All six houses	All six houses	All six houses	All six houses	None

Floor murals included shapes such as triangle, oval, circle and parallel lines as indicated on Figure 4 to Figure 7.

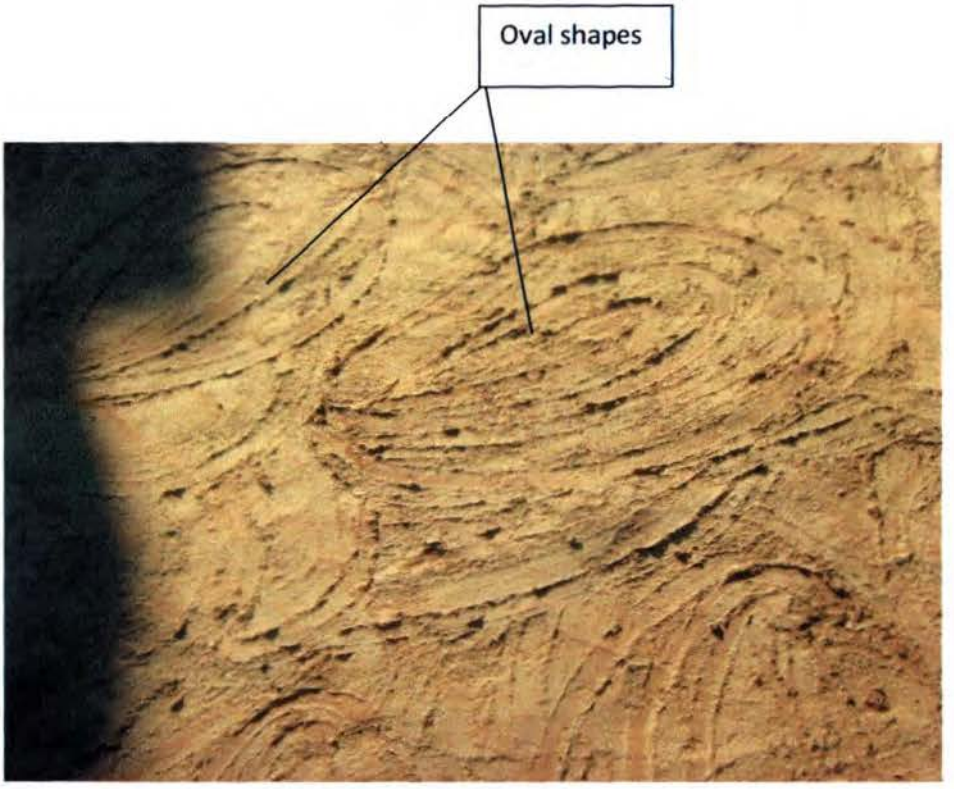

Figure 4: Oval shapes observed on the floor mural

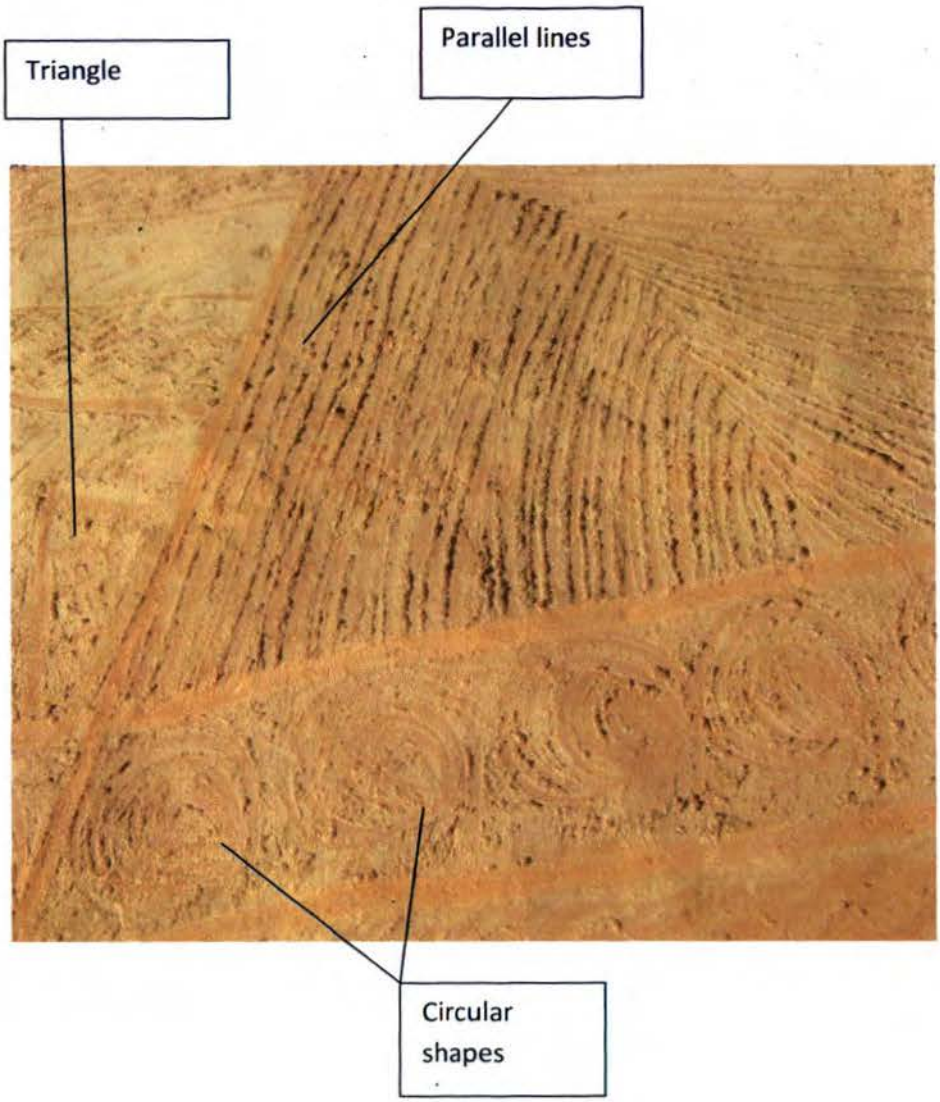

Figure 5: Floor decorations of circles, triangles and parallel lines

Decorations showing circular shapes, parallel lines and triangles were observed. The figures could be used to teach the *properties, the area and the perimeter of a triangle, and the problems associated with parallelograms.*

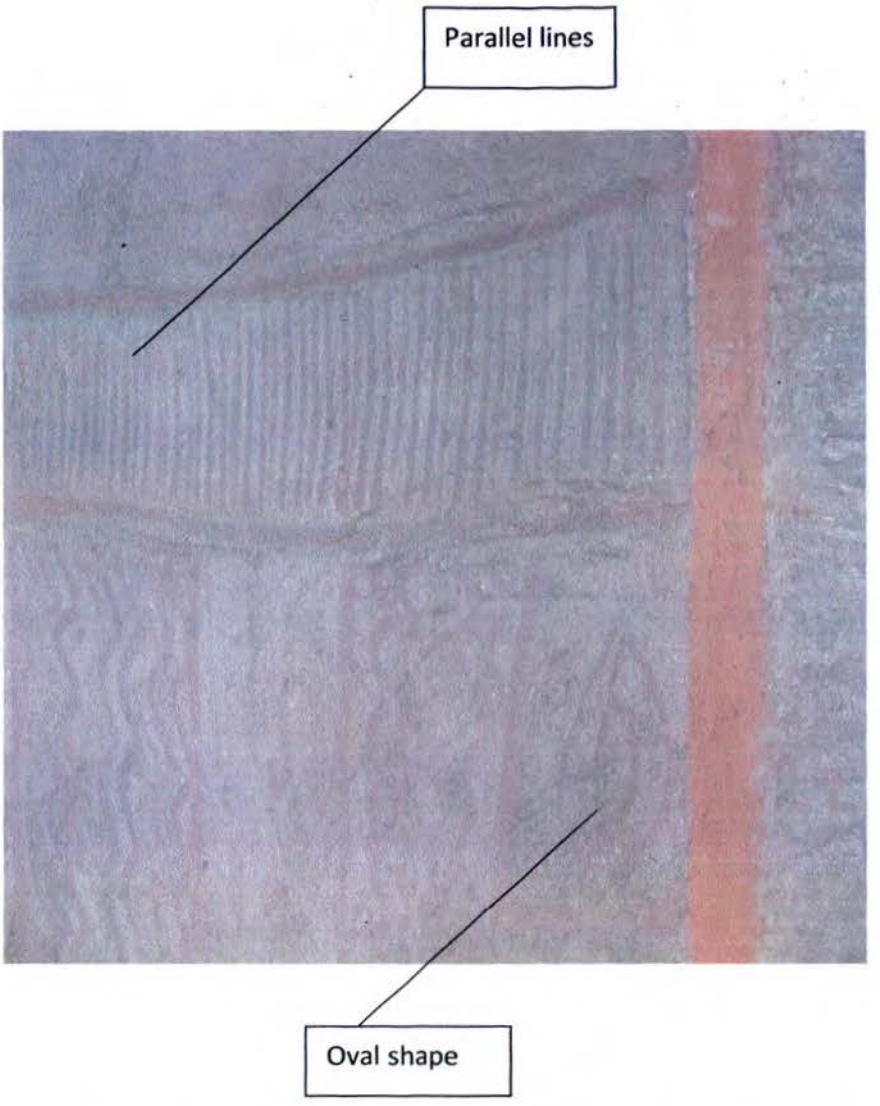

Figure 6: Parallel lines and oval shapes on the floor decorations

Mathematical shapes and concepts observed in Figure 6 include oval shape and parallel lines. *The properties of lines and angles* could be taught using Figure 5 and Figure 6.

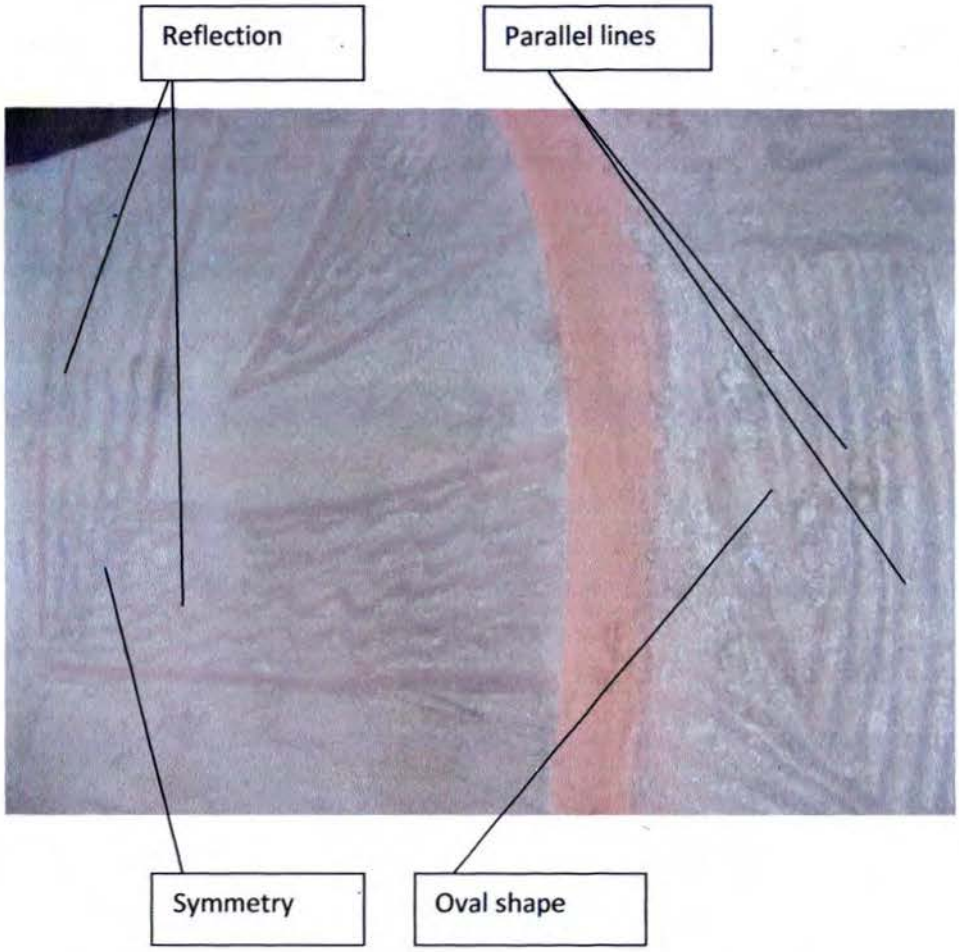

Figure 7: Reflections, symmetry and parallel lines on the floor murals

Decorations showing parallel lines, symmetry, reflections and oval shape were observed. This shows that mathematics was practised by all communities either directly or indirectly in this study.

As shown in Table 2, out of the six buildings observed for this research, oval, circular, parallel lines and triangular shapes were found in all six houses (100%). Other mathematical concepts i.e. symmetry and reflections were observed in one building in Mopani district. The above mentioned concepts show that mathematical concepts and shapes were embodied in the floor decorations of the houses. These shapes and concepts support the assertion by Mogari (2001) that mathematical knowledge is used by all communities in their everyday lives.

4.2.3. Wall of the house

- **Structure of the wall**

The researcher also noted that the complete wall of the hut was cylindrical with a circular base. This implies that characteristics of cylinders and circles were identified. The huts could therefore be used to contextualize calculations involving circles and cylinders.

Figure 8: Frame structure of the hut without a roof.

The area and the volume of the wall could be calculated by using the formula for the area and the volume of a cylinder where $area\ (A) = \pi r^2$ and volume (V) $= \pi r^2$h. Figure 8 could be used to solve problems associated with a *cylinder.*

Figure 9: Cylindrical wall made of poles

Figure 9 shows the arrangement of the poles used to reinforce the walls of the huts which were also arranged cylindrically. It was noticed that the base of the wall was circular but the building itself was cylindrical in shape. Its measurement can be calculated using the appropriate formulae for a cylinder. Figure 9 could be used to calculate *the area, volume and the surface area of a cylinder.*

- **Mathematical shapes or concepts on the wall murals**

It was also discovered that all the six buildings had: oval shape, square, rectangular, triangular and rhombus. It was also noticed that the following mathematical shapes and concepts were on the walls: translations; reflections; rotations; symmetry, similarities; congruent figures and tessellations.

Figures 10 to 15 represent different houses with decorations.

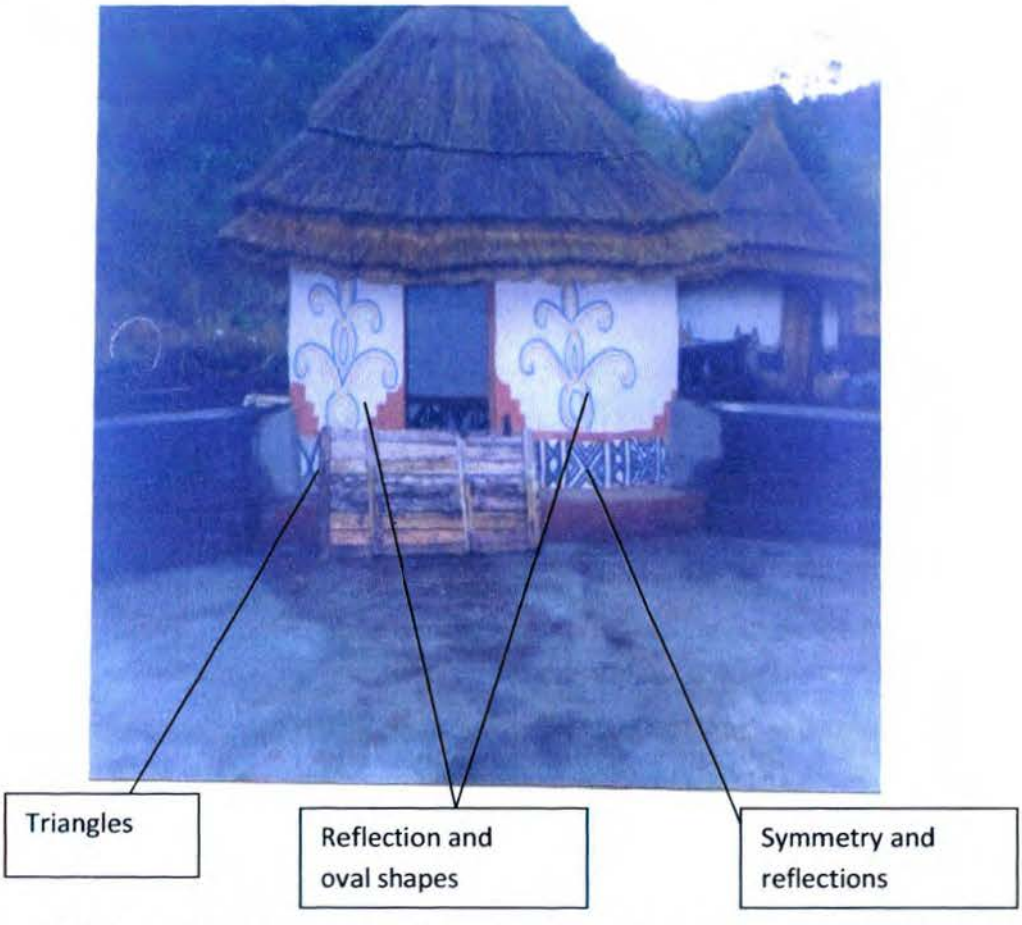

Figure 10: Mathematical concepts such as reflections, triangles, symmetry and oval shapes on the wall murals

The following mathematical concepts and shapes were recognised from Figure 10: Reflections, translations, symmetry, similarities, rhombus, triangles, rectangles, parallel lines, squares and ovals.

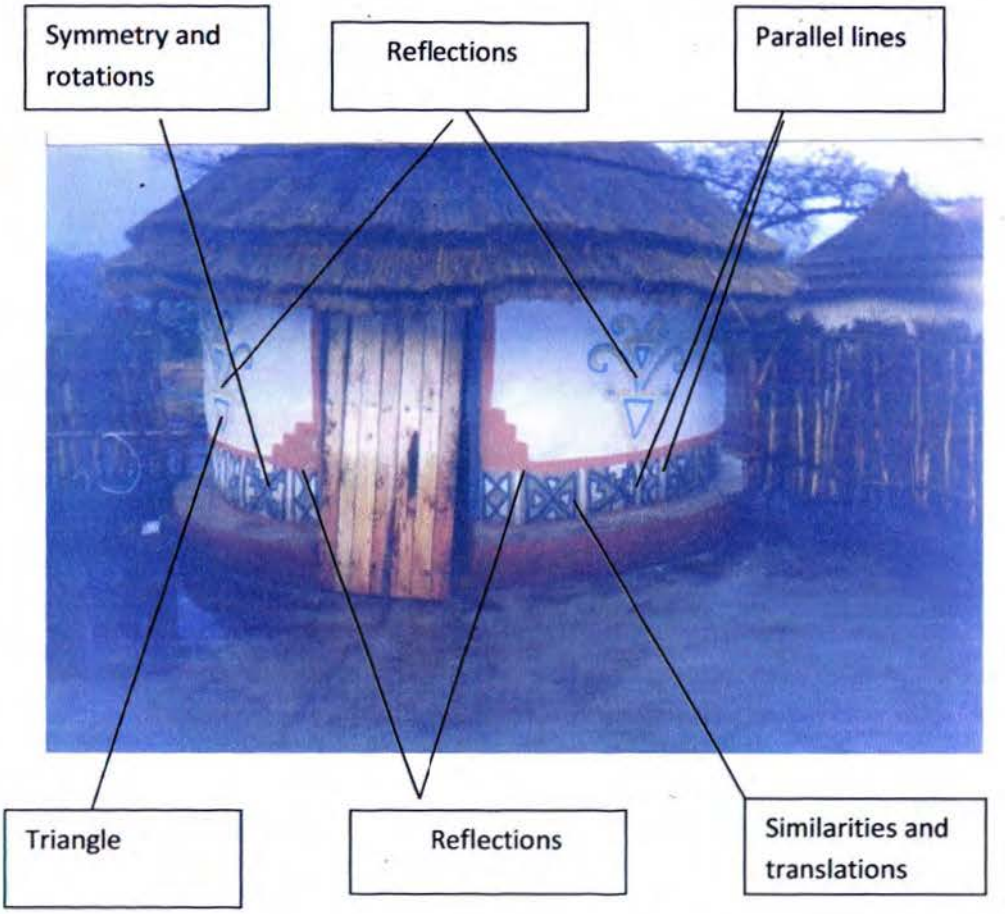

Figure 11: Similarities, reflections, translations, reflections, symmetry, triangles and parallel lines on the mural

Figure 11 shows reflection, translation, symmetry, similarity, rhombus, triangle, rectangle, parallel lines, and squares. Figure 10 and Figure 11 could be used to solve problems associated with *triangles, quadrilaterals, symmetry and transformation*.

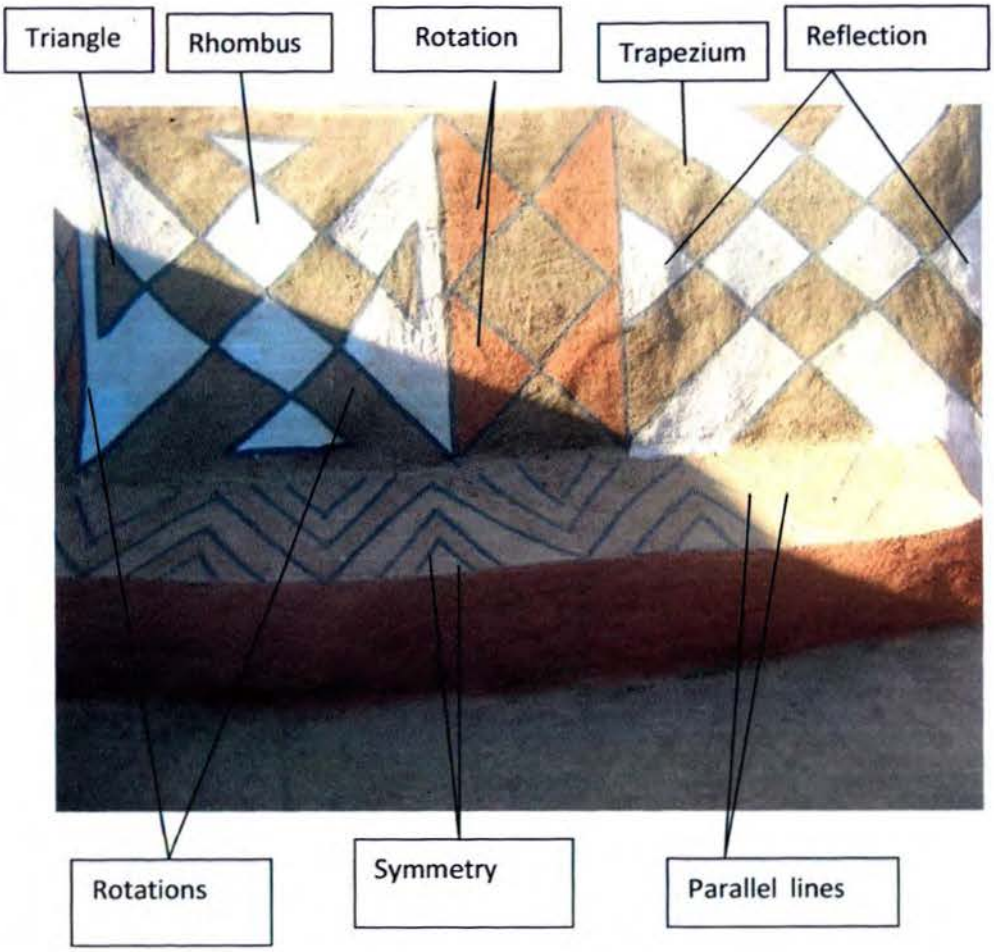

Figure 12: Various mathematics concepts such as rotations, rhombus, trapeziums, and triangles on the wall decorations

Mathematical structures observed in Figure 12 include: rhombus, trapezium, parallel lines, triangle, reflections, rotations, symmetry and rectangle. These show that there are mathematical concepts and shapes embodied in the wall decorations of the Limpopo Province, South Africa.

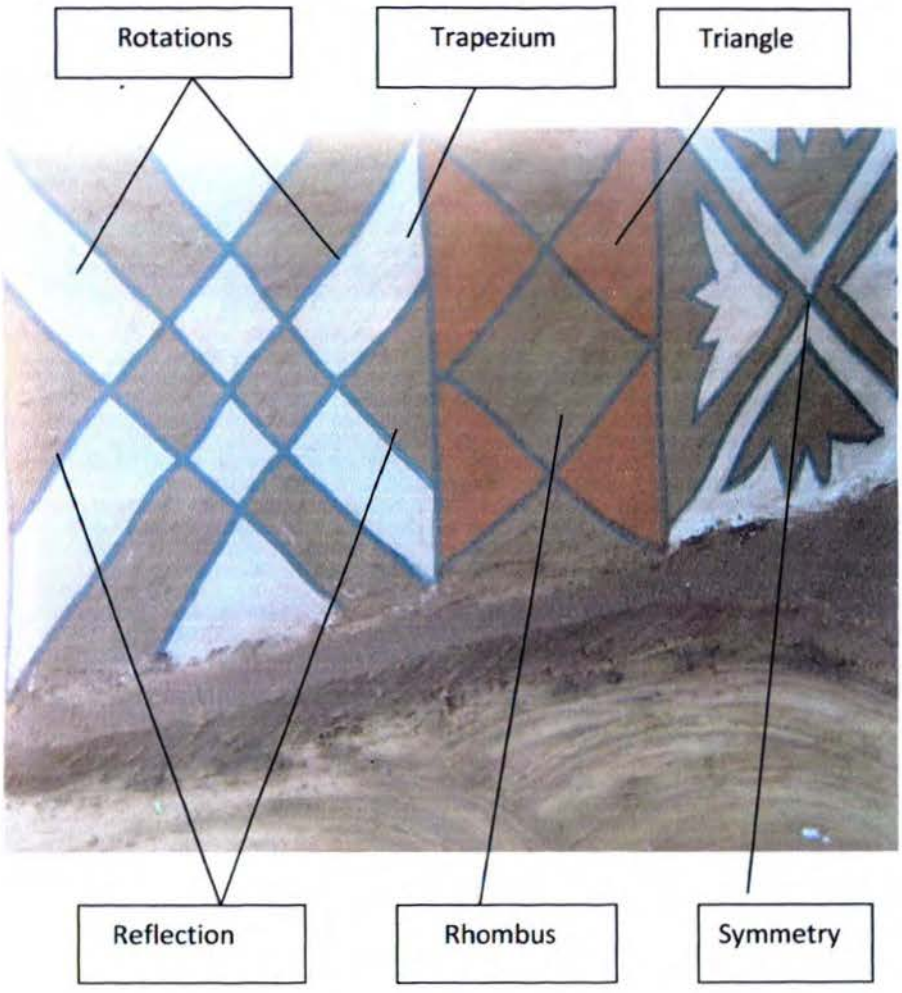

Figure 13: Wall decorations showing more mathematical shapes such as rhombus, trapezium, triangle.

Figure 13 displays the following mathematical shapes and concepts: rhombus, triangle, trapezium, reflection, symmetry and rotation. Figure 12 and Figure 13 could be used to teach *rotational symmetry, translation, reflection and rotations.*

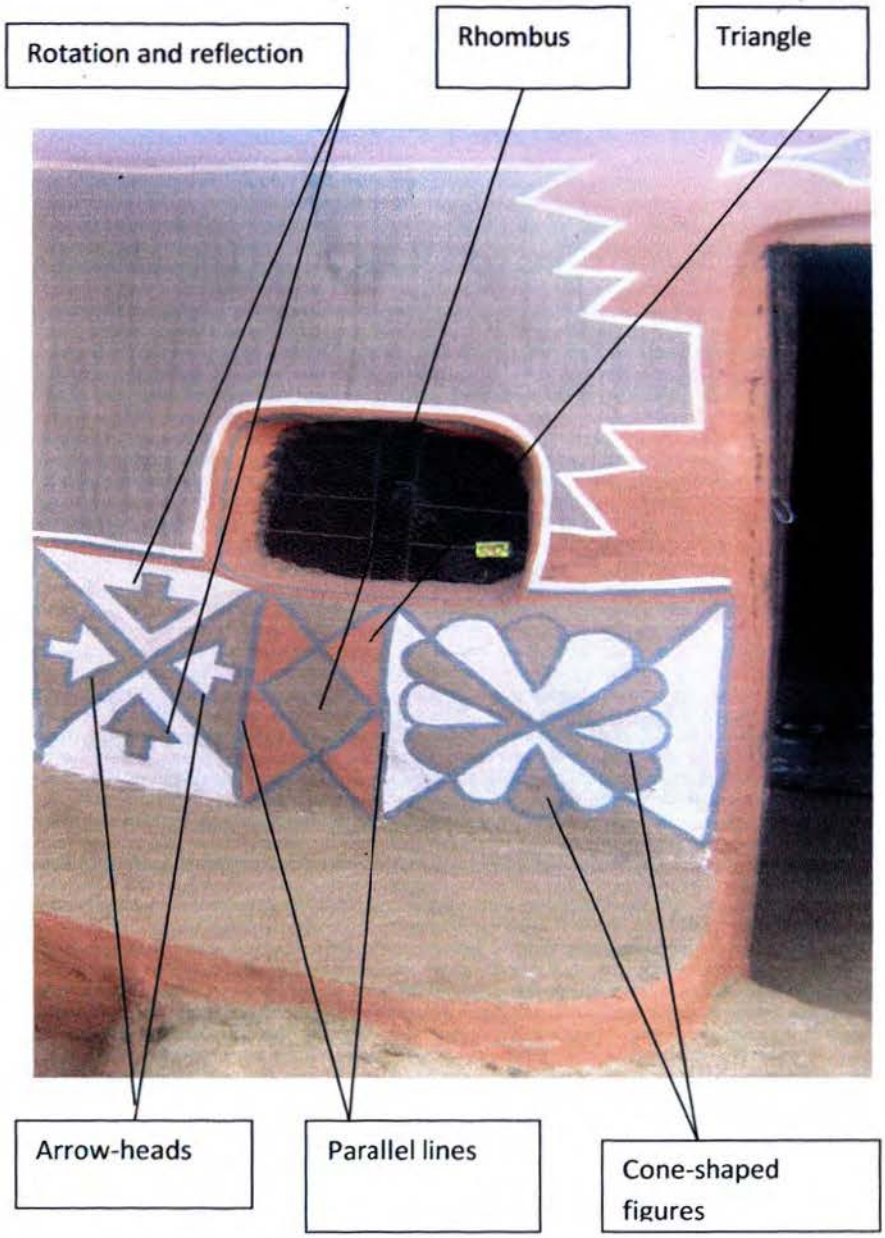

Figure 14: Wall decorations indicating more mathematical concepts and shapes such as arrow-head etc

The following mathematical structures or concepts were observed on Figure 14: Arrow-head, reflection, cone-shaped figures, symmetry, triangle, rhombus and parallel lines.

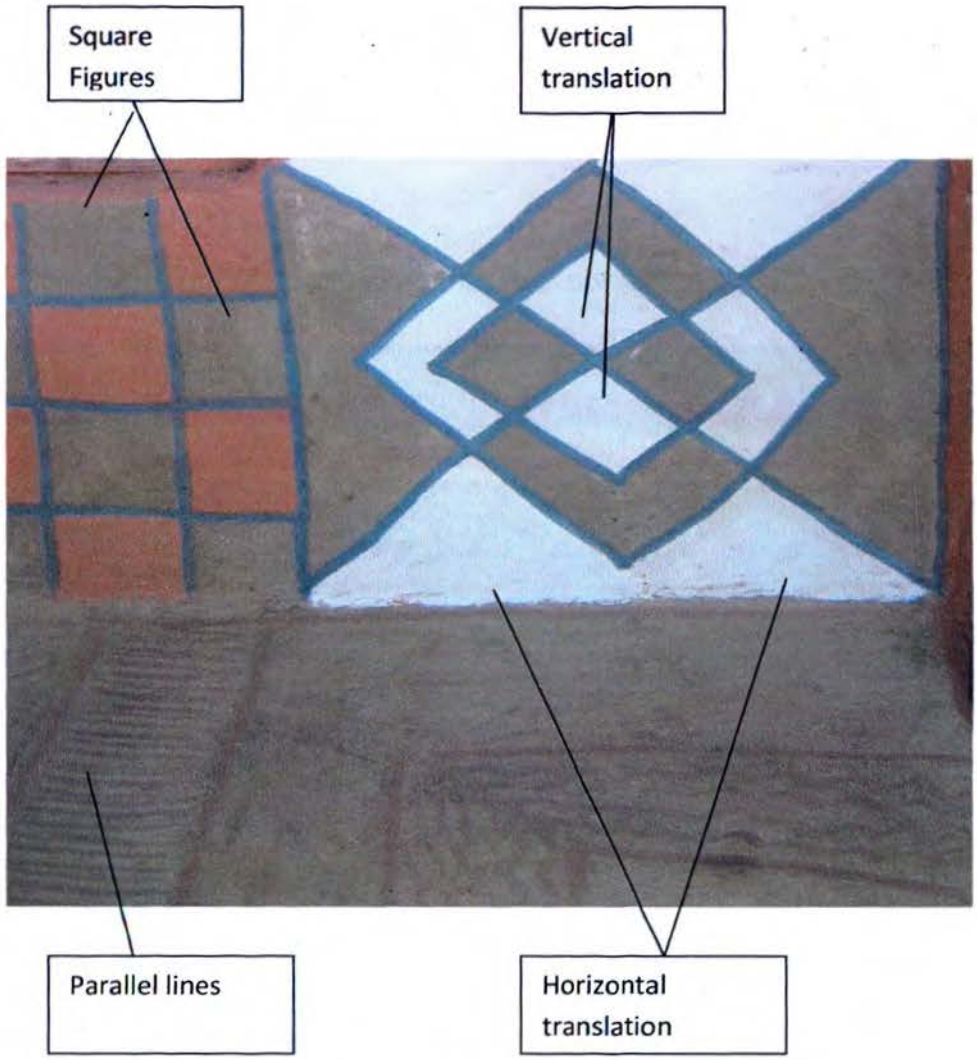

Figure 15: Murals with mathematical shapes such as square, rhombus and reflections

The following mathematical shapes and concepts were observed in Figure 15: square, rhombus, reflections, rotations and parallel lines. These mathematical shapes and concepts are similar to the ones taught in high school mathematics curriculum and therefore could be used as teaching and learning aids in the teaching of *parallelogram, fractions, percentages, angles, triangles, quadrilaterals, translation, and others.*

These mathematical shapes and concepts found in the traditional buildings of the Limpopo Province support the assertion by Laridon (2000) that mathematical knowledge was used by all communities in their everyday lives.

4.2.4. Roof of the house

- **Structure of the roof**

Figure 16 shows a roof of the building that was conical in shape.

Figure: 16: Roof structure before thatching

Figure 16 and Figure 17 were the two roof structures that indicated the inner side of the roof. The roof had a wooden block at the top called the "lenotlo" (apex). The apex was the centre of the roof. Laths (thin timbers used to fasten the poles and grass) ran round the timber to tighten and strengthen the roof. The spaces between the laths seemed to be equal in length. Around the roof the laths were parallel to each other.

Figure 17: Roof structure after thatching

The roof of the building could be used in solving problems involving cones such as the areas, volumes, and circumference of the base of the cone. The parallel arranged laths can be used to calculate problems on parallel structures such as *parallelogram, rectangle and rhombus.*

Figure 18 presents the outer structure of the traditional circular building without thatching grass.

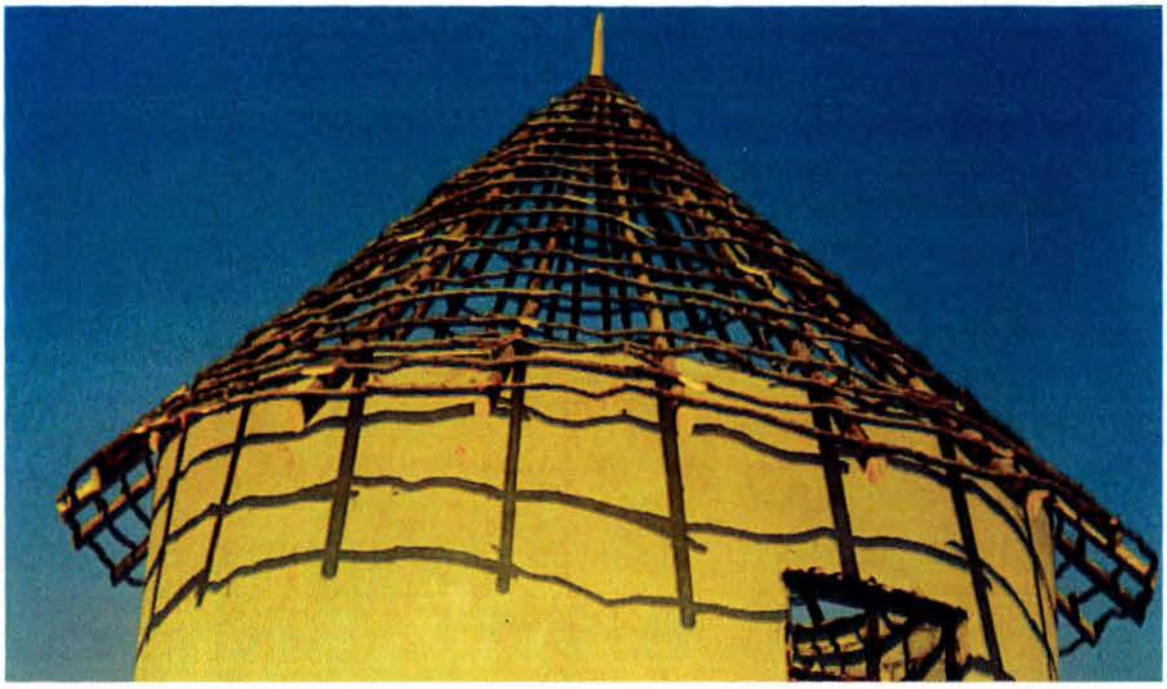

Figure 18: The outer shape of the traditional circular building

- **Mathematical concepts on the roof patterning**

Various grasses were used to make different patterns or decorations on the roof. Parallel lines made with grasses were recognised on the roof patterning or decorations. Steps were made on the roof as a form of decoration. These steps were parallel around the roof. See Figure 19 and Figure 20.

Figure 19: Cone-shaped and parallel lines displayed on the roof patterning or decorations.

Figure 20: More parallel lines indicated on the roof decorations or patterning

These parallel lines are similar to the ones taught in high school mathematics. The parallel arranged grasses could be used to solve problems on *parallelograms and other parallel structures. For example, problems associated with calculating the size of angles for various parallel structures.*

4.3. Analysis and interpretation of questionnaire.

All 18 mathematics educators selected for the research responded positively and submitted their completed questionnaires. This constituted a response rate of 100%. The data were analysed under the following research questions:

- Which mathematical concepts embedded in the traditional buildings of the Limpopo Province can be used to teach high school mathematics?
- What challenges do high school mathematics educators face in contextualising their teaching?
- Which suggestions can be made to assist mathematics educators to make use of the cultural artefacts to contextualise their teaching?

4.3.1 School demography

Answers provided by the educators based on their school demography were presented in various Tables and Figures below.

(a). **Ages of the educators**

Table 3: Ages of the educators

Age group	Frequency
≤30	I
31-35	2
36-40	8
41-45	3
46-49	1
≥50	3
Total	18

Table 3 indicates that out of 18 mathematics educators who participated in this study, only one (1) was less than thirty (30) years, two (2) were between 31 and

35 years, eight (8) were between 36 and 40 years, three (3) were between 41 and 45 years, one (1) was between 46 and 49, and three (3) were 50 and above. Only three of them were younger than thirty five (35) years of age.

Some of the mathematics educators who participated in this study went to the teacher-training institutions during the previous Bantu Education System before 1994 (Bantu Education Act, 1953). It was indicated in Table 10 under teacher support and development that more than 75% of them did not have qualifications in NCS methods. Therefore, it was not easy for some of them to adjust to the new syllabus because they were conditioned by the way they had been "trained" during their teacher education. Some had then translated teacher education into an authoritarian teaching style in the classroom (Rakgokong, 1993). They viewed an activity-based teaching as time-consuming and preventing them to cover the prescribed syllabus (Rakgokong, 1993).

Therefore, there is a need for mathematics educators to be trained in NCS methods and more workshops in CAPS need to be conducted.

(b). Gender

Table 4: Gender

Male	Female	Total
11	7	18
61%	39%	100%

Table 4 indicates the total percentages of male and female educators who participated in this study. Out of 18 mathematics educators, 11 which constitute 61% were males and 7 (39%) were females.

(c). Qualifications for the educators

The educators' qualifications fell into three discrete groups: Diploma, Degree, and Honours

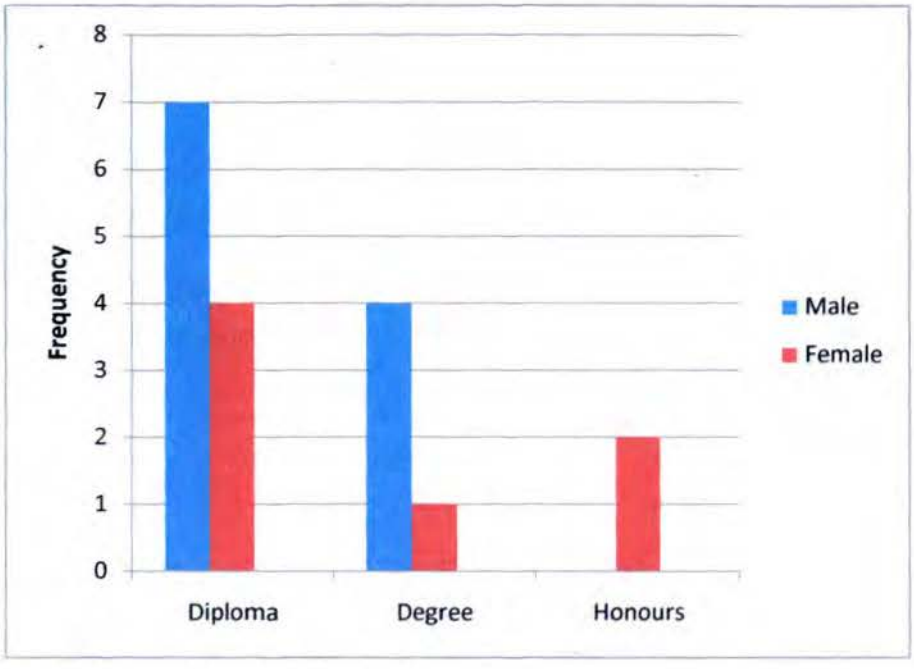

Figure 21: Qualifications of the educators

As indicated in Figure 21, all eighteen (18) educators meet the minimum qualification which is a diploma to teach at secondary level. Eleven (11) educators had diplomas, five (5) of them had degrees, and only two educators had honours degrees. Those who had degrees and honours degrees did not major in mathematics. They had majored in educational management. Therefore, mathematics teachers are encouraged to improve their studies.

(d). Subject Specialisation for educators

Table 5: Subject specialisation

Mathematics	Mathematical Literacy	Total
18	0	18

Subject specialisation focused only on mathematics and mathematical literacy. Table 5 indicates that one hundred percent (100%) of mathematics educators specialised in mathematics and no one had specialised in mathematical literacy. It shows that all teachers who were teaching mathematics were qualified to teach mathematics. In my opinion, subject content might not be a problem for these educators, but the problem might be with the methods of teaching mathematics in context.

(e). Number of educators in each district

The number of educators within the selected districts is presented in Figure 22. Mathematics teachers from Mopani, Vhembe and Sekhukhune participated in the research study.

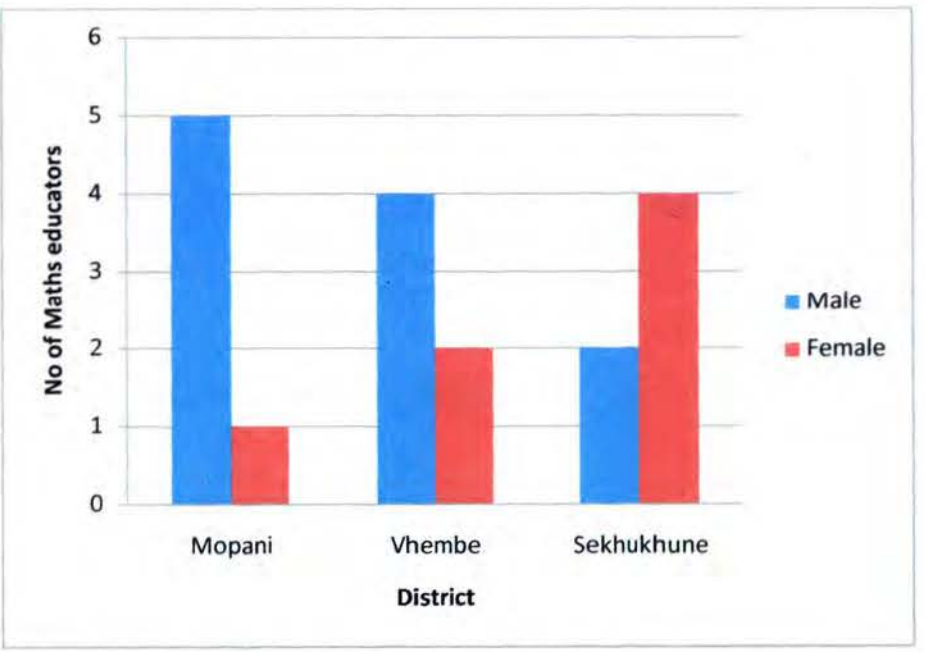

Figure 22: The number of educators in each district

Figure 22 indicates that the number of male mathematics educators in Mopani and Vhembe was more than that of the females. It was only in Sekhukhune where female educators were more than the males. In Mopani, out of six mathematics educators that participated in the survey, five were male while only

one was female. In Vhembe, four were male and two were female. In Sekhukhune it was different, with two males and four females.

(f). School situation

Table 6: School situation

Town	Location	Village	Total
0	I	17	18

School situations or location were subdivided into Town, Location, and Village. Table 6 indicates that seventeen of the participants were from rural places. Only one was from the township, and no one was from the town. Therefore, the research was conducted in a familiar setting for the educators. The educators knew the traditional buildings and some slept inside these types of houses. The findings indicated a true reflection of the research.

(g). Grades taught

Grades taught were identified from 8 to 12 to check other grades the educators were teaching during the research study besides Grade 12.

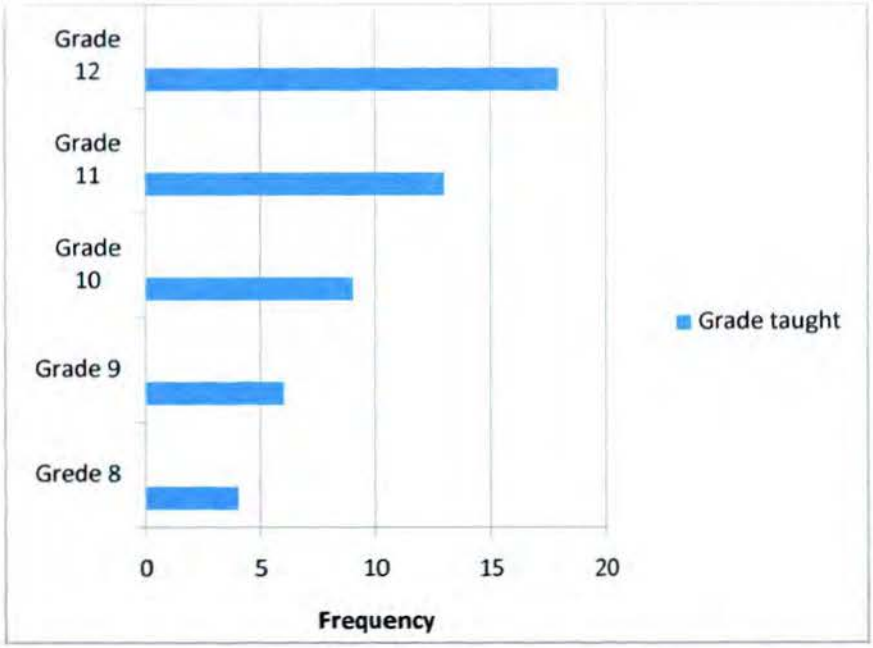

Figure 23: The number of mathematics educators who teaches Grade 8-12

Figure 23 indicates that all 18 mathematics educators who participated in this study were teaching Grade 12. Besides Grade 12, thirteen (13) of them were also teaching Grade 11, nine (9) were teaching Grade 10, six (6) were also teaching Grade 9, and four were teaching Grade 8.

(h). Number of Grade 12 Mathematics educators

Most schools in the Limpopo Province have shortages of highly qualified mathematics educators (DoE Emis Report, 2011). Since the closure of all Teacher Training Colleges of Education, the province is no longer producing enough mathematics and science educators. The Department of Education has started to rely much on the mathematics educators from other African countries (DoE EMIS Report, 2011).

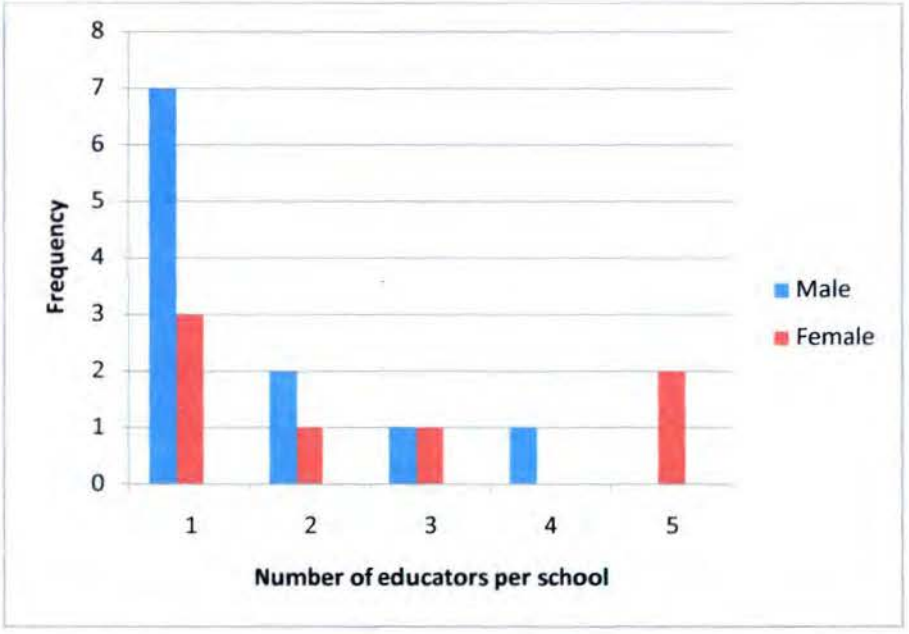

Figure 24: The number of grade 12 mathematics educators

Figure 24 indicates that ten schools had only one mathematics educator. Seven schools had only one male mathematics educator and three schools had one female educator. Three schools had two educators, two schools had three educators, one school had four and two schools had six educators each. Figure 24 indicates that most schools had only one mathematics educator per school.

(i). Number of Grade 12 learners in mathematics class.

The number of learners was grouped according to the following interval: ≤ 10, 11-19, 20-29, 30-39, 40-49 and ≥ 50. See Figure 25.

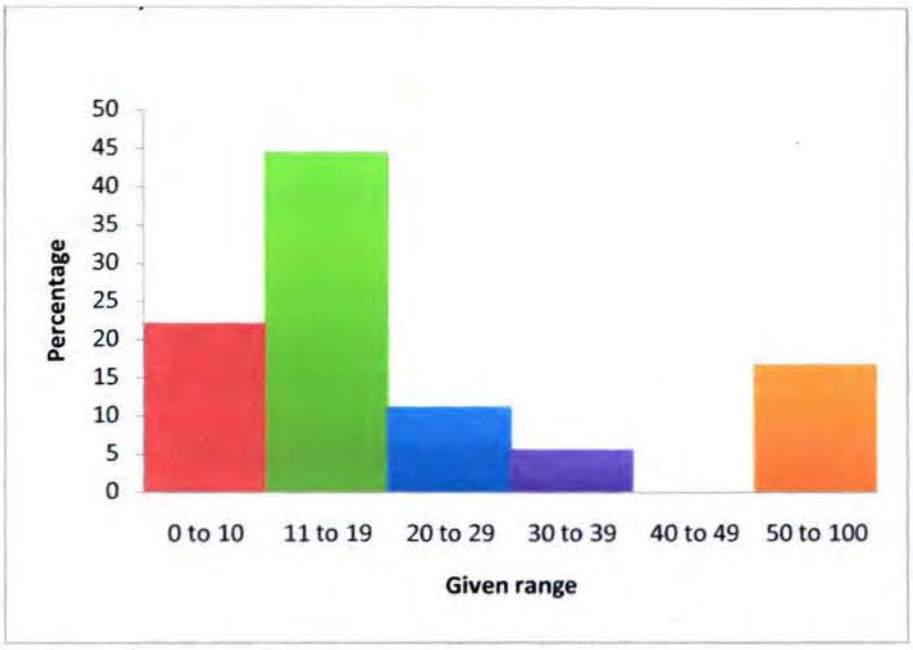

Figure 25: The number of Grade 12 learners

As indicated in Figure 25, 44 % of mathematics classes had between 11 and 19 learners in the class. That is followed by the classes that had less than 10 learners in the class, which constitute 22 %. The percentage of classes that had more than 50 is 17 %. Between 20 and 29 learners per class is 11%. The number of classes that had learners of between 30 and 39 constituted only 6 %. In the interval between 40 and 49 there was a (zero) 0 %. Figure 25 further indicates that most Grade 12 mathematics classes were not overcrowded. They had between 0 and 30 learners per class.

(j). **Number of Grade 12 Mathematics classes**

The number of Grade 12 mathematics classes ranged from 1 to 6 classes per school. See Figure 26 for the answers to this question.

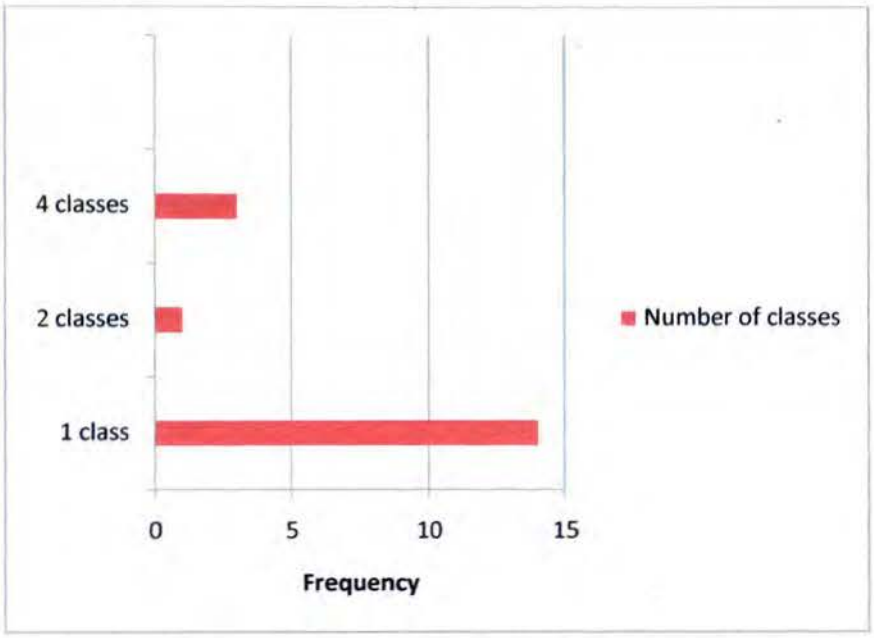

Figure 26: Number of Grade 12 Mathematics classes

Figure 26 indicates that, in general, mathematics classes were not many at schools in Mopani and Sekhukhune districts. Fourteen schools had only one class, two schools had two mathematics classes and three schools had four mathematics classes. Schools that had many learners in mathematics classes were mostly from Vhembe district.

(k). Teaching experience in mathematics

The number of years of teaching experience was indicated according to specific intervals. The intervals were as follows: ≤4, 5-9, 10-14, 15-19, 20-29, ≥30. (Refer to Table 5).

Table 7: Teaching experience of mathematics educators

Numbers of years	Frequency
≤4	3
5-9	5
10-14	3
15-19	3
20-29	2
≥30	2

Table 7 shows that fifteen educators had five years and more experience teaching experience in mathematics. Only three had less than five years teaching experience. The teachers had adequate teaching experience to produce good results. In my opinion, the problem might be the strategies they use to teach mathematics.

(L). Total number of mathematics educators at schools

The total number of mathematics educators per school was grouped according to the following intervals: ≤2, 3-4, 5-6, 7-8, and ≥9. See Table 8.

Table 8: Total number of mathematics educators

Interval	Frequency
≤2	2
3 – 4	6
5 – 6	4
7 – 8	6
≥9	0
Total	18

Table 8 shows that intervals 3 – 4 and 7– 8 had a modal number of six, followed by 5 – 6 with the frequency of four. Schools with ≤2 educators had a frequency of two. In the study, there was no school with 9 and more mathematics educators.

4.3.2. Mathematics Teaching and Learning Support Materials

Questions of Section B (Annexure B) focused on mathematics teaching and learning support materials. Questions were arranged from 1 to 11. Table 9 provides answers to these questions.

Table 9: Mathematics Teaching and Learning Support Materials

Mathematics teaching and Learning Support Material	**YES**	**NO**
1. Does the school have a library?	9	9
2. Is the library well equipped with mathematics books?	4	14
3. Does the school have mathematical instruments?	12	6
4. Are the instruments enough for all the learners?	1	17
5. Do learners take mathematical instruments home?	7	11
6.Does the school have mathematics text books	18	0
7. Are mathematics text books enough for the learners?	14	4
8. Do learners take mathematics text books home?	18	0
9. Does the school have teaching and learning aids?	4	14
10. Are learning aids sufficient for all the learners?	0	18
11. Do learners have mathematics note books/portfolios?	16	2

It was noticed from Table 9 that there was a great shortage of mathematics teaching and learning support materials. Teachers think that these shortages might be one of the contributory factors to the poor results in mathematics. These shortages occurred in almost all the three districts chosen for the study.

- There were shortages of libraries;
- There was a shortage of mathematical instruments;
- Not enough mathematical textbooks;
- Shortage of teaching and learning aids; and
- Mathematical note books not enough.

Teachers think that these shortages seem to contribute negatively to the effective teaching and learning of mathematics.

4.3.3. Mathematics Teacher Support and Development

The answers to questions in Section G (Annexure B) focused on mathematics teacher support and development. Questions were arranged from 1 to 11. Answers to these questions are provided in Table 10.

Table 10: Mathematics teacher support and development

Teacher support and development	YES	NO
1.You have qualification in NCS methods	4	14
2. Your knowledge on NCS is from workshops organized by the Department of Education.	13	5
3. You have never had any mathematics workshop on NCS	5	13
4. You receive instructions on NCS from the Department of Education	16	2
5. Your knowledge on NCS is from colleagues	6	12
6. Workshops on NCS are sufficient for your needs	9	9

7. More workshops are needed on NCS strategies	16	2
8. You have regular discussions with colleagues on NCS	13	5
9. NCS is good for learners	13	5
10. NCS makes teaching uninteresting	6	12
11. More NCS workshops are needed in the geometry section	17	1

It was noticed from Table 10 that:

- Fourteen teachers had no qualifications in NCS/CAPS methods;
- Some teachers had little knowledge of NCS;
- Thirteen teachers have never attended mathematics workshop on NCS;
- Workshops on NCS and CAPS were not sufficient; and
- More workshops on NCS and CAPS were needed;

4.3.4. Preparation for the teaching of Mathematics

The answers to questions in section H (Annexure B) focused on preparations for the teaching of mathematics. Questions were arranged from 1 to 11. Answers to these questions are provided in Table 11.

Table 11: How teachers prepare for the teaching of mathematics

Questions	**YES**	**NO**
1.Year programme is developed by you	01	17
2.Year programme is provided by the department	16	02
3.You prepare daily lesson plan to suit the topic	17	1

4. Lesson plans have outcomes formulated by you	7	11
5.Lesson plans have no outcomes	0	18
6. Outcomes are provided by department.	14	4
7.Learner activities are prepared by you	14	4
8.Learner activities are given by text book/dept.	16	2
9. Assessment standards are given by department.	16	2
10. Assessment standards are developed by you.	6	12
11.Your lessons follow the syllabuses strictly	14	4
12. You arrange topics to follow each other to suit your own programme.	11	7
13. Learners are provided with notes/handouts for the lesson.	16	2
14. Learners are asked to bring mathematics equipments/aids for activities to schools.	13	5
15. Educators provide mathematics equipments as required by the Department of Education.	11	7
16. Do you think the learners' immediate environment can be included in the preparation for the teaching of mathematics?	18	0
17. Do you think cultural artefacts such as baskets, mats and beads can be used as aids to teach mathematics in context?	18	0

In this study, the focus was on the perceptions of mathematics teachers about the inclusion of (a) the learners' immediate environment, and (b) cultural artefacts such as beads, mats, traditional circular buildings and baskets as teaching and learning aids in their preparations. The educators provided the following answers for the above questions.

(a). **Perceptions of teachers about the inclusion of learners' immediate environment in the preparation for the teaching of mathematics**

In Table 11 question 16, all 18 respondents agreed with the assertion that the learners' immediate learning environment had to be included as one of the teaching and learning aids in mathematics teaching. No one was against the idea. They all agreed that teachers should give learners practical activities and allow them to work in pairs or groups. These activities should be thoroughly planned in the preparatory stage the teacher goes to class. For the learners' to develop critical thinking powers and problem solving, teachers should assist them to construct their own meaning and understanding by giving them practical activities.

(b). **Perceptions of teachers about the use of cultural artefacts to teach mathematics**

In Table 11 question 17, all 18 participants agreed with the assertion that cultural artefacts should be used as teaching and learning aids to teach mathematics in context. The teaching of mathematics should not be devoid of social and cultural connotations. The teachers need to develop their own contextualised teaching and learning materials and use or implement them during the lesson presentation. Some teachers further alluded that teachers need to assess the "learned curriculum" where learners work on the traditional buildings or other cultural artefacts projects or activities. Books should be used as supporting materials.

4.3.5. Mathematics Lesson Presentation

Table 12 provides answers to questions 1-13 of section D on Annexure B

Table 12: How teachers present mathematics lesson

Teaching Approach	Number of educators following the approach
1.You start the lesson by writing the topic on the board always	12
2. You ask learners about their knowledge on the topic.	17
3. Give lessons activity sheets with instructions.	12
4.Learners work individually	13
5.Learners work in pairs	17
6.Learners work in groups	17
7.Learners write own notes	11
8.Learners copy notes from the board	11
9.You teach from the front of the class often	12
10.You visit groups to see what they are doing and to offer help	16
11.You use the textbook often due to lack of other resources	16
12.You explain outcomes to the learners to achieve with them	11
13.You often use example from learners' immediate environment as teaching and learning aids	11

It was noticed in Table 12 that, twelve educators always started the lesson by writing the topic on the chalkboard, often taught from the front of the class and gave lessons activity sheets with instructions. Seventeen of them started the lesson by asking the learners about their pre-knowledge on the topic and thereafter allowed learners to work in pairs or groups. Eleven educators gave learners opportunity to either copy the notes from the board or to write their own notes and often used examples from learners' immediate environment to teach mathematics in context. Sixteen of them used the textbook often due to lack of other resources but always visited groups to see what they were doing and offered help. Thirteen educators allowed learners to work individually on their own.

Learners should be assisted to construct their own meaning and understanding within the created learning environments so that their critical thinking powers and problem solving ability be developed (Department of Education, 2003). Table 12 also shows the 11 educators do often used examples from the learners' immediate learning environment to teach mathematics in context.

On the question of using learners' immediate environment to teach mathematics in context, eleven educators said they often used the learners' immediate learning environment as teaching and learning aids. The remaining seven educators did not use the learners' immediate environments often to teach mathematics in context.

Considering the fact that those learners' critical thinking powers and problem solving ability should be developed, it is really a big challenge that needs to be addressed. Learners should be assisted to construct their own meaning and understanding of mathematics within the created learning environments.

4.3.6. Mathematics teaching strategies

Teaching strategies were coded as follows: Whole class discussion (E1), Group work (E2), Lecturing (E3), Cooperative learning (E4), Problem solving (E5), Learner research (E6), Project (E7), Group reports (E8), Worksheets (E9), Question and answer (E10), Investigation (E11) and Discussion (E12). Numbers of educators using the above mentioned strategies are represented by Figure 27.

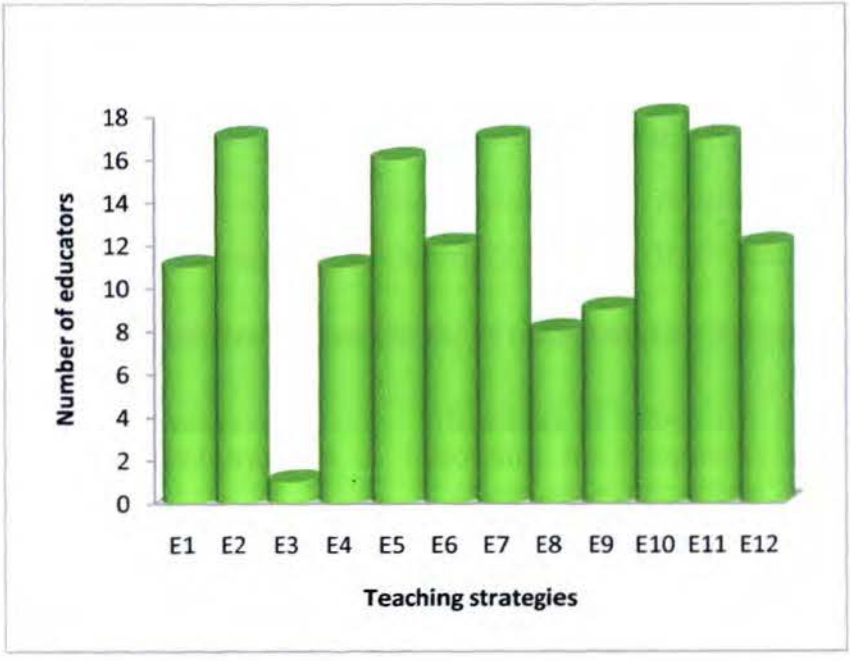

Figure 27: Teaching strategies used by educators

As indicated in Figure 27, all the 18 educators used Question and answer method, 17 Group work, 17 Projects, 17 Investigation, 16 Problem solving, 12 Learner research, 12 Discussion, 11 Co-operative learning and 11 Whole class discussion. It shows that the traditional method of teaching (lecturing method) which was commonly used was no longer preferred as the best method of teaching. It emerged from this study that only one teacher used the lecturing method.

These findings were supported by the ways in which lessons were presented (See Table 12). It was indicated in Table 12 that most educators started by asking learners about their pre-knowledge on the topic and thereafter allowed the learners to work in pairs or groups. The learners were allowed to write their own notes and educators used examples from learners' immediate environment to teach mathematics. The educators allowed learners to work individually but always visited pairs or groups to see what they were doing and offered help where needed. By giving learners practical activities to construct their own meaning and understanding, help them to develop their critical thinking powers and problem solving ability (Department of Education, 2003).

4.3.7. Assessment practices in mathematics teaching

This research also focused on the assessment practices used by the mathematics educators to assess the learners (Refer to the Table 13).

Table 13: Assessment practices in mathematics teaching

Frequency of assessment practice	**Number of educators following the frequency of assessment practice**
Daily	16
Weekly	4
Fortnightly)	6
As per Department	15
Nature of assessment practice	**Number of educators using the assessment practice**
Tests	18
Examinations	17
Assignments	18
Portfolios	5
Projects	17
Class/Homework	18
Problem solving	17

The results in Table 13 show that daily tasks, tests, assignments, projects and class work/homework were the most commonly used assessment practices by educators. Class work/homework, tests, and assignments were used by all 18 educators selected for this study. Projects, examinations, problem, and daily assessment practises were preferred by 17 educators. It was encouraging to realise that mathematical tasks were no longer given on weekly or fortnightly basis, but given on a daily basis.

4.3.8. Mathematical concepts observed by the educators

Various mathematical concepts or shapes observed by the educators on the traditional buildings were represented by different colours indicated in Figure 28.

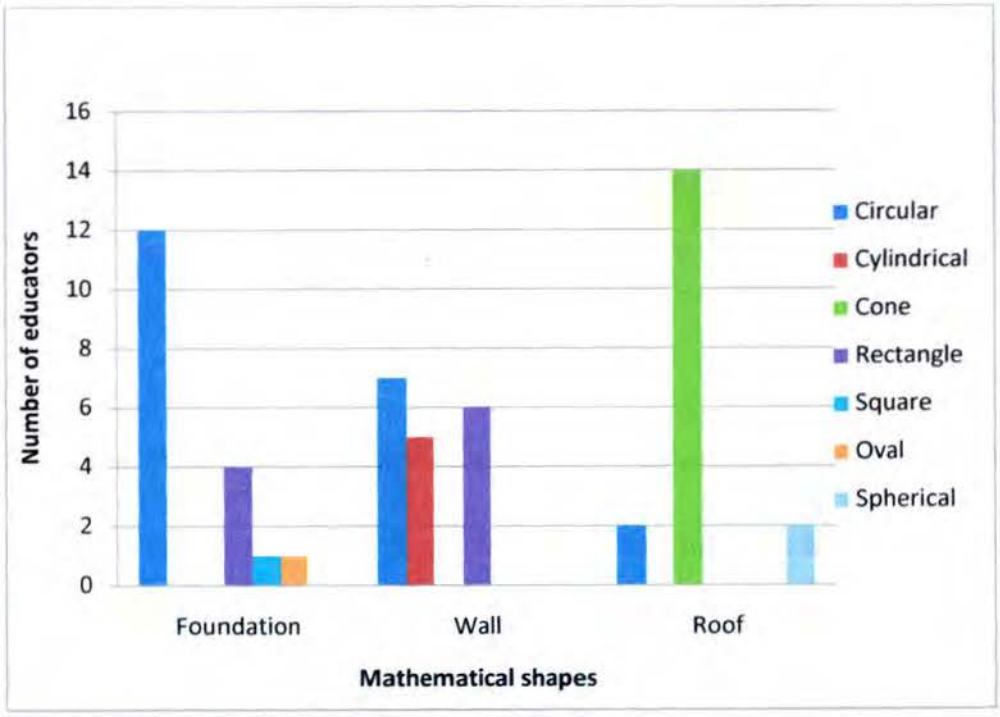

Figure 28: Mathematical shapes identified by educators on the foundation, the wall and the roof

As indicated in Figure 28, builders applied mathematical knowledge in the construction and decorations of the traditional buildings. The educators found that huts had circular foundations, cylindrical walls and conical roofs.

4.3.9. Mathematical concepts or shapes on mural paintings

The following mathematical shapes were identified by the educators on mural paintings as shown in Figure 29: Triangle, Trapezium, Oval and Rectangle.

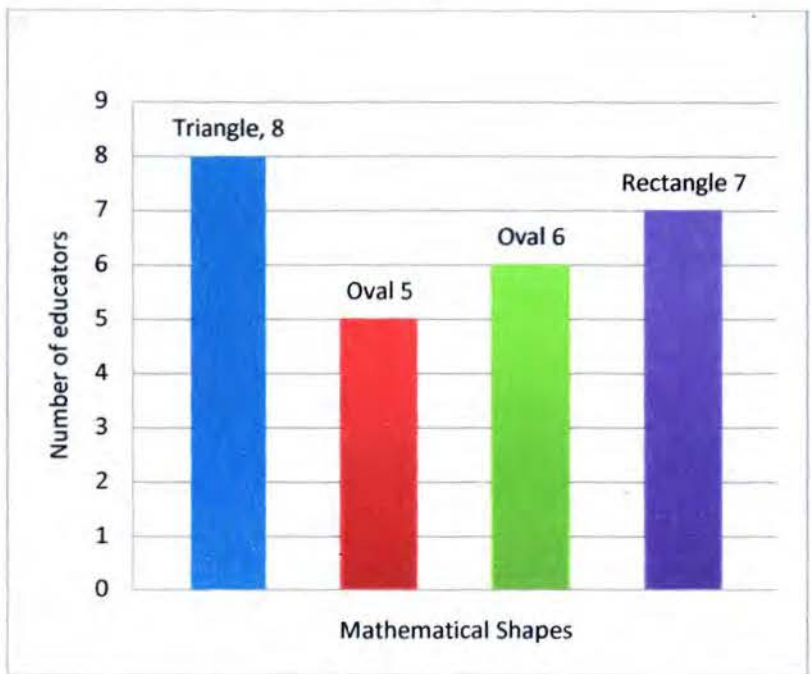

Figure 29: Mathematical shapes identified by educators on mural paintings

The results in Figure 29 show that the number of triangles were 8, followed by rectangles with 7, oval shapes 6 and lastly trapezium with 5.

4.3.10. Mathematical shapes and concepts of the traditional buildings and the teaching of high school mathematics

Table 14 represents the perceptions of educators on mathematical shapes and concepts found on the traditional buildings and their integration into high school mathematics.

Table 14: Perceptions of educators on mathematical concepts found on the traditional circular buildings and their integration into high school mathematics

Statements	Strongly agree	Agree	Not sure	Don't agree
1. Mathematical shapes and concepts found on the traditional buildings are similar to the ones taught in high school mathematics	7	10	1	0
2. Mathematical concepts or shapes can be integrated into high school mathematics	10	7	1	0
3. The concepts or shapes can be used to teach mathematics in context.	8	9	1	0
4.Cultural artefacts can be used as aids to teach mathematics in context	8	9	1	0
5.Mathematics can be taught effectively and meaningfully by using the examples from the learners' immediate environment	10	7	1	0

Table 14 shows the respondents' views on the use and application of the mathematical shapes or concepts of the traditional artefacts in the teaching of mathematics. The teachers agreed that the mathematical concepts could be integrated into high school mathematics. Below follows the analysis of Table 12

.

- Traditional shapes are similar to the ones taught in high school mathematics

Seventeen educators agreed that mathematical symbols or shapes found in the traditional buildings were similar to the ones taught in high school mathematics, with seven strongly agreeing and 10 agreeing. However, only one seemed not to be sure of the shapes or symbols.

- Mathematical shapes can be integrated into high school mathematics

As indicated in Table 14, 17 educators agreed with the statement, with 10 strongly agreeing and seven agreeing, and one being unsure.

- The shapes can be used to contextualise the teaching of mathematics

The results in Table 14 indicate that 17 educators agreed with the statement, with eight teachers strongly agreeing and nine of them agreeing. Only one seemed not to be sure of the shapes that could be used to teach mathematics in context.

- Cultural artefacts can be used as aids to teach mathematics in context

Table 14 indicates that 17 educators agreed that cultural artefacts could be used as aids to teach mathematics in context, with eight of them strongly agreeing while nine agreeing and one seemed to be unsure.

- Mathematics can be taught effectively and meaningfully by using the examples from learners' immediate environment

As indicated in Table 14, 17 educators agreed with the statement, 10 strongly agreed and seven agreed, and one seemed to be unsure.

- Do educators use traditional buildings as examples to teach mathematics in context?

It was established that even though educators believed that examples from the learners' immediate environment such as traditional buildings could be used to

teach mathematics more effectively and meaningfully, they did not use traditional buildings as examples. They saw that traditional shapes found on the buildings were similar to mathematical shapes taught in high school mathematics, therefore, mathematical concepts found on cultural artefacts such as pots, mats, buildings, and beads could be used as aids to teach mathematics in context.

4.3.11. Problems/challenges faced by educators in teaching mathematics in context and their suggestions for improvements.

On the questions of the problems or challenges faced by mathematics in the teaching of mathematics in context, and their suggested solutions for improvements, are provided in the following way, (a) are problems or challenges while (b) are suggestions for improvement.

(a) **Problems or Challenges faced by mathematics educators**

Responses given by the teachers indicated that the mathematics educators experienced the following challenges:

- Lack of knowledge about National Curriculum Statement;
- No qualification in NCS methods;
- Removing of Euclidian Geometry from the syllabus;
- Lack of NCS workshops in Euclidian Geometry section;
- Lack of mathematical resources;
- Language problem or language barrier;
- Teaching mathematics in abstract way;
- Answers in learners' books made learners to copy without creative thinking; and
- Low qualifications in mathematics.

(b) **Suggestions for improvements**

The following suggestions were provided by the educators to improve the teaching of mathematics:

- More courses or workshops in NCS methods;
- Re-introduction of Euclidian Geometry;
- More NCS workshops are needed on Geometry section;
- Enough mathematical resources should be provided;
- Learners should read more English books to improve their language;
- The learners' immediate learning environment could be used as teaching and learning aids;
- Answers should be in teachers' guide only;
- Appoint well-qualified mathematics educators; and
- Further qualification in mathematics.

When studying the challenges educators faced, it became evident that teachers had little knowledge of the NCS and CAPS thus, more CAPS workshops were needed. Teachers needed to attend more workshops on NCS teaching methods. Teacher training courses and programmes should include training on culture, society, the relationship between mathematics and culture, and the history of evolution of mathematical concepts. Change in the mathematics curriculum is very much effective, but it needed teachers to understand the change in all its dimensions.

4.4. Analysis and interpretations of interviews

The responses to the questions were subdivided into themes. Answers that belonged to the same thematic ideas were grouped together. Extracts from the conducted interviews were grouped according to the following main themes. See Appendix D. Interviewees 1 and 2 were Va-Tsonga from Mopani, 3 and 4 were Bapedi from Sekhukhune, while 5 and 6 were Vha-Venda from Vhembe.

Open ended and semi-structured questions based on the following themes were constructed on the interview schedule: See annexure A.

- The shape of the house (foundation, wall and roof);
- Symbols or shapes on the traditional circular buildings;
- The meaning of the symbols to people;
- The source of the different symbols or shapes on the house;
- Symbolism to the people (cultural identity, cultural structure);
- Measurement of the traditional circular house; and
- Construction of the traditional circular house.

The interview guide helped to elicit responses from the builders of the houses.

Summary of the answers provided by all the six participants were written down in the note book.

- The shape of the house

To the question of the shape of the house, interviewees 1 and 2 said the shape of the foundations is *"Xirentelele"*, which means "*circle*" in Xitsonga.

Interviewees 3 and 4 said "*nkgokolo"*, which means circle in Sepedi.

Interviewees 5 and 6 said "*Gumba*" (circle) in Tshivenda.

All the six builders agreed that the foundation shape of the house was circular.

- Builders' answers on why the houses were circular in shape

Interviewees 1, 3, 4 and 6 stated that: *"Ke dintlo tša rena tša setšo"* (They are our traditional houses). Builders 2 and 5 said: ``*di bonolo go di aga"* (They are easy to construct). Out of the six participants, four said it was their cultural or traditional houses while two said they were easy to construct.

- The source of symbols or shapes

All six participants said: *"Makgolo a a tšwa ka mo dikgopolong tša rena. Ga ra a ela sekolong"*. (They are from our minds. We never went to a formal school).

Builders used their creative thinking to come out with various mathematical shapes and concepts. It is an intergenerational knowledge.

- The meaning of the symbols.

As interviewees 3 and 4 put it: **"***Dintlo tše di bontšha ditšo tša rena ka go fapana fapana. Ge o ka di lebelela ga botse ga di swane le tša ditšo tša ba bangwe.*" (They symbolise our cultural identity and structures). The artists believed that:

> *Mural decorations brought homage to the ancestors and in more recent times, they represent aspects of celebration, ritual and initiation.Colours of the decorations themselves have strong symbolic and religious relevance. Murals around windows and doors sometimes prohibit evil spirits from entering into the house. White colours symbolise happiness and peace while black and dark colours symbollise negative emotions such as grief or sadness.*

- Measurement and allocation of the houses

All six participants said: *"Thapo yeo re e kgokelelang mo koteng ya gare ga ntlo, ke yona e re thušang go bona goe re aga ntlo e kaakang."* (The length of the string tightened at the centre of the house helped to determine the size of the house). When the string is short, the house becomes small, and when the rope is longer, the house becomes bigger. In most cases big houses belonged to the adults while small ones belonged to the boys, girls and children. All the builders also agreed that the number of people in the house depended on the size of the house. Respondent number four further indicated that the houses for the boys were built next to the kraal so that they could protect the cattle from thieves.

- Construction of the foundation

All six (6) builders interviewed provided more or less the same answers to the questions. For example, in response to the question on how the foundation was constructed, interviewees 1 and 2 said:

> ``*Like any building, an indigenous circular house has a foundation. The type of material used in the construction of traditional house plays a significant role in determining the type of foundation and a wall to be built. Usually we start by identifying the centre of the house and nail down a small stick at the point. Thereafter, we tighten a string to the stick and stretch the rope to a second stick. Then we pull the fastened string and move around to make a circle on the ground".*

- Construction of the wall

On the question on how the wall was constructed, interviewees 1 and 2 responded by saying:

> ``*In the construction of the wall made of poles and stones, the poles are bound to each other by means of the laths (dipalelo). The laths are fastened round the poles at a specific distance or space between them. Then we build the wall using a combination of stones and mud between the poles. We use a mixture of soil and water to hold mud or stones together. These types of houses are used for sleeping."*

- Construction of the roof

In response to the question on how the roof was constructed, interviewees 1 and 2 said:

> ``*We firstly dig the hole at the centre of the house. In the hole a long, big and strong pole is inserted. The pole is put in such a way that it goes straight up to the roof. On top of this pole, we put a circular wooden block which has an edge that protrudes to the top of the roof.*

The wooden block at the top 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."

Interviewees 4, 5 and 6 further explained that: "*Just like the foundation, the roof also has a centre. The wooden block at the top of the roof serves as the centre of the roof. The poles that are nailed on the wooden block are of equal length from the wall plate to the centre of the roof. On the wall plate the roof is circular shaped (nkgokolo) but it makes a funnel-shape towards the apex of the roof. The poles round the wall plate leave equal spacing."*

- **General findings from interviews**

The answers from all six respondents indicated that the methods used to construct the foundations and the walls were the same. The only difference appeared at the roof decorations (patterning). The parallel lines that appeared at the roof patterning were found on the houses of Bapedi tribe. The two tribes (that is Va-Tsonga and Vha-Venda) used to make the roofs that were plain without any decorations.

Although the builders could not explain why they used the mathematical symbols and notations in the construction of the houses, mathematical concepts were applied. It became evident that mathematics was a cultural product used by the builders to construct the huts. This support the assertion by Mogai (2001) that, mathematical knowledge is used by all in their everyday lives. Mathematical concepts were embodied in the structure and mural decorations of the traditional buildings. These concepts are similar to the ones taught in high school mathematics. Thus, to enhance the teaching and learning of mathematics, teachers should expose learners to the mathematical practical activities. Therefore, these concepts could be used to teach mathematics in context.

4.5. Summary

In this chapter, analysis and interpretation of data was presented. Tables, various types of figures and frequency counts were used to present, to analyse and to interpret data. That was followed by presentation of the main findings of the study, grouped according to the main research questions and data collection methods. The next chapter discusses the findings revealed from the analysis, draws conclusions from the discussions and makes some recommendations depending on the conclusions.

CHAPTER FIVE

DISCUSSION, CONCLUSION AND RECOMMENDATIONS

5.1. Introduction

In this chapter the researcher discusses the main findings of the study, presents conclusions and makes some recommendations. The presentation of the main findings of the research were guided and grouped in accordance with the three main research questions.

In this study, an attempt was made to explore the mathematical concepts or shapes of the traditional buildings of the Limpopo Province, South Africa and the teaching of high school mathematics. The rationale for the study was to explore the extent to which mathematical shapes or concepts of the traditional buildings of the Limpopo Province could be used to enhance the teaching and learning of mathematics in context. The research questions that guided the exploration were:

1. Which mathematical concepts embedded in the traditional buildings of the Limpopo Province can be used to teach high school mathematics?

2. What challenges do high school mathematics educators face in contextualising their teaching?

3. Which suggestions can be made to assist mathematics educators to contextualise their teaching?

The study was conceived to address the problem statement identified as the extent to which teachers incorporate mathematical concepts or symbols found on the traditional circular buildings in the teaching and learning of mathematics. Findings from the above research questions are discussed below.

5.2. Discussions

5.2.1. Which mathematical concepts in the traditional buildings of the Limpopo Province can be used to teach high school mathematics?

➢ **Mathematical concepts found on the foundation of the houses.**

As shown in Figures 2 and 3, and from the answers provided by the builders on page 148 to 151, it was noticed that the foundation for all six traditional buildings were circular in shape. The area of the foundation could be calculated using the appropriate formulae. The foundations of the circular buildings showed the following properties and characteristics of a circle:

- The foundation was circular and represented the *circumference (C)* of the circle. The pole at the centre of the foundation depicts the centre of a circle.

- The string between the centre pole and the edge of the circular foundation depicted the *radius (r)* of a circle.

- The *circumference* of the circular foundation could be found by using the formula $C = 2\pi r$ or $C = \pi d$ where the radius is the *length of the string*, C is the circumference, π is 3.14 and d is the diameter.

- The *area of the foundation* of the house can be found by using the formula $A = \pi r^2$

From the above, teachers could use the foundation of the huts in teaching *circumference, area, radius and diameter of a circle.* Therefore, these foundations could be used to *solve problems associated with the tangent, secant, cosine and sine rule, and area rule.* The foundation could be used to teach activities *associated with circle geometry.*

The murals found on the floor of the huts were mathematically oriented because transformations such as reflection and symmetry, and shapes such as *triangle, trapezium, oval and circular shape* were displayed on the floor. Figure 4 showed oval shapes, Figure 5 showed triangles, parallel lines and circular shapes, Figure 6 showed oval shapes and parallel lines and Figure 7 showed oval shapes, parallel lines, reflections and symmetry.

All these mathematical concepts appear in the high school mathematics curriculum and could be used in the study of *fractions*, *percentages, circle geometry, angles, triangles, quadrilaterals* and so forth. Murals found on the floor could be integrated into high school mathematics. The shapes could be used as examples to calculate and solve practical problems associated with area, volume, height, sine and cosine rule of triangles and quadrilaterals.

Although the builders who participated in this study could not explain why they used mathematical shapes and structures, mathematical knowledge was used in building the huts. It became evident that mathematics is a cultural product as the builders practiced some form of mathematics in the constructions and decorations of the traditional buildings. Thus, to enhance the teaching and learning of mathematics in context, learners should be exposed to their immediate learning environments such as the shapes and concepts on the traditional buildings.

- **Mathematical concepts found on the walls of the buildings**

It was noticed that the base and the upper shape of the wall was circular in shape but the building itself was cylindrical in shape. Figure 8 and Figure 9 show the cylindrical shape of the hut with a circular base. The Figures could be used to calculate the area, the volume and the surface area of a cylinder and to solve the problems associated with a cylinder.

The walls of Figures 8 and 9 portrayed the properties and characteristics of a cylinder:

- The walls were *cylindrical in shape*. The base area of the building could be calculated using the formula $A = \pi r^2$, *where r is the length from the centre of the house to the wall.*

- The volume could also be calculated by using the following formula: *($V = \pi r^2 h$) or ($V = Ah$), where* $A = \pi r^2$ *and h is the height of the wall.*

The shape of the wall could be used to solve *problems associated with cylinders and spherical structures.* It goes without saying that cultural artefacts such as buildings could be used as examples from the learners' immediate environment to teach mathematics in context.

The murals on the walls show the following mathematical concepts and shapes. Figures 10 to 15 show transformations such as translation, reflection, rotation; mathematical concepts such as tessellations, symmetry, and mathematical shapes such as *rectangle, triangle, trapezium, oval, square, parallelogram, parallel lines and rhombus*. Each figure shows many mathematical shapes and concepts that are named and indicated by lines.

These mathematical concepts and shapes appear in the high school mathematics curriculum and could be used in the study of *fractions, percentages, circle geometry, angles, triangles, quadrilaterals etc.* For example, all the various quadrilaterals displayed on the walls could be used to *calculate the area, perimeter and volume of a quadrilateral. The circular shapes could used to calculate the circumference and the area of a circle.* Therefore, decorations seen on the buildings could be used or integrated into high school mathematics. These could be the basis for solving problems associated with *geometric patterns, surface area, volume, and so on.*

The fact that the knowledge of mathematics was used in the construction and decorations of the indigenous buildings suggests that one can learn mathematics by interacting with one's immediate environment, as one uses aspects of mathematics in daily life (Mosimege, 2001). Mathematics, therefore, should be associated with sets of social practices, each with its history, persons, institutions and social locations, symbolic forms, purposes and power relations (DoE, 2001).

Mathematics is thus cultural knowledge, like the rest of human knowledge. 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, and remote (Ernest, 1996).

- **Mathematical concepts found on the roof of the buildings**

It was noticed that the shape of the roof for all six traditional circular buildings observed was cone-shaped or funnel-shaped or conical. Figures 16 and 17 showed the conical shapes of the traditional roofs. The roof had circular base but conical in shape.

The shape of the roof had the following properties of a cone-shaped object:

- The shape of the indigenous roof had circular base and conical or funnel in structure towards the apex. As shown in Figures 16 to 18, the apex (lenotlo), where all the poles that were spread round the wall plates were nailed, served as a centre of the roof. The shape of the roof was also *symmetrical.*

- The surface area of the roof, in this case the cone, is the *sum of the base area and the area of the curved surface* ($A = \pi r^2 + \pi rh$), where s is the slant height of the roof. In this case the *base area* is the area of the base circular shape of the roof. This depicts the surface area of the cone.

- The volume of the indigenous roof (cone) can be measured and calculated using this formula: *one-third of the base area of the roof multiplied by the height of the roof* ($V = \frac{1}{3}Ah$) *or* $V = (\frac{1}{3}\pi r^2 h)$.

Mathematical concepts found on the roof of the buildings were *all the properties and the characteristics of conical shape. The roof could be used to find the base area, the volume of a cone, the surface area, etc.* If the pole was placed at the centre of the roof and a rope is stretched to the base of the roof, the base area, the volume and the surface area could be calculated. These can be used to solve practical and mathematical problems associated with the *base area, surface area, volume, and the height of the cone.*

➢ **Mathematical concepts found on the roof decorations**

Various grasses were used to make different patterns or decorations on the roof of the traditional buildings. Parallel lines made with grasses were recognised on the roof patterning or decorations of the traditional buildings. Steps were made on the roof as a form of decoration. These steps were parallel around the roof. The parallel lines were visible in Figure 19 and Figure 20.

These shapes and concepts are similar to the ones taught in high school mathematics curriculum. *The parallel arranged grasses could be used to solve problems on parallelograms, rectangles and rhombus.*

➢ **Measurement and allocation of the houses**

The builders determined the size of the houses they wanted to build. All the 6 respondents alluded to and agreed that the length of the string tightened at the centre stick (the radius) determined the size of the house. They also agreed that the number of people in the house depended on the size of the house. The builders further hinted that the big houses belonged to adults or parents while the smaller ones belonged to boys, girls and children.

Two of the six respondents also indicated that the houses for the boys were built next to the kraal, which was also circular in shape so that the boys could assist in protecting the cattle from the thieves.

Contextualization therefore appears to be an appropriate strategy in teaching and learning mathematics.

- **The source and the meaning of the shapes or symbols**

As indicated in the builders' responses, all six respondents agreed that these were their intergenerational knowledge. It passes on from one generation to another. No formal schooling was attended. Locally based knowledge systems were transmitted in different ways from the elders. Although some indigenous knowledge was recorded in texts, most was orally based and was often revealed in stories and legends, as well as through actual practice (Bob, 2001). Indigenous Knowledge Systems depended on living people as sources.

Actions and spoken words were used. In the case of learning how to construct traditional buildings, skills were passed on from one generation to the next by the act of teaching-by-doing. Knowledge was acquired through accumulation of experience and informal experiments. Novices observed the expert and practiced until they acquired the knowledge. There was no formal schooling or training. Instead, knowledge was acquired and transmitted to the next generation by the act of teaching-by-doing.

This supports the assertion by Laridon (2000) that mathematical knowledge does not originate from one community only, but it is developed by all communities.

From the interviews with the builders, all six participants agreed that the symbols represented their cultural identity or cultural structures. The builders said:

> *"Decorations were a form of religious art relating to their beliefs concerning the ancestors. Historically some used mural decorations to bring homage to their ancestors and in more*

recent times, they represented aspects of celebration, ritual and initiation"

"Colours of the decorations had strong symbolic and religious relevance. In the African culture, murals around windows and doors sometimes prohibited evil spirits or people supposed to have dealings with the devil from entering into the house."

"White colours symbolised happiness and peace while black and dark colours symbolised negative emotions such as grief or sadness."

From the interviews conducted with the six builders, the researcher realised that builders practised some form of mathematics. Thus, mathematical knowledge does not originate from one community only, but it is practised and developed by all communities. This supports the assertion by Mwakapend (1995) that mathematical knowledge is a component of culture, since aspects of mathematics manifest themselves in daily activities of the people.

5.2.2. What challenges or problems do high school mathematics educators face in contextualising their teaching?

Figures 2 to 20 and Table 2 indicate the mathematical concepts or structures on the traditional buildings that were similar to the ones taught in high school mathematics. Surprisingly teachers were unable to use them to contextualise the teaching of mathematics. The research revealed that teachers were unable to use learners' immediate learning environment to teach mathematics in context. In section 4.3.11, teachers gave the following challenges or problems as the ones that prevented them from teaching mathematics in context.

- Lack of knowledge about details of the National Curriculum Statement;
- No qualification in NCS methods;
- Insufficient NCS workshops;

- Lack of mathematical resources;
- Learners' language problems;
- Teaching mathematics in an abstract way;
- Answers in learners' textbooks made learners to copy without thinking creatively; and
- Low qualifications for mathematics teachers.

One cannot accept all these excuses for not using examples from the learners' background to contextualise the teaching of mathematics. For example, the issue of textbooks does not play a part in teaching mathematics in context. Learners' background can be used to teach without textbooks. Answers in the learners' textbooks do not prohibit teachers from teaching mathematics in context.

➢ **School demography**

- ***Qualifications***

The research found that some mathematics teachers were not qualified in mathematics let alone to know about the applications involving mathematics. Eleven educators had a diploma qualification in mathematics. The remaining seven had degrees, but did not major in mathematics. This situation contributed negatively to the learners' performance in mathematics in the Limpopo Province.

This revelation shows that there is a need for mathematics teachers to improve their studies in mathematics so that they can deliver quality education to the learners. Teachers with no qualifications in NCS methods and who lack knowledge in curriculum as well as pedagogic matters, lack confidence to deliver quality education and as such they are unable to produce good results. For mathematics teachers to address their challenges, the research encourages them to improve their studies and attend more NCS workshops and gain more knowledge about details of the CAPS.

- ***Specialisation***

It was discovered that all 18 teachers had specialized in mathematics only at the diploma level. That is why they were unable to use mathematical concepts on traditional buildings to teach mathematics in context. This indicates that the methods of teaching mathematics were not adequate. This could be traced to the background of the teachers, the fact that they were not properly trained in curriculum as well as pedagogic matters. These poorly trained educators therefore passed their poor education on to their students and thus as a vicious circle. Therefore, there is a need for mathematics educators to specialise in mathematics at the degree level and be properly trained in curriculum as well as in pedagogic matters.

- ***School situation or location***

It is encouraging to note that seventeen participants were from rural places. Only one educator was from the township and no one was from the town or city. It was noticed that the school location played very little part in teacher ability to use learners' environment in teaching. This was reflected in teachers' answers to questions on Table 6. The Table indicated that the research was conducted in familiar settings. Educators and learners knew the traditional buildings and some slept inside these houses but they were unable to use mathematical concepts on the buildings to teach mathematics.

- ***Age of educators***

As indicated in Table 3, eight mathematics educators who participated in the study were between 36 and 40 years. Seven of them were older than 45 years. Only three of them were still younger than or equal to 35 years of age. Some of them had been trained during their teacher training and did not have qualifications in NCS methods. There is a need for mathematics educators to improve their studies in NCS methods and to attend more workshops at CAPS

training. Otherwise the poorly trained educators will continue to pass their poor education on to their learners.

- ***Number of mathematics educators in each school***

The research revealed that eleven schools had only one mathematics educator each. Three schools had two educators each, two schools had three educators each, one school had four educators and two schools had six educators at each school. Figure 24 show that most schools had only one mathematics educator who was teaching grade 8 to 12. This is a serious challenge because if the teacher is not trained properly, he will pass on his/her poor education to the whole class. Such a class will produce poor results in mathematics for as long as that particular teacher is still there.

- ***Grade taught***

All 18 mathematics educators who participated in the study were teaching Grade 12. Besides Grade 12, 13 of them were also teaching Grade 11, nine were teaching Grade 10, six were also teaching Grade 9, and four were teaching Grade 8. It was assumed that all the participants were familiar with the geometric patterns or transformation geometry and the properties of a circle, but the research revealed that teachers did not use them to teach mathematics in context.

It was surprising to discover that teachers were unable to use mathematical concepts found on the buildings or even to realise that the shapes are similar to the ones taught in the high school mathematics curriculum. This could be traced to the educational background of the teachers.

- ***Number of mathematics Grade 12 learners in class***

The research revealed that, eight mathematics classes had between 11 and 19 learners in the class. That was followed by the classes that had less than 10 learners. The number of classes that had more than 50 learners was three.

Between 20 and 29 per class was only one school. The number of classes that had between 30 and 39 learners was only one. In the interval between 40 and 49 there was none. In general mathematics classes were not overcrowded. They ranged between zero and 20 learners per class because most learners had gone to the former model C (former whites schools only) schools.

It was surprising that some qualified mathematics teachers with a class of less than 20 learners, were unable to pass at least 50 percent if not 100 percent. The pass percentage in mathematics was not satisfactory compared to other subjects. For example, from the 2012 national analysis of results, the pass rate in mathematics was 54%, Mpumalanga 53.1%, Limpopo 52.4%, Kwazulu Natal 48.1% and Eastern Cape 38.1%. It was noticed that it is not the number of learners in the class that determines pass rates. There are several contextual factors that affect learner performance.

- ***Teaching experience***

It was discovered that all 18 teachers who participated in the study had long teaching experience to teach mathematics and produce good results. Table 7 indicates that 15 educators had more than five years teaching experience in mathematics. Only three had less than five years teaching experience.

The above information implied that teachers should not have problems in using mathematical symbols found on the cultural artefacts to contextualize the teaching of mathematics. This shows that long teaching experience does not mean effective teaching and good results

➢ **Teaching strategies**

Figure 27 indicated that the traditional method of teaching (lecture method) was no longer preferred as the best method of teaching. Only one educator preferred the lecture method. Now learners' critical thinking powers and problem solving abilities are developed as supported by CAPS (Department of Basic Education, 2011).

The research revealed that teachers had difficulty on how to teach mathematics in context. Their biggest challenge was how to integrate the mathematical concepts found on the traditional objects into high school mathematics. The inability of teachers to use mathematical concepts and structures embedded in the learners' immediate environments to teach mathematics could be traced to the teachers' background. If teachers were poorly trained, they would pass on their poor education to their learners which constitute a vicious circle. Therefore, teachers need to study the new methods of teaching and learning mathematics.

Teachers believed that learners could learn better when learning was approached from a practical experience. Cultural artefacts such as pots, beads and traditional buildings should be used as aids to contextualize the teaching of mathematics. Teachers should make sure that contextualisation is considered during the preparatory stage.

- **Assessment practices in mathematics**

As indicated in Table 13, daily tasks, tests, assignments, projects and class work/homework were the most common assessment practices used by educators. All teachers used the above mentioned types of assessment. Mathematics is regarded as one of the most important subjects for many career paths (Brombacher, 2000); therefore tasks should be given on a daily basis. More practical mathematics problems should be given to the learners to practice for the learners to pass tests and examinations. Activities from the learners' immediate environment should be used to assess them and learners should be given enough time to practice because "practice makes perfect".

- **Teacher support materials**

The research revealed that there were shortages of mathematics teachers and learner support materials. These might be contributory factors to the poor performance of learners in mathematics.

As indicated in Table 9, the teachers provided the following teacher support materials as the ones that affected their performance:

- Lack of libraries;
- Shortage of mathematical instruments;
- Shortage of mathematical textbooks; and
- Shortage of teaching and learning aids.

These shortages seemed to have contributed negatively to the effective teaching and learning of mathematics. Teachers said they were unable to teach properly due to these shortages. In my opinion, these are not real excuses because teacher support materials do not contextualise the teaching of mathematics. The Department of Education should provide schools with mathematical instruments, mathematical textbooks and other teaching, and learning aids.

➢ **Lesson presentation**

It was discovered that 12 educators used to start the lesson by writing the topic on the chalkboard, taught from the front of the class and gave lesson activity sheets with instructions. Seventeen of them asked learners about their pre-knowledge on the topic and thereafter allowed learners to work in pairs or groups. Eleven educators gave learners opportunity to write their own notes and used practical examples to teach mathematics. Sixteen of them used the textbook often due to lack of other resources but always visited groups to see what they were doing and offered help. Thirteen educators allowed learners to work individually on their own.

Learners' critical thinking powers and problem solving ability should be developed. They should be assisted to construct their own meaning and understanding by giving them practical activities. The research shows that some educators often used the learners' immediate learning environment to teach mathematics in context. The researcher encourages teachers to use examples from the learners' social and cultural background so that learners could learn from their own experiences.

➢ **Teacher support development**

The research revealed that lack of qualifications in the NCS/CAPS methods, little knowledge of CAPS methods, insufficient NCS and CAPS workshops were some of the challenges to educators in teaching mathematics in context. Therefore, more workshops on NCS and CAPS are needed to improve the teaching and learning of mathematics. Teachers also need to study NCS methods of teaching mathematics and also improve their qualifications

5.2.3. Suggestions to assist mathematics educators to make use of cultural artefacts to contextualise their teaching

The following are suggestions provided by the educators on how to improve the teaching of mathematics in context:

- More courses or workshops in NCS methods;
- More NCS workshops are needed on geometry section of mathematics;
- Provision of mathematical resources such as mathematics instruments;
- Learners and teachers should read more English books to improve their language skills;
- Use of learners' immediate learning environment as teaching and learning aids; and
- Appointing qualified mathematics educators.

The inability of teachers to use mathematical concepts and structures from the learners' immediate environments to teach can be traced to the teachers' background. Teacher training courses and programmes form a good starting point to move in the direction for teaching mathematics effectively. Teachers need to know and understand the mathematics curriculum to be able to teach effectively.

Learning new topics in mathematics and new methods of teaching mathematics are the two important qualities in the teaching of mathematics. The two qualities alone cannot help the learners to acquire insights and relevance without the use of learners' background and learners' immediate learning environment. Teacher training in content, methods and assessment should include the value of IKS in the curriculum. Social experiences and cultural background play a significant role in teaching mathematics in context.

The shortage of teacher support materials contributes negatively to the effective teaching and learning of mathematics. Teachers are unable to perform their duties properly due to these shortages. The Department of Education should provide schools with mathematical instruments, mathematics textbooks and other teaching and learning materials.

5.3. Conclusions

5.3.1. Mathematical concepts embedded in the traditional buildings

From the discussions above, one can conclude that mathematical shapes and concepts are embedded in the traditional buildings of the Limpopo Province. Mathematical concepts and shapes such as translation, reflection, rotation, parallel lines, oval, rectangular, cone-shaped figure were discovered on the traditional buildings. All these mathematical concepts and shapes appear in the high school mathematics curriculum and could be used to solve practical problems associated with *fractions, percentages, circle geometry, angles, triangles, quadrilaterals* and others.

The inability of teachers to use mathematical concepts and structures from the learners' immediate environments to teach mathematics could be traced to their background, the fact that they might not have been trained properly in curriculum as well as pedagogic matters.

5.3.2. Challenges faced by mathematics educators

From the above discussions, one can conclude that:

- All eighteen mathematics teachers who participated in this study have studied mathematics curriculum as well as pedagogic matter only at the diploma level;
- The school situation or location played very little part in teacher ability to use learners' immediate environment to teach mathematics;
- Some teachers were highly experienced but they lacked knowledge of the NCS methods. They had been trained during the old Bantu Education system (South Africa's old curriculum before 1994);
- Eleven schools had only one teacher who offered mathematics from Grade 8 to 12;
- The lecturing method was no longer the preferred method of teaching and there was insufficient assessment due to shortage of teacher support materials; and
- Contextualisation was not considered by the teachers during the preparatory stage, presentation stage and assessment stage.

Social experiences and cultural background play a significant role in teaching mathematics in context (Fasheh, 1997). Learning new topics in mathematics and new methods of teaching mathematics are the two most important qualities in the teaching of mathematics. The two qualities alone cannot help the learners to acquire insight and relevance without the use of learners' background and learners' immediate learning environment. Therefore, teachers should develop their own contextualised teaching and learning materials use them during the lesson presentation.

5.3.3. Suggestions to assist mathematics educators

Based on the suggestions given by the educators, one can conclude that:

- Teachers were not properly trained in curriculum as well as pedagogic matters;
- Teachers had low qualifications in mathematics;
- Attendance of CAPS workshops was not sufficient; and
- There was a shortage of teacher support materials.

NWU LIBRARY

5.4. Recommendations

In the light of the above findings and identified challenges faced by the mathematics educators in contextualising their teaching, the following recommendations are proposed:

5.4.1. Teaching of mathematics

Based on the above conclusions, for the meaningful teaching and learning of mathematics to take place, the following recommendations are proposed:

- The teaching of mathematics should not be devoid of social and cultural connotations. To achieve this, contextualization appears to be one of the appropriate strategies to use to teach and learn mathematics.

- The role of IKS should be emphasised in the syllabus and contextualized materials should be developed and used in the presentation and assessment of the lesson.

- Teachers should give learners mathematical practical activities based on cultural artefacts so that learners' critical thinking powers and problem solving ability could be developed.

Therefore, in order to make mathematics more relevant and useful, learners' social and cultural backgrounds should be used so that learners could become more interested in mathematics and learn better from practical experience.

5.4.2. Teacher training courses

Teacher training courses and programmes form a good starting point to move in the positive direction for teaching mathematics effectively. But learning new topics in mathematics or new methods of teaching them is not enough to acquire insight and relevance. Therefore, pre-training courses and programmes at Colleges of Education and Universities should include also courses on culture, society, the relationship between mathematics and culture, and the history of evolution of mathematical concepts.

No change in mathematics curriculum is effective unless the teachers understand the curriculum changes. More workshops on the relationship between mathematics and culture should be conducted. Change in the mathematics curriculum is very much efficient but it needs teachers to understand the change in all its dimensions.

The role of IKS should be included in the syllabus to help teachers to interpret traditional or cultural artefacts and use them to teach mathematics in context. Training in content, methods and assessment should include the value of IKS in the curriculum.

5.4.3. Workshops

Teachers need to attend more in-service training courses on NCS or CAPS methods and programmes to learn new methods of teaching mathematics. More workshops on how to integrate ethno-mathematics examples in the classroom mathematics need to be conducted. This will assist mathematics educators with various alternative methods and strategies of teaching mathematics in context.

CAPS, for example, encourages that learners' critical thinking powers and problem-solving abilities be developed. To achieve these skills, contextualization appears to be the appropriate strategy in teaching and learning of mathematics. Therefore, teachers should be encouraged to use the learners' immediate learning environment to teach mathematics in context. More developmental workshops in mathematics should be conducted.

5.4.3. Improve qualifications in mathematics

Teachers need to further their studies and improve their qualifications in order to be effective in the teaching of mathematics. They must be properly trained in curriculum as well as pedagogic matters. They need to further their studies to develop themselves in mathematics curriculum as well as pedagogic matters.

5.4.4. Provision of teacher support materials.

The Department of Education should provide schools with mathematical instruments, mathematical textbooks and sufficient teaching and learning support materials. Even though according to NCS, learners' social and cultural background can be used to teach mathematics in context, books are needed as supporting materials.

5.4.5. Further research development in the area of ethnomathematics

Further research on ethnomathematics need to be conducted. Mathematical concepts embedded in cultural artefacts need to be further explored and integrated into classroom mathematics.

The following research developments are suggested for the mathematics teachers:

- Teachers to assess the "learned curriculum " where learners work on the traditional buildings or other cultural artefacts projects.

- Teachers to develop their own contextualized teaching and learning materials and implement them during lessons and assess the impact thereof.

- Workshops on how to include ethno-mathematics examples in the teaching of mathematics need to be conducted.

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7. ANNEXURES

REQUEST FOR PERMISSION TO CONDUCT RESEARCH

AND THE APPROVAL LETTER

Enq: Seroto N.M.
Student N0: 21799687
Cell N0: 083 744 8053

P O Box 284
Lenyenye
0857

5 March 2011

Head of Department
Limpopo Department of Education
Private Bag X9489
Polokwane
0700

Sir/Madam

Re: Request for the use of mathematics educators to collect data. (PhD: Mathematics Education)

1. The above matter refers.
2. Ngwako Seroto student N0: 21799687, is conducting academic research study and is attached to the University of North-West. The research study is for the Doctor of Philosophy (PhD) in Mathematics Education degree.
3. The title of the research study is ``***Mathematical Concepts of the Traditional Buildings of the Limpopo Province that Can be Used to Teach High School Mathematics***''.

4. Kindly, we are requesting the Department of Education to allow Ngwako to collect data from mathematics educators within Mopani, Vhembe and Sekhukhune districts.
5. The data is about the use the learner's immediate environment such as cultural artifacts to teach mathematics in context.
6. To verify and/or confirm the details kindly contact supervisors of this research study as follows: Prof. Thapelo Mamiala, Tel N0: 018 389 2032, Cell N0: 076 569 1737, Email address: Thapelo.Mamiala@nwu.ac.za and Dr Frederick Kwayisi, Tel Number: 018 389 2451, Cell Number: 082 200 8019, Email address: Frederick.Kwayisi@nwu.ac.za
7. Looking forward to your cooperation in this regard.

Yours Faithfully

Seroto Ngwako Michael

LIMPOPO
PROVINCIAL GOVERNMENT
REPUBLIC OF SOUTH AFRICA

DEPARTMENT OF EDUCATION
OFFICE OF THE HEAD OF DEPARTMENT

Enquiries : Nemalili Eastern(Manager: Office of the HOD)
Tel Ext. : (015) 290 7702

Date : 31 March 2011

Mr.N.M.Seroto
P.O.Box 284
Lenyenye
0857

Email:Fredick.Kwayisi@nwu.ac.za
Thapelo.Mamiala@nwu.ac.za
0837448053/ 018 389 2032

Dear Sir

RE: REQUEST FOR PERMISSION TO CONDUCT RESEARCH: SEROTO N.M.(Student No: 21799687)

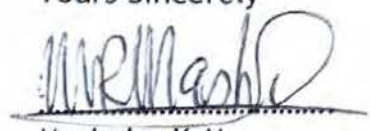
1. Thank you for your letter dated the 15 March 2011. We are indeed humbled by the interest displayed by you on matters which of course affects our Education system.
2. In the light of your request, i therefore grant you permission to conduct research for your Doctor of Philosophy (PhD) in mathematics Education degree (University of North West).With understanding that the data will be collected from mathematics educators in Mopani, Vhembe and Sekhukhune Districts, it is however important to indicate that prior arrangements to

Cnr 113 Biccard & 24 Excelsior Street, POLOKWANE, 0700 Private bag X9489, POLOKWANE, 0700
Tel.: (015) 290 7602/7655, Fax:; (015) 297 0937, E-mail: mnisivv@edu.limpopo.gov, ramukhadim@edu.limpopo.gov

conduct the latter should be arranged in advance so that teaching and learning is not sacrificed.

3. Once more, we wish you all of the best in your studies and assure you of our cooperation in this regard.

Yours Sincerely



31 March 2011

Mashaba K.M.
Acting Head of Department-Education
Limpopo Province

Cc: Senior General Manager: Mr.M.Thamaga
District Senior Manager (Mopani): Dr.L.L.Mafenya
District Senior Manager (Vhembe): Dr.N.G.Rambiyana
District Senior Manager (Sekhukhune): Mr.T.G.Nkadimeng

APPENDIX A: INTERVIEW SCHEDULE FOR BUILDERS

TOPIC: Mathematical Concepts of the Traditional Buildings of the Limpopo Province that Can be Used to Teach High School Mathematics.

BACKGROUND

Mr. Ngwako Seroto is conducting an academic research study and is attached to the University of North-West. This research study is for the Doctor of Philosophy (PhD) in Mathematics Education degree. The title of the research study is ``***Mathematical Concepts of the Traditional Buildings of the Limpopo Province that Can be Used to Teach High School Mathematics***''. The research design and methodology of the research study entails ***interview*** as part of the data collection methods, with respondents who are knowledgeable on the subject of enquiry. On the basis of the sampling technique, you have been purposively selected to participate in the research study, which will be tape-recorded or notes shall be taken.

Researcher: Ngwako Seroto

INSTRUCTIONS:

Please assist us by answering the questions as ***objectively as possible.*** We would like to assure you that your responses will be treated with ***strictest confidentiality*** and that the thesis will only contain a summary of the views expressed by various people who are taking part in the study. ***Under no circumstances will your name be identified in the thesis***.

A.INTRODUCTION:

Good morning. My name is Ngwako Seroto, but you can call me Ngwako. The interview is about the mathematical symbols embedded in traditional circular buildings of Limpopo Province. I would like you to relax and feel free to participate in the interview, and know that we are friends.

B. BIOGRAPHICAL QUESTIONS:

1. What is your name?
2. How old are you?
3. What is your home language?
4. When did you start to build this type of houses?
5. Do you really enjoy building these types of houses?
6. Approximately how many houses have you built since from you started building these houses?

C. QUESTIONS ON CIRCULAR BUILDINGS:

7. What is the shape of the houses?
8. Why are the houses circular in shape?
9. I see many symbols or shapes on the buildings. What are these for?
10. What is the source of these different shapes or symbols?
11. Do the symbols represent any cultural identity?
12. Do the symbols help to identify any tribe?
13. Do the symbols also represent any cultural structures?

14. What do you use to construct the foundation of the house and how do you use it?
15. I can see the walls are not the same, some are made of mud while others are made of sticks, why and how do you construct them?
16. Why are they not the same or why do they differ?
17. How do you identify the centre of the house?
18. Some houses are big and others are small. How do you determine the size of the house?
19. Usually, how many people stay in the house?
20. How do you determine which house belong to adults or children or wives or husbands?
21. How do you make sure enough air and light enter the house?
22. What is the shape of the roof?
23. How do you construct the roof of a circular building?
24. Is there anything else you may want to talk about the shapes or symbols embedded in these buildings?

Thank you very much for your co-operation and time.

APPENDIX B: QUESTIONNAIRE FOR EDUCATORS

TOPIC: Mathematical Concepts of the Traditional Buildings of the Limpopo Province that Can be Used to Teach High School Mathematics.

BACKGROUND

Ngwako Seroto is a Doctor of Philosophy (PhD) candidate in Mathematics Education, Faculty of Education degree at North-West University. The working title of his doctoral research study is`` ***Mathematical Concepts of the Traditional Buildings of the Limpopo Province that Can be Used to Teach High School Mathematics''***. Part of the research study requires that a self-completion ***questionnaire*** be administered to sampled respondents. Accordingly, you have been randomly selected to take part in the survey and, feel freely to participate in the study and try to answer the questions as objectively as possible.

Researcher: Ngwako Seroto

INSTRUCTIONS

At the beginning of the questionnaire, a few ***demographic questions*** are asked. The information gathered from this section will be used to write a ***general description*** of the research environment. We would be grateful if you could please assist us by completing this questionnaire as ***objectively as possible.***

In order to ensure that you remain ***anonymous,*** please do not write down your name anywhere on this questionnaire. We would like to assure you that your responses will be treated ***confidentially*** and that the thesis will only contain a summary of the views expressed by various people who are taking part in the survey. ***Under no circumstances will your name be identified in the thesis***.

The questionnaire consists mostly of series of statements informed by the problem statement, research questions, purpose of the research and literature review. In most cases, you are required to simply indicate the extent to which you agree or disagree with each statement using the scale provided. ***There is no right or wrong answer***.

At the end, open-ended questions are asked, which relate to the mathematical concepts embedded in the traditional circular buildings of Limpopo Province. Please indicate problems or challenges you face in teaching mathematics in context and give suggestions for improvement.

Your completed questionnaire will be collected ***not later than 15 April 2011.***

A. SCHOOL DEMOGRAPHY

Kindly provide the correct answer with either a ``tick'' or ``cross''.

Respondent Information	Answers					
1.Age	≤30 yrs	31-35 yrs	36-40 yrs	41-45	46-50	≥50yrs
2. Gender	Male	Female				
3. Qualifications	Certificate	Diploma	Degree	Hons	Masters	Doctor
4. Specialization	Maths	Mat Lit				
5. District	Mopani	Vhembe	Sekhukhune			
6. School situation	Town	Location	Village			
7. Grades you teach	08	09	10	11	12	
8. Number of grade 12 Maths Educators	1	2	3	4	5	6
9. Number of grade 12 Maths Learners	≤10	11-19	20-29	30-39	40-49	≥50
10. Number of grade 12 Maths Classes	1	2	3	4	5	6
11. Teaching Experience in Maths	≤4 yrs	5-9 yrs	10-14 yrs	15-19	20-29	≥30yrs
12. Total number of maths educator	≤2	3-4	4-5	6-7	≥8	

B. MATHEMATICS TEACHING AND LEARNING SUPPORT MATERIALS

For the following questions tick ``YES'' or ``NO'' in the boxes provided.

Questions	YES	NO
1. Does the school have a library?		
2. Is the library well equipped with mathematics books?		
3. Does the school have mathematical instruments?		
4. Are the mathematical instruments enough for all the learners?		
5. Do learners take the mathematical instruments home?		
6. Does the school have mathematics text books?		
7. Are the mathematics text books enough for the learners?		
8. Do learners take the mathematics text books home?		
9. Does the school have teaching and learning aids/media?		
10. Are they sufficient for all the learners?		
11. Do learners have mathematics note books/ portfolios?		

C. PREPARATIONS FOR THE TEACHING OF MATHEMATICS

Tick ``YES'' or ``NO'' for the following:

Preparations	YES	NO
1. Year programme is developed by you		
2. Year program is provided by the department		
3. You prepare daily lesson plans to suit the topic		
4. Lesson plans have outcomes formulated by you		
5. Lesson plans have no outcomes		
6. Lesson plans have outcomes given by department		
7. Lesson plans contains learner activities prepared by you		
8. Lesson plans contains activities given by text book or the Department		
9. Lesson plans have assessment standards given by department		
10. Lesson plans have assessment standards developed by you		
11. Your lessons follow the syllabuses strictly		
12. You arrange topics to follow each other to suit your own Programmed		
13. Learners are provided with notes or handouts for the lesson		
14. Learners are asked to bring mathematics equipments/aids for activities to school		
15. Educators provides mathematics equipments as required by the Department		
16. Do you use examples from the immediate environment as teaching and learning aids		
17. Do you think cultural artifacts such as baskets, mats, beads etc can be used as aids to teach mathematics in context		

D. MATHEMATICS LESSON PRESENTATION

For the following circle all the relevant boxes.

Lesson presentation	O
1.You start the lesson by writing the topic on the board always	1
2. You ask learners about their knowledge on the topic	2
3.You give lessons activity sheets with instructions	3
4.Learners work individually	4
5.Learners work in pairs	5
6. Learners work in groups	6
7. Learners writes own notes	7
8. Learners copy notes from the board	8
9. You teach from the front of the class often	9
10. You visit groups to see what they are doing and to offer help	10
11. You use the textbook often due to lack of other resources	11
12. You explain outcomes to the learners to achieve with them	12
13. You often use example from learner's immediate environment as teaching and learning aids	13

E. MATHEMATICS TEACHING STRATEGIES

Which of the following do you use? Indicate by circling option.

Teaching strategies	O
1. Whole class discussion	1
2.Group work	2
3. Lecturing	3
4. Co-operative learning	4
5. Problem solving	5
6. Learner research	6
7. Projects	7
8. Group reports	8
9. Worksheets	9
10. Question and answer	10
11. Investigation	11
12. Discussion	12

F. ASSESSMENT PRACTICE IN MATHEMATICS TEACHING

Kindly circle which of the following methods describe how you assess learners.

Learner assessment	O
1.Daily	1
2. Weekly	2
3. Fortnightly	3
4. As required by the department	4
5. Through tests	5
6. Through examinations	6
7. Through assignments	7
8. Through portfolio's	8
9. Through projects	9
10. Through homework/ classwork	10
11. Through problem solving	11

G. MATHEMATICS TEACHER SUPPORT AND DEVELOMENT

For the following indicate by ticking either ``YES'' or ``NO''

Teachers' information	YES	NO
1.You have qualification in NCS methods		
2. Your knowledge on NCS is from workshops organized by the Department.		
3. You have never had any mathematics workshop on NCS		
4. You receive instructions on NCS from the department		
5. Your knowledge on NCS is from colleagues		
6. Workshops on NCS are sufficient for your needs		
7. More workshops are needed on NCS strategies		
8. You have regular discussions with colleagues on NCS		
9. NCS is good for learners		
10. NCS makes teaching uninteresting		
11. More NCS workshops are needed on geometry section		

H. MATHEMATICAL SYMBOLS ON THE CIRCULAR TRADITIONAL BUILDINGS

Choose the most correct answer and mark with a ``tick'' or ``cross''

Questions	1	2	3	4
1.What is the shape of the foundation?	Oval	Square	Circular	Rectangular
2. What is the shape of the wall?	Rectangular	Circular	Kite	Cylindrically
3. What is the shape of the roof?	Circular	Cone shaped	Sphere	Round
4. Mathematical shapes found on the mural decorations	Triangle	Trapezium	Oval	Rectangle
5. These symbols are similar to the once taught in high school mathematics	Strongly agree	Agree	Not sure	Don't agree
6.These shapes can be integrated into high school mathematics	Strongly agree	Agree	Not sure	Don't agree
7. The shapes can be used to contextualize the teaching of mathematics	Strongly agree	Agree	Not sure	Don't agree

8.Cultural artifacts can be used as aids to teach mathematics in context	Strongly agree	Agree	Not sure	Don't agree
9.Mathematics can be taught effectively and meaningfully by using the example from learner's immediate environment	Strongly agree	Agree	Not sure	Don't agree

I. PROBLEMS/CHALLENGES AND SUGGESTIONS

In the space provided below kindly indicate problems or challenges you face in teaching mathematics in context. Give suggestions for improvement.

PROBLEMS/CHALLENGES

SUGGESTIONS FOR IMPROVEMENT

THANK YOU SO MUCH FOR YOUR CO-OPERATION AND TIME

APPENDIX C: ONSERVATIONS SCHEDULE

(THE RESEARCHER)

TOPIC: Mathematical Concepts of the Traditional Buildings of the Limpopo Province that Can be Used to Teach High School Mathematics.

RESEARCHER: NGWAKO SEROTO

The researcher indicate the choice of the appropriate answer by means of a`` tick'' or a ``cross'' in the box below

Shapes	Oval	Square	Circular	Rectangular	Triangular	kite	Cylindrically	Cone-shape
1.Shape of the Foundation								
2. Shape of the wall								
3. Shape of the roof								
4.Maths shapes on floor decoration								
5.Maths shapes on wall decoration								

6.Maths shapes on roof decoration								
Total score								

APPENDIX D: EXTRACTS FROM INTEVIEWS

INTERVIEW ONE

TRANSCRIPTS	THEME
Interview with Builder 1 *Greetings, ice breaking activity* *Purpose on the interview explained..* *Object of interview explained.*	
Interviewer: What is the shape of the houses? Interviewee: Xirentelele (circle)	Shape of the house
Interviewer: Why are the houses circular in shape? Interviewee: Because this is our traditional or cultural houses. We are use to built only these type of thatching circular houses.	Shape of the house
Interviewer: I see many symbols or shapes on The buildings, what are these for? Interviewee: Aah, they are just for decorations, But some believe that mural Decorations around the windows and doors prohibit evil spirit or Devil from entering into the house	Symbolism

Interviewer: What is the source of these different of shapes or symbols? Interviewee: These symbols comes from our heads or minds. This is our originality.	Source of symbols
Interviewer: Do the symbols represent any cultural identity? Interviewee: Ooh yes, they represent our Xitsong culture. You can see that there are not similar to the ones built by Bapedi.	Symbolism
Interviewer: Do the symbols help to identify any tribe? Interviewee: Yes, tribes are easily identified by these shapes, and of course each tribe has its own shapes.	Symbolism
Interviewer: Do the symbols also represent any cultural structure? Interviewee: Ooh yes, they represent our cultural diversity.	Symbolism

Interviewer: What do you use to construct the foundation of the house and how do you use it? Interviewee: We use two thing, strings and sticks. We first identify the centre of the house and nail down a small stick. Then we tighten a string to the nailed stick at the centre with the second stick that we use to make a foundation. Then we pull the string and moves around the centre stick making a circle for the foundation.	Construction
Interviewer: I can see the walls are not the same, some are made of mud while others are made of sticks, how do you construct them? Interviewee: For the mud houses, they were built with mud with stones while the other one was built with poles or sticks and laths to tighten the poles.	Construction
Interviewer: Why are they not the same or why do they differ? Interviewee: The mud ones were used for sleeping while the ones built with poles and laths were used as a kitchen.	Construction

Interviewer: How do you identify the centre of the house? Interviewee: A place where a centre stick is nailed is regarded as the centre of the house. Interviewer: Some houses are big while others are small. How do you determine the size of the house? Interviewee: The size of the house depend on the length of the string tightened at the centre of the house. Interviewer: Usually how many people stay in the house? Interviewee: The number of people staying in the house depend on the size of the house. Interviewer: How do you determine which house belong to adults or children or wives or husbands? Interviewee: Big houses belongs to the adults While small ones are for children, boys and girls. Usually boys stays next to the kraal. Interviewer: How do you make enough air and Light enter the house? Interviewee: Usually there is an open space between the wall plate and the roof. air and lights also enters through the door made of reeds	Construction Measurement Measurement Symbolism Construction

Interviewer: What is the shape of the roof? Interviewee: It is funnel-shaped, yaa.	Construction
Interviewer: How do you construct the roof of a circular building? Interviewee: A big pole is inserted at the centre of the house. At the apex of the centre pole, other poles are fastened and spread around the wall plate to make a roof. The poles are tighten by laths to make the roof strong.	Construction
Interviewer: Is there anything else you may want to talk about the shapes or symbols embedded in these buildings? Interviewee: My friend, you must know we have Our own way or knowledge of building our houses. Mural decorations are made by women not men.	Source of symbols
Interviewer: Thank you very much for your cooperation and time. Our conversation was very fruitful. Thank you again, have a nice day. Interviewee: Thank you.	

INTERVIEW TWO

TRANSCRIPTS	THEME
Interview with Builder 2 *Greetings, ice breaking activity* *Purpose on the interview explained.* *Object of interview explained.*	
Interviewer: What is the shape of the houses? Interviewee: Xirentelele (circle)	Shape of the house
Interviewer: Why are the houses circular in shape? Interviewee: Because this is type of houses were Easy to construct with sticks and String without measuring tape.	Shape of the house
Interviewer: I see many symbols or shapes on The buildings, what are these for? Interviewee: Aah, they are just for decorations, but some believe that mural decorations are a form of religious at relating to beliefs concerning the ancestors	Symbolism

Interviewer: What is the source of these different or shapes or symbols? Interviewee: These symbols are from our heads or mind. This is our originality.	Source of symbols
Interviewer: Do the symbols represent any cultural identity? Interviewee: Yes, they represent our culture, I mean Xitsonga culture which is different from others..	Symbolism
Interviewer: Do the symbols help to identify any tribe? Interviewee: Yaa(Yes) , tribes are easily identified by these shapes, and each tribe has its own symbols.	Symbolism
Interviewer: Do the symbols also represent any cultural structure? Interviewee: Ooh yes, they represent our cultural diversity.	Symbolism
Interviewer: What do you use to construct the foundation of the house and how do you use it? Interviewee: We use two thing, strings and sticks . We first identify the centre of the house and nail down a small stick . Then we tighten a string to the nailed stick at the centre with the second	Construction

stick that we use to make a foundation. Then we pull the string and moves around the centre stick making a circle for the foundation. Interviewer: I can see the walls are not the same, some are made of mud while others are made of sticks, how do you construct them? Interviewee: For the mud houses, they were built with mud with stones while the other one was built with poles or sticks and laths to tighten the poles. Interviewer: Why are they not the same or why do they differ? Interviewee: The mud ones were used for sleeping while the ones built with poles and laths were used as a kitchen. Interviewer: How do you identify the centre of the house? Interviewee: A place a centre stick is nailed is regarded as the centre of the house. Interviewer: Some houses are big while others are small. How do you determine the size of the house?	Construction Construction Construction

Interviewee: The size of the house depend on the length of the string tightened at the centre of the house.	Measurement
Interviewer: Usually how many people stay in the house?	
Interviewee: The number of people staying in the house depend on the size of the house.	Measurement
Interviewer: How do you determine which house belong to adults or children or wives or husbands?	Symbolism
Interviewee: Big houses belongs to the adults while small ones are for children, boys and girls.	
Interviewer: How do you make enough air and light enter the house?	Construction
Interviewee: Usually there is an open space between the wall plate and the roof. air and lights also enters through the door made of reeds	
Interviewer: What is the shape of the roof?	
Interviewee: It is funnel-shaped.	Construction

Interviewer: How do you construct the roof of a circular building? Interviewee: A big pole is inserted at the centre of the house. At the apex of the centre pole, other poles are fastened and spread around the wall plate to make a roof. The poles are tighten by laths to make the roof strong. Interviewer: Is there anything else you may want to talk about the shapes or symbols embedded in these buildings? Interviewee: Man, there were no tapes to measure. Only minds were used to construct these houses. Interviewer: Thank you very much for your cooperation and time. Our conversation was very fruitful. Thank you again have a nice day. Interviewee: Thank you.	Construction Source of symbols

INTERVIEW THREE

TRANSCRIPTS	THEME
Interview with Builder 3 *Greetings, ice breaking activity* *Purpose on the interview explained.* *Object of interview explained.*	
Interviewer: What is the shape of the houses? Interviewee: Nkgokolo (circle)	Shape of the house
Interviewer: Why are the houses circular in shape? Interviewee: Because this is our traditional or cultural houses. We use to built only these type of thatching circular houses.	Shape of the house
Interviewer: I see many symbols or shapes on the buildings, what are these for? Interviewee: Aah, they are just for decorations, but historically they brought homage to the ancestors.	Symbolism
Interviewer: What is the source of these different or shapes or symbols? Interviewee: These symbols are from our heads or mind. This is our original ideas.	Source of symbols

Interviewer: Do the symbols represent any cultural identity? Interviewee: Ooh yes, they represent our Sepedi culture. You can see that there are not similar to the ones built by Va-tsonga or Vha-Venda.	Symbolism
Interviewer: Do the symbols help to identify any tribe? Interviewee: Yes, tribes are easily identified by these shapes, and of course each tribe has it own shapes.	Symbolism
Interviewer: Do the symbols also represent any cultural structure? Interviewee: Ooh yes, they represent our cultural structures.	Symbolism
Interviewer: What do you use to construct the foundation of the house and how do you use it? Interviewee: We use two thing, strings and sticks. We first identify the centre of the house and nail down a small stick. Then we tighten a string to the nailed stick at the centre with the second stick that we use to make a foundation. Then we pull the string and moves around the centre stick making a circle for the foundation.	Construction

Interviewer: I can see the walls are not the same, some are made of mud while others \are made of sticks, how do you construct them? Interviewee: For the mud houses, they were built with mud with stones while the other one was built with poles or sticks and laths to tighten the poles.	Construction
Interviewer: Why are they not the same or why do they differ? Interviewee: The mud ones were used for sleeping while the ones built with poles and laths were used as a kitchen.	Construction
Interviewer: How do you identify the centre of the house? Interviewee: A place a centre stick is nailed is regarded as the centre of the house.	Construction
Interviewer: Some houses are big while others are small. How do you determine the size of the house? Interviewee: The size of the house depend on the length of the string tightened at the centre of the house.	Measurement

Interviewer: Usually how many people stay in the house? Interviewee: The number of people staying in the house depend on the size of the house.	Measurement
Interviewer: How do you determine which house belong to adults or children or wives or husbands? Interviewee: Big houses belongs to the adults, husbands and wives while small ones are for children, boys and girls.	Symbolism
Interviewer: How do you make enough air and light enter the house? Interviewee: A small circle wooden block was used to make a small open window for air and light to get in.	Construction
Interviewer: What is the shape of the roof? Interviewee: It is funnel-shaped, yaa.	Construction
Interviewer: How do you construct the roof of a circular building? Interviewee: A big pole is inserted at the centre of the house. At the apex of the centre pole, other poles are fastened and spread around the wall plate to make a roof. The poles are tighten by laths to make the roof strong.	Construction

Interviewer: Is there anything else you may want to talk about the shapes or symbols embedded in these buildings? Interviewee: My friend, what I can tell you is that all the symbols come from our heads or minds. Interviewer: Thank you very much for your cooperation and time. Our conversation was very fruitful. Thank you again have a nice day. Interviewee: Thank you.	Source of symbols

INTERVIEW FOUR

TRANSCRIPTS	THEME
Interview with Builder 4	
Greetings, ice breaking activity *Purpose on the interview explained.* *Object of interview explained.*	
Interviewer: What is the shape of the houses?	
Interviewee: Nkgokolo (circle)	Shape of the house
Interviewer: Why are the houses circular in shape?	
Interviewee: Because this is our traditional or Cultural houses. We use to built only these type of thatching circular houses.	Shape of the house
Interviewer: I see many symbols or shapes on The buildings, what are these for?	
Interviewee: Aah, they are just for decorations, but some believe that mural decorations represent aspects of celebration, ritual and initiation.	Symbolism

Interviewer: What is the source of these different Or shapes or symbols? Interviewee: These symbols are from our heads or mind. This is our originality.	Source of symbols
Interviewer: Do the symbols represent any cultural identity? Interviewee: Ooh yes, they represent our Sepedi culture. You can see they differ from other cultures like Tshivend..	Symbolism
Interviewer: Do the symbols help to identify any tribe? Interviewee: Yes, tribes are easily identified by these shapes, and of course each tribe has its own of doing things.	Symbolism
Interviewer: Do the symbols also represent any cultural structure? Interviewee: Ooh yes, they represent our cultural diversity. Our cultures are not the same	Symbolism

Interviewer: What do you use to construct the foundation of the house and how do you use it? Interviewee: We use two thing, strings and sticks . We first identify the centre of the house and nail down a small stick. Then we tighten a string to the nailed stick at the centre with the second stick that we use to make a foundation. Then we pull the string and moves around the centre stick making a circle for the foundation.	Construction
Interviewer: I can see the walls are not the same, some are made of mud while others are made of sticks, how do you construct them? Interviewee: For the mud houses, they were built with mud with stones while the other one was built with poles or sticks and laths to tighten the poles.	Construction
Interviewer: Why are they not the same or why do they differ? Interviewee: The mud ones were used for sleeping while the ones built with poles and laths were used as a kitchen.	Construction

Interviewer: How do you identify the centre of the house? Interviewee: A place a centre stick is nailed is regarded as the centre of the house.	Construction
Interviewer: Some houses are big while others are small. How do you determine the size of the house? Interviewee: The size of the house depend on the length of the string tightened at the centre of the house.	Measurement
Interviewer: Usually how many people stay in the house? Interviewee: The number of people staying in the house depend on the size of the house.	Measurement
Interviewer: How do you determine which house belong to adults or children or wives or husbands? Interviewee: Big houses belongs to the adults while small ones are for children, boys and girls. Usually boys stays next to the gate or kraal.	Symbolism
Interviewer: How do you make enough air and light enter the house? Interviewee: Grass do not absorb heat and ir and lights also enter through the door made of reeds	Construction

Interviewer: What is the shape of the roof? Interviewee: It is funnel-shaped, yaa.	Shape
Interviewer: How do you construct the roof of a circular building? Interviewee: A big pole is inserted at the centre of the house. At the apex of the centre pole, other poles are fastened and spread around the wall plate to make a roof. The poles are tighten by laths to make the roof strong.	Construction
Interviewer: Is there anything else you may want to talk about the shapes or symbols embedded in these buildings? Interviewee: Houses for boys were built next to the kraal for to guard the cattle.	Construction
Interviewer: Thank you very much for your cooperation and time. Our conversation was very fruitful. Thank you again have a nice day. Interviewee: Thank you.	

INTERVIEW FIVE

TRANSCRIPTS	
Interview with Builder 5	
Greetings, ice breaking activity *Purpose on the interview explained.* *Object of interview explained.*	
Interviewer: What is the shape of the houses? Interviewee: Gumba (circle)	Shape of the house
Interviewer: Why are the houses circular in shape? Interviewee: They were easy to construct with string and sticks.	Shape of the house
Interviewer: I see many symbols or shapes on the buildings, what are these for? Interviewee: Yes, they are just for decorations, but some believe that this mural decorations colours have strong symbolic relevance and religious. White colours symbolize happiness and piece while black colours symbolize negative emotions such as grieve, sadness etc.	Symbolism
Interviewer: What is the source of these different or shapes or symbols? Interviewee: These symbols are from our heads or mind. This is our originality.	Source of symbol

Interviewer: Do the symbols represent any cultural identity? Interviewee: Ooh yes, they represent our Bapedi culture. You can see that they are not similar to other cultures.	Symbolism
Interviewer: Do the symbols help to identify any tribe? Interviewee: Yes, tribes are easily identified by these shapes, and of course each tribe has its own shapes.	Symbolism
Interviewer: Do the symbols also represent any cultural structure? Interviewee: Ooh yes, they represent our cultural diversity.	Symbolism
Interviewer: What do you use to construct the foundation of the house and how do you use it? Interviewee: We use two thing, strings and sticks. We first identify the centre of the house and nail down a small stick. Then we tighten a string to the nailed stick at the centre with the second stick that we use to make a foundation. Then we pull the string and moves around the centre stick making a circle for the foundation.	Construction

Interviewer: I can see the walls are not the same, some are made of mud while others are made of sticks, how do you construct them? Interviewee: For the mud houses, they were built with mud with stones while the other one was built with poles or sticks and laths to tighten the poles.	Construction
Interviewer: Why are they not the same or why do they differ? Interviewee: The mud ones were used for sleeping while the ones built with poles and lath were used as a kitchen.	Construction
Interviewer: How do you identify the centre of the house? Interviewee: A place a centre stick is nailed is regarded as the centre of the house.	Construction
Interviewer: Some houses are big while others are small. How do you determine the size of the house? Interviewee: The size of the house depend on the length of the string tightened at the centre of the house.	Measurement

Interviewer: Usually how many people stay in the house? Interviewee: The number of people staying in the house depend on the size of the house.	Measurement
Interviewer: How do you determine which house belong to adults or children or wives or husbands? Interviewee: Big houses belongs to the adults while small ones are for children, boys and girls. Usually boys stays next to the kraal.	Symbolism
Interviewer: How do you make enough air and light enter the house? Interviewee: Usually there is an open space between the wall plate and the roof. air and lights also enters through the door made of reeds	Construction
Interviewer: What is the shape of the roof? Interviewee: It is funnel-shaped, yaa. Interviewer: How do you construct the roof of a circular building? Interviewee: A big pole is inserted at the centre of the house. At the apex of the centre pole, other poles are fastened and spread around the wall plate to make a roof. The poles are tighten by laths to make the roof strong.	Construction Construction

Interviewer: Is there anything else you may want to talk about the shapes or symbols embedded in these buildings? Interviewee: Each and every tribe has each own way of buildings. Novice ones learn from the ones with experience. Interviewer: Thank you very much for your cooperation and time. Our conversation was very fruitful. Thank you again have a nice day. Interviewee: Thank you.	

INTERVIEW SIX

TRANSCRIPTS	THEME
Interview with Builder 6	
Greetings, ice breaking activity *Purpose on the interview explained.* *Object of interview explained.*	
Interviewer: What is the shape of the houses? Interviewee: Gumba (circle)	Shape of the house
Interviewer: Why are the houses circular in shape? Interviewee: Because this is our traditional or cultural houses. We use to built only these type of thatching circular houses.	Shape of the house
Interviewer: I see many symbols or shapes on the buildings, what are these for? Interviewee: No, they are just for decorations, but some believe that mural decorations around the windows and doors prohibit people suppose to have dealing with Devil or evil spirits from entering into the house	Symbolism

Interviewer: What is the source of these different or shapes or symbols? Interviewee: These symbols are from our heads or mind. This is our originality.	Source symbols
Interviewer: Do the symbols represent any cultural identity? Interviewee: Ooh yes, they represent our Thsivenda culture. You can see that there are not similar to the ones built by Bapedi and Va-Tsonga.	Symbolism
Interviewer: Do the symbols help to identify any tribe? Interviewee: Yes, tribes are easily identified by these shapes, and each tribe has its own shapes or symbols.	Symbolism
Interviewer: Do the symbols also represent any cultural structure? Interviewee: Ooh yes, they represent our cultural diversity.	Symbolism

Interviewer: What do you use to construct the foundation of the house and how do you use it? Interviewee: We use strings and sticks. We first identify the centre of the house and nail down a small stick. Then we tighten a string to the nailed stick at the centre with the second stick that we use to make a foundation. Then we pull the string and moves around the centre stick making a circle for the foundation.	Construction
Interviewer: I can see the walls are not the same, some are made of mud while others are made of sticks, how do you construct them? Interviewee: For the mud houses, they were built with mud with stones while the other one was built with poles or sticks and laths to tighten the poles.	Construction
Interviewer: Why are they not the same or why do they differ? Interviewee: The mud ones were used for sleeping while the ones built with poles and laths were used as a kitchen.	Construction

Interviewer: How do you identify the centre of the house? Interviewee: A place a centre stick is nailed is regarded as the centre of the house.	Construction
Interviewer: Some houses are big while others are small. How do you determine the size of the house? Interviewee: The size of the house depend on the length of the string tightened at the centre of the house.	Measurement
Interviewer: Usually how many people stay in the house? Interviewee: The number of people staying in the house depend on the size of the house.	Measurement
Interviewer: How do you determine which house belong to adults or children or wives or husbands? Interviewee: Big houses belongs to the adults while small ones are for children, boys and girls.	Symbolism
Interviewer: How do you make enough air and light enter the house? Interviewee: Usually there is an open space between the wall plate and the roof. Air and lights also enters through the door made of reeds	Construction

Interviewer: What is the shape of the roof? Interviewee: It is funnel-shaped, yaa.	Construction
Interviewer: How do you construct the roof of a circular building? Interviewee: A big pole is inserted at the centre of the house. At the apex of the centre pole, other poles are fastened and spread around the wall plate to make a roof. The poles are tighten by laths to make the roof strong.	Construction
Interviewer: Is there anything else you may want to talk about the shapes or symbols embedded in these buildings? Interviewee: Man, these houses were built next to the mountains and the doors always face against the wind. We use to know the direction of the wind.	
Interviewer: Thank you very much for your cooperation and time. Our conversation was very fruitful. Thank you again have a nice day. Interviewee: Thank you.	

APPENDIX E: QUESTIONNAIRE GIVEN TO GRADE 12 TEACHERS: PILOT STUDY

TOPIC: Mathematical Concepts of the Traditional Buildings of the Limpopo Province that Can be Used to Teach High School Mathematics.

RESEARCHER: NGWAKO SEROTO

- What is the shape of the traditional circular building?
- Does it have 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 have all the characteristics of a circle as you have learned them in a classroom situation?
- Which geometrical shapes found on the foundation, wall and roof are similar to the ones you have learned in the classroom situation?
- Which geometrical shapes found on the floor, wall and roof decorations are similar to the ones you have learned in the classroom?

- Which geometrical shapes or concepts are embedded in the mural decorations? Does the geometrical concepts or shapes found on the mural decorations similar to the ones learned in the classroom situation?
- How do you relate the identified geometry concepts found on the traditional circular buildings to high school mathematics?