EXPLORING IN-SERVICE ZIMBABWEAN MATHEMATICS TEACHERS' PREPAREDNESS TO INCORPORATE ETHNOMATHEMATICS APPROACHES TO GEOMETRY TEACHING AND LEARNING

by

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DECLARATION

I declare that "**Exploring in-service Zimbabwean mathematics teachers' preparedness to incorporate ethnomathematics approaches to geometry teaching and learning**" is my own innovative work and it has not been formerly submitted to any higher education institution for any degree purposes.

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ABSTRACT

Geometry teachers and learners in Zimbabwe come from a wide range of cultural and social backgrounds. This provides opportunities and challenges in the teaching and learning of geometry. The wide variety of cultural and social backgrounds that the learners bring into the geometry classroom point towards the teachers' use of learners' prior knowledge and other cultural experiences as well as activities to improve their performance. The integration of ethnomathematics approaches into the teaching of geometry is beneficial for pedagogical purposes, specifically for improving learners' performance in geometry. This study explored in-service mathematics teachers' preparedness to integrate ethnomathematics approaches into the teaching and learning of geometry.

The research was grounded, hypothetically, in social constructivism views of mathematics teaching and learning. Using a pragmatist research paradigm, this convergent parallel mixed methods study involved a questionnaire and focus group discussions with forty second year in-service teachers enrolled in a three-year Bachelor of Science Education Honours program. Proportional stratified random sampling was employed to select the participating teachers for the questionnaire, whilst research based recruitment was used for the focus group discussions. The forty teachers who were involved in the completion of the questionnaires formed the five focus groups.

Data was analysed in an endeavour to determine the teacher's training on geometry and ethnomathematics approaches. Further, teachers' views towards the integration of ethnomathematics approaches and challenges faced on the integration of ethnomathematics approaches into the teaching of geometry were also analysed. Inductive data analysis and interpretive data analysis were employed in this study for qualitative and quantitative data analysis respectively. Findings show that both traditional and learner-centred approaches were used by their lecturers during their teacher training period. The approaches that were used during their training were the same that they were using in schools to teach geometry. Findings also show that some of the teachers were not adequately trained to teach geometry. Teachers indicated that they did not do any specific course on ethnomathematics approaches and on how to integrate it into the teaching of geometry.

The study also reveals that most of the teachers were of the view that ethnomathematics approaches should be integrated into the teaching of geometry because of the various benefits associated with its use. The study reveals that some of the teachers are using the principles of ethnomathematics approaches such as teaching geometry that builds on learners' prior knowledge, background and the role that learners' cultural background as well as the environment play during their learning. However, teachers face various challenges in the integration of ethnomathematics approaches into the teaching of geometry, such as, lack of resources, cultural diversity, lack of geometrical content knowledge, lack of knowledge on ethnomathematics approaches and resistance to change by both teachers and learners.

The role of teachers in the integration of ethnomathematics approaches into the teaching of geometry is of great significance. It is suggested that the government should take greater responsibility to involve the teachers in syllabus development with clear goals and content, develop teachers' capacity in integrating ethnomathematics approaches when teaching and provide teaching and learning resources for successful integration.

Key Words: ethnomathematics approaches, geometry, social constructivism, nature of mathematics

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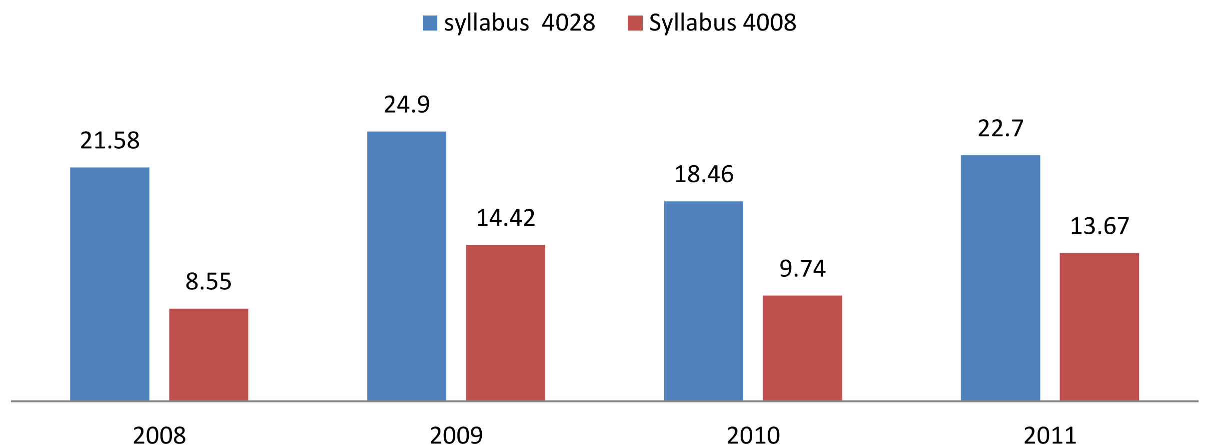
CHAPTER 1: INTRODUCTION AND STUDY BACKGROUND

1.1 Introduction

This chapter introduces the study on how the teachers are prepared to incorporate ethnomathematics approaches into geometry teaching in the school mathematics curriculum. The study presents some aspects of the readiness of in-service teachers to integrate ethnomathematics approaches in geometry teaching in Zimbabwe's school mathematics curriculum as a technique for improving learners' performance in mathematics education. The performance of Zimbabwean learners in mathematics in general has been dreadful for several years; as revealed for instance in the report by Zimbabwe School Examination Council (ZIMSEC) for the four year period, 2008-2011 (Chiwiye, 2013). Figure 1.1 presents a summary of the ZIMSEC report for the periods 2008-2011.

Figure 1.1: Pass rate in mathematics in Ordinary level examinations: 2008-2011



Key: Syllabus 4008 = Mathematics calculator version
Syllabus 4028 =Mathematics Non –calculator version

Source: Chiwiye (2013, p.3)

Figure 1.1 shows that the majority of the candidates for public examinations in Zimbabwe's secondary sector are underachieving in mathematics. In recent times different opinions have been put forward to deal with the problem of learners' poor performance in mathematics. One possible method of tackling the challenge is by relating to the cultural backgrounds of learners and using the prior knowledge that they bring to the classroom as teaching tip on learners' behalf (D'Ambrosio, 2001; Rosa & Orey, 2013; Paraide, 2015). This suggestion implies finding officially permitted ways of integrating learners' world views, home-grown or indigenous knowledge into the mathematics curriculum for improved learner performance. Teachers have the responsibility of finding relevant cultural geometrical activities and then integrate them into the mathematics curriculum.

Currently, for pedagogical reasons, there has been increasing interest in how ethnomathematics approaches can be incorporated or integrated into the school mathematics curricula (Adam, 2004; Gerdes, 2005; Paraide, 2015; Jurdak, 2016). This study, therefore, sought to find some insight into how teachers are prepared to integrate ethnomathematics approaches in geometry teaching in the school mathematics curricula for the benefit of learners. However, the epistemological differences between the nature of mathematics and nature of Ethnomathematics are a major challenge for an inclusive mathematics and ethnomathematics teaching approach in the school mathematics curriculum.

1.2 Background to the study

In Figure 1.1, it is evident that the performance of Zimbabwean mathematics learners has been dreadful for the four years under discussion. The low pass rate in Figure 1.1, results in mathematics acting as a filter of learners out of careers such as engineering, medicine, geology and the school itself.

Mathematics remains the most useful subject in all disciplines and fields of human work and has become an essential tool in the study of humanities, sciences, technology and several related human activities (Chiwiye, 2013). As a response to the demands by industry, the Zimbabwe School Examination Council (ZIMSEC) (2013) has experienced an upsurge entry in mathematics at Ordinary ('O') Level. The high enrolment in mathematics in Zimbabwe is due to the subject's relevance in society and it's compulsory in schools. Despite the significance of mathematics in all aspects of life, current deliberation on the falling standards of learners' performance in mathematics has brought about intensifying attention for parents, educators, researchers, and education authorities in their search for a solution over the past two decades (Blum, 2002 cited in Ampadu, 2012). Learners' poor performance in mathematics is not just a concern for some countries, but has become a global concern over the years (Pisa, 2012). Zimbabwe has not been an exception in the problems of low achievement in mathematics.

ZIMSEC examiners' reports (2009, 2011, 2012, 2013, 2014 and 2015) identified geometry as one of the topics of mathematics in which learners have difficulties. Regardless of the value attached to mathematics, including geometry, and the very high enrolments in the subject, it is disappointing that failure to use appropriate teaching strategies lead to memorisation of concepts and making use of symbols mechanically that do not enhance their understanding or connect the teaching of mathematics to everyday life experiences that allows them to solve problems in life (Chikodzi & Nyota, 2010).

1.2.1. The teaching and learning of mathematics in Zimbabwe

It was observed that "in Zimbabwe teachers rely mostly on the syllabus provided by ZIMSEC and the prescribed textbooks in their instructional practices" (Chauraya, 2006:227). The syllabus presents mathematics as a combined subject, which consists of various topics such as; algebra, statistics, trigonometry, and geometry just to mention a few. The rationale of this study is to explore how in-service teachers are prepared to integrate ethnomathematics approaches into the teaching and learning of geometry.

Geometry was chosen because its study contributes tremendously in helping learners to develop critical thinking skills, inferring, problem-solving ability, logical reasoning, valid argument and proof (Jones, 2002). Geometric illustrations are useful in assisting learners to understand other topics of mathematic, for instance, multiplication, fractions, the associations between the graphs of functions and graphical representations of data in statistics (Jones, 2002). Geometry appeals to pictorial, imaginative and instinctive senses, which is intimately connected with development of mathematics (Jones, 2002). As a result, teaching geometry appropriately as an essential element of mathematics could enable learners to be successful in all mathematical activities (Jones, 2002).

It is not an exaggeration, therefore, to articulate that geometry occupies the utmost practical element of mathematics. Geometry is perceived as a means for solving real life issues, and could contribute to making mathematics an interesting subject.

The ‘O’ Level mathematics syllabus is assessed through the non-calculator version (syllabus 4008) and the calculator version (syllabus 4028). In the public examinations, both 4008 and 4028 have two papers; the paper one 4008/1 and 4028/1 and the paper two 4008/2 and 4028/2. Mathematical tables and electronic calculators are prohibited in both papers, 4008/1 and 4028/1. The aspect of the calculator and non-calculator version comes in paper two. In 4008/2, learners use logarithmic tables while in 4028/2 learners make use of calculators. In terms of content and structure, the two mathematics paper codes are the same. However, the difference is based on the efficient use of mathematical tables in 4008/2 and the efficient use of electronic calculators is expected in 4028/2. The differences in the marking schemes of these papers are mainly the degree of accuracy and penalty for omission of working. The penalty of omission of working disadvantages learners who enter for 4008/2. In 4028/2 mathematical tables may be used to supplement the use of calculators. Most schools offering 4028 are urban schools, private colleges and mission schools that are well resourced and move with technology. On the other hand, 84, 25% of rural and high density suburb schools offer 4008 (Nyaumwe, 2006). The non-calculator version is taken by the majority of the learners.

It is believed that the adoption of technologies such as calcultors enhances the teaching and learning of mathematics (Chiwiye, 2013). However, the performance of learners in the calculator version (4028) is still undesirable, implying that learners still have difficulties in mathematics even when allowed to use calculators. The use of calculators reduces the computational errors, thereby improving the accuracy of the results. Since the mathematical instruction remains traditional, therefore, the use of calcultors makes the learners to become centered on getting the correct answers and this does not enhance conceptual understanding. Calculators should be used in meaningful, creative and relavant ways to encourage problem solving and application of mathematical concepts in real life situations. According to D’Ambrosio (2001) and Orey and Rosa (2006) the use of calculators should be integrated into the concept of Ethnomathematics, since the emphasis in Ethnomathematics is considered conceptual.

The poor achievement in mathematics are noted in all versions but the problem is linked to the gaps in opportunities for all the learners to learn mathematics in ways they view as relevant to their identities and societies. Mathematics concepts are best understood in the way they are experienced and applied in different socities and cultures, hence the need to change the teaching practices of mathematics. The changes need to be viewed in a wider context of changes to the society and changing the way the teaching and learning of mathematics is viewed (Chiwiye, 2013).

The goals of mathematics syllabus 4008 and 4028 are to enable learners to:

- Obtain mathematical/geometry skills that might be used in learners' real lives and for the development of the nation.
- Appreciate the process of discovery and the historical development of mathematics/geometry as an integral part of human culture.
- Develop the skills to apply and interpret mathematics/geometry in daily life situations (syllabus 4008/4028).

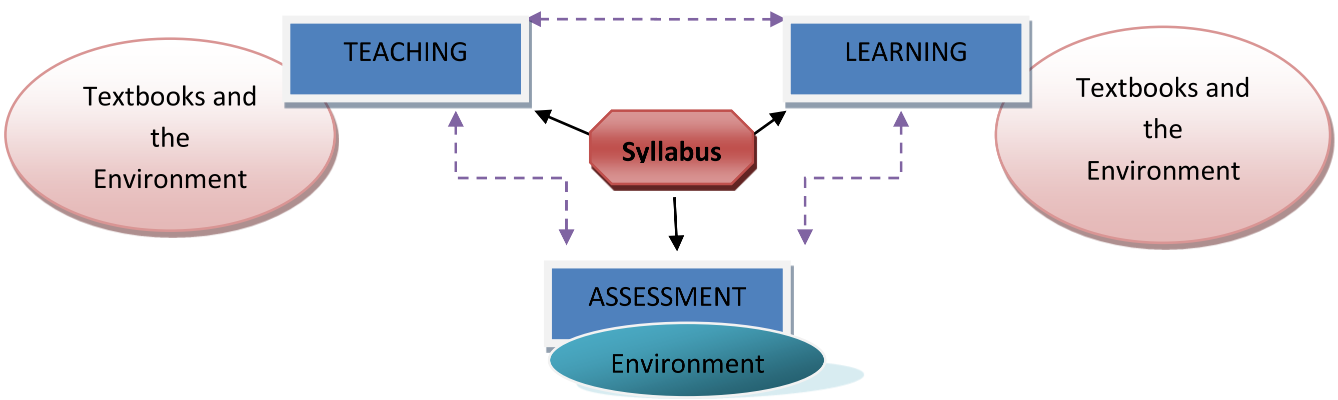
The ZIMSEC 'O' Level mathematics syllabi (4008/4028) suggests teaching approaches which view mathematics in general and geometry particularly as a process. It recommends that concepts should be developed from concrete situations in the immediate environment and moving to abstract, and that learners should be taught to identify problems in their environment, put them in geometrical form and solve them through project work. It is, therefore, essential to relate cultural geometrical abilities that learners build up from activities in their surroundings with school geometry through the use of culturally distinct situations in the classroom. The teaching of geometry, while exploiting on learners' cultural contexts, may possibly, consist of important examples from the learners' own culture and exposing them to a range of cultural contexts in which ideas of geometry are deep-rooted. This amalgamation of cultural and school mathematics may eliminate the abstract procedures in which geometrical concepts are taught in schools and facilitate learners' understanding of the topic.

From the above stated goals and the suggested teaching approaches, the mathematics curricula is underpinned by a learner-centred approach that emphasises understanding and application of geometry concepts, in real life problem situations. The mathematics syllabus suggest that culture and environment be used as resources in the teaching of geometry (ZIMSEC, 2015), this forms a basis for integrating ethnomathematics approaches into the teaching of geometry. Geometry needs to be placed in relevant contexts in order for it to have meaning to learners. The goals emphasise the use of geometrical knowledge in learners' real life situations, acquired through collaboration and social interactions that would result in the understanding of geometry theories, concepts and facts (Nyaumwe, Ngoepe & Phoshoko, 2010). Given, the above scenario, it was crucial to investigate how in-service teachers were equipped to integrate ethnomathematics approaches in geometry teaching and learning, so as to improve the learners' performance.

1.2.2 Assessment of mathematics at ZIMSEC

ZIMSEC assessment is both formative and summative in nature. Formative assessment is a continuous process that provides the course work mark for each learner. The summative assessment is meant to assign learners an examination mark which is then combined with course work mark to give the final grade. According to Chiwiye (2013), ZIMSEC examinations are ethno-based where real life situations from the learner's background, experiences and environment are examined. Thus, teachers are expected to embrace the ethno-based assessment with the aim of developing problem-solving skills that would enable learners to solve real-life problems that they will encounter when they leave school. Figure 1.2 shows ZIMSEC's conceptualisation of teaching, learning and ethno-based assessment.

Figure 1.2: Syllabus Conceptualisation



Source: Chiwiye (2013 p.2)

From Figure 1.2, teaching, learning and assessment activities should be constructed from the syllabus and the environment (Chiwiye, 2013). This requires the teacher to be creative and to become critical thinkers so that they will be in a position to make use of the learners' cultural backgrounds in developing both the teaching activities and assessment tasks. But the question is, how prepared are the teachers to integrate the ethnomathematics approaches into the teaching of geometry?

1.3 The rationale of the study

The foregoing discussion draws its thrust from the three main issues: learners' performance, relevance and curriculum change. These are discussed in detail in the following sections.

1.3.1 Learners' performance

The poor achievement in mathematics could be attributed to a number of factors that may be derived from several sources. For instance, there are those that stem from learners and teachers, and from the belief that mathematics is abstract. Geometry has been mentioned by researchers like Healy & Hoyles (2000), Noraini (2009), Telima (2011), Mashingaidze (2012) and Lama (2014) as a difficult topic for both learners and teachers because of lack of proper identification of teaching instruction. Learners and teachers exhibit serious shortcomings in their understanding of geometry (Mashingaidze, 2012). This lack of understanding in learning geometry often causes discouragement among the learners, which in most instances leads to poor achievement in geometry particularly and mathematics generally (Noraini, 2009). The incorporation of ethnomathematics approaches into the teaching of mathematics in general and geometry in particular have been found to be one of the effective instructional approaches that improves learners' performance (Adam, 2004; Matang, 2002; 2009; Rosa & Orey, 2009; 2010). Thus, this study explores how the in-service teachers were prepared to integrate ethnomathematics approaches into the teaching of geometry.

Some of the reasons for poor performance have to do with the teacher such as lack of expertise or content matter knowledge and some non-educational factors such as large classes and lack of resources (Chiwiye, 2013). In addition, "teachers appear to have difficulties with their own content knowledge in geometry" (Mashingaidze, 2012, p197). If a geometry concept is problematic for the teacher, then it often becomes an obstacle to learners' understanding (ibid). It emerged that problems encountered by learners are a result of lack of conceptual understanding (Mashingaidze, 2012, p197) as well as the teaching they experience in learning geometry (ibid). This study, however, focuses on the preparedness of teachers in integrating ethnomathematics approaches into the teaching of geometry.

In geometry, for example, geometry language/terminology, visualization abilities, and ineffective instruction were mentioned by Bishop (1986), Cangelosi (1996) and Noraini (2006) as some of the causes of learners' poor performance. Mashingaidze (2012) bewailed the poor state of mathematics teaching approaches in Zimbabwe and stated that the challenges associated with the quality of instructional approaches are from various sources. For instance, in South African schools, Wessels (2001) reported that one particular reason for geometry to be in an absolute catastrophe was due to the fact that it's teaching is poorly done, while Van Niekerk (1997) reported that it results from poorly trained teachers.

Teacher educators hardly treat trainee teachers as active participants who are capable of constructing mathematical knowledge. The trainee teachers are viewed as empty vessels who lack both mathematical knowledge and skills. Teacher educators do not take into account the trainee's prior knowledge and experiences which may explain why they teach mathematics just as they were taught (Ball & Forzani 2009). Most trainee teachers continue to have a teaching experience associated with the traditional knowledge transmission model, based on memorisation and training of routine procedures, and they were not involved in the construction of knowledge during their learning experience in school and in tertiary education (Adler, 1996 cited in Rosa & Orey, 2013).

The most important resource required in order to provide quality teaching and learning in mathematics is the teacher (Hayes, Mills, Christie & Lingard, 2006), since learners' understanding of mathematics concepts is moulded by their experiences in the classroom (NCTM, 2000). In Zimbabwe, mathematics teachers have been blamed for the poor performance in mathematics (Curriculum Team Research Report, 2010 cited in Mashingaidze, 2012). The teacher has also been accused of causing low quality learners' mathematics performance (Cooney, 1994 cited in Telima, 2011). These accusations are mainly due to the use of poor and outdated teaching methods in the teaching and learning of mathematics. The quality of instruction is fundamental in reducing challenges emanating from the teaching and learning of mathematics (Dursun & Dede, 2004 cited in Andaya, 2014). The quality of instruction contributes greatly to the overall learners' understanding and achievement in mathematics (Andaya, 2014).

1.3.2 Relevance

Rowe (2006) observed that teachers are the most important resources in the teaching and learning of mathematics, hence it is crucial for them to be equipped with pedagogic expertise that enables them to meet the essentials of the learners during teacher training. This implies that the teachers must be equipped with pedagogical skills that would make the learners to perceive the geometry lessons that are taught in schools as interesting and relevant. The teaching and learning practices of mathematics has been complained for because it is unconnected to the learners' cultural backgrounds and environment (Shirely, 2001; Bishop, 2008; Knijnik, 2012).

This lack of relevance of geometry concepts to the learners' real life experiences is also a contributing factor to poor performance (Ezeife, 2002). Even though, high achievement in ZIMSEC examination does not guarantee spontaneous application of geometry in everyday life, it was observed by examiners that the learners did not have the ability and skills to use mathematics concepts in general and geometry specifically in life (ZIMSEC, 2001). Zimbabwe's education system has been blamed for producing graduates who are not capable of applying the mathematical knowledge in everyday life in spite of good results in ZIMSEC examinations (Nziramasanga, 1999). The results of mathematics in schools are always poor and the acquired mathematical knowledge is not put into use (Nziramasanga, 1999).

The problem of non-transferability of knowledge and of poor performance in mathematics in general and geometry specifically, could be attributed to lack of cultural consonance in the teaching and learning of mathematics (Adam, 2004). Researchers such as Presmeg (1998) and Bishop (1998) observe that teaching of geometry specifically as a culture free topic is responsible for decline in learners' motivation and their struggle in learning geometry. Even though, the National Council of Teacher of Mathematics (NCTM, 2000) in its guiding principle, recommended that mathematics teaching and learning be connected to the learners' background and environment, researchers such as Ladson-Billings (2006) and Nieto (2000) showed that the disconnections between the learners' real life experiences and the learning process that takes place in school is a major cause of poor performance in mathematics in general and geometry specifically. The geometry problems that learners are supposed to solve are commonly viewed by the learners as useless, irrelevant and are not connected to their interests (Rosa & Orey, 2009).

Focussing on meaningful learning and making relevant connections between geometry and the learners' prior knowledge increases the learners' understanding of the concepts (Rosa & Orey, 2011). It appears this crisis of relevance is accounted for partly because mathematics topics such as geometry are mostly taught in such a way that the learners do not realise the link between what they learn and their day-day experiences (Rosa, 2010; Gerdes, 2001; Adam, 2004). As pointed out by (Gerdes, 1996; Matang 2002; Bishop, 2004; Rosa & Orey, 2013) the crisis of relevance is accounted for partly by teachers' failure to enact a relevant mathematics education that takes cognizance of learners' background experiences of local issues and practices or the incorporation of community-based resources and contexts into the school mathematics curriculum. In Zimbabwe, research has revealed the weaknesses of the traditional approaches such as lecturing, which is partly as a result of teachers' lack of skills and knowledge to change the way they teach (Sunzuma, Ndemo, Zinyeka & Zezekwa, 2012).

Chiwiye (2013), following his analysis of ZIMSEC pass rate over four years has put forward several suggestions for improving learners' performance in mathematics and geometry specifically. Among these is the idea that teaching should take into account that learners actively construct knowledge related with social and cultural settings. Similarly, Bishop (1998) is of the idea of bridging the gap between school mathematics and the learners' worlds, through a new movement in mathematics instruction that calls for mathematics teaching in cultural contexts relevant to learners (Ethnomathematics). This idea is in agreement with suggestions from numerous scholars that when learners realise the link between what they learn and their day-to-day experiences, they are likely to be motivated to learn geometry, which leads to increased motivation and consecutively results in improved performance in mathematics (Gerdes, 2005; 2006; Rosa & Orey, 2013; Madusise & Mwakapenda, 2014). These authors argue that the integration of ethnomathematics approaches into the mathematics curricula will benefit both teachers and learners to comprehend geometry and its universality.

1.3.3 Curriculum Change

Despite numerous factors that might have contributed to learners' difficulties in learning geometry, this study argues that the lack of knowledge about learners' cultural background and environment and not using ethnomathematics approaches in the teaching and learning of geometry is also responsible for learners' learning difficulties in geometry. In an effort to address learners' poor performance in mathematics, several reforms in mathematics education with different titles, for instance, culturally responsive pedagogy (Rosa & Orey, 2010), realistic mathematics pedagogy (Beswick, 2010), humanistic mathematics education (Aikenhead, 2006), everyday mathematics (D'Ambrosio, 1985; Bose & Subramaniam, 2011) and Ethnomathematics (D'Ambrosio, 1985; Gerdes, 1998; Rosa & Orey, 2010) were developed. However, all these titles were based on a similar issue, that of connecting mathematical concepts to learners' background and culture. According to Achor, Imoko & Uloko (2009) the major reason for scholars in mathematics education to advocate for such reforms is due to the learners' low achievements and poor understanding of mathematics concepts. The reforms were meant to encourage the use of learners' cultural experiences and prior knowledge in the teaching of mathematics.

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In Zimbabwe, for the past two decades there have been discussions in government, the education sector, non-governmental organisations, the industry world and other social parts about the nature of the educational system. Discussions focused on its underperformance and on measures of changing or improving the situation in schools in order to produce learners who are capable of contributing meaningfully to the economic and social development of the country. As a result, Nziramasanga Commission of Inquiry into Education and Training (CIET) known as the Nziramasanga Commission, was set up. It pointed out that education in Zimbabwe as far back as the colonial period was too academic in nature and did not cater for learners' interest. In addition, the Nziramasanga Commission of Inquiry into Zimbabwean Education (1999) reported high failure rate in mathematics as a sign of calamity, that led different stakeholders to advocate for curriculum change so that the needs of the learners be catered for and that Ethnomathematics be an essential component of the mainstream curriculum.

The Nziramasanga Commission of Inquiry into Zimbabwean Education (1999) argues that learners should be taught mathematics from their own cultural viewpoint. They believed that if an ethnomathematics approach is incorporated into the mathematics classroom, it is capable of improving the learners' performance and interest in mathematics. Nonetheless, the question still remains, that how are the in-service teachers prepared to integrate ethnomathematics approaches in geometry teaching?

The integration of Ethnomathematics into the school mathematics syllabus requires major alterations in the teaching methods (Jurdak, 2016). A major concern of mathematics teachers is the practical ways of incorporating ethnomathematical practices into the school mathematics curricula. The geometry in ethnomathematics activities is hidden, which results in problems when transforming it into the classroom setup (Jurdak, 2016). Mathematics teachers are required to make use of the learners' ethnomathematical knowledge from their daily experiences, to make appropriate links with school geometry and to explain the abstract meanings related with the nonconcrete school geometry (Matang, 2002). The current research is about the preparedness of teachers to integrate ethnomathematics approaches into the teaching of geometry.

1.4 The problem of the study

Given ongoing discussions and debates on how to integrate ethnomathematics approaches in the school mathematics curriculum in a valid and legitimate way (Gerdes, 2005; D'Ambrosio & D'Ambrosio, 2013), this study intends to find out how in-service teachers are prepared to integrate ethnomathematics approaches in geometry teaching. This section states the statement of the problem, research objectives and research questions.

1.4.1 Statement of the problem

Zimbabwe, as a developing country, strives for quality education, however, the performance of learners in mathematics at Ordinary level ('O' Level) remains poor (Mashingaidze, 2012; Chiwiye, 2013). The instructional approaches used in mathematics classrooms have been identified by researchers (Wenglinsky, 2002; Noraini, 2006; Mashingaidze, 2012) as one of the factors responsible for the poor performance. These researchers blame traditional approaches employed in geometry teaching and learning. There is enough evidence that the poor achievement in mathematics is due to the use of inappropriate teaching approaches in geometry specifically, yet, recently, new pedagogical approaches to geometry teaching have been advocated for. For instance, making use of the current technologies (Laborde, Kynigos, Hollebrands & Strässer, 2006; Jones, 2011), application of the history of geometry with appropriate historical sources, incorporation of ethnomathematical approaches (Gerdes, 2008; D'Ambrosio, 2001; Stathopoulou & Kotarinou, 2008; Mukhopadhyay, 2009). Researchers have advocated for the development of educational situations that actively involve learners in the teaching and learning of geometry (Stathopoulou, Kotarinou & Appelbau, 2015).

According to D’Ambrosio (2001) Ethnomathematics is a mathematics teaching approach that builds on the learners’ background experiences, prior knowledge and their immediate environment. It is an approach that emphasises culture-rooted mathematical practices that are grounded in the constructivist methodology, which depict learning as an active process of constructing knowledge through social practice supported by the teacher (Massarwe, Verner & Bshouty, 2012). According to Mogari (2014) ethnomathematics approaches are leaner-centred and activity-oriented teaching approaches that focusses on the teaching and learning of mathematics using relevant examples and activities that the learners are familiar with. There is a relationship between geometry and everyday context and culture which can play a vital role in geometry teaching (D’Ambrosio, 2001), since geometry is at the centre of culture and Ethnomathematics (Gerdes, 2008).

Incorporating ethnomathematics approaches into the geometry teaching and learning gives the learners an opportunity to familiarise to their cultural environments and to explore geometrical aspects rooted in their social activities (Zhang & Zhang, 2010) and facilitates, makes learning more meaningful and adds relevance to the content learnt (Matang, 2008; Rosa & Orey, 2010). However, integrating ethnomathematics approaches in geometry lessons would require the teacher to identify real-life activities embedded with geometry aspects. One of the problems, concerning this matter is to prepare teachers to create geometry activities based on Ethnomathematics (Greer, 2013). However, the challenge is the preparedness of the teachers to incorporate ethnomathematics approaches into the teaching and learning of geometry. In this study, the focus is to investigate the preparedness of in-service teachers in integrating ethnomathematics approaches in geometry teaching and learning.

1.5 Research objectives

This study aims to:

1. Explore in-service teachers’ preparedness in integrating ethnomathematics approaches into the teaching of geometry.
2. Explore views of in-service teachers on integrating ethnomathematics approaches into the teaching of geometry.

3. Determine challenges in-service teachers could face when integrating ethnomathematics approaches into the teaching of geometry.

1.6 Research questions

1. How are in-service teachers prepared to integrate ethnomathematics approaches into the teaching of geometry?

   Sub-question

   a) How were in-service teachers trained to teach geometry?
   b) How were in-service teachers trained to integrate ethnomathematics approaches into the teaching of geometry?
2. How do in-service teachers view the integrating of ethnomathematics approaches into the teaching of geometry?

   Sub-question

   a) How do in-service teachers view ethnomathematics approaches?
   b) What are the views of the in-service teachers regarding the integration of ethnomathematics approaches into the teaching of geometry?
3. Why are the in-service teachers not integrating ethnomathematics approaches into the teaching of geometry?

   Sub-question

   a) What do in-service teachers perceive as challenges to the integration of ethnomathematics approaches into the teaching of geometry?

1.7 Overview of the methodology

This study is a convergent parallel mixed method study that is located within the pragmatist paradigm. The pragmatism worldview emerges out of events, circumstances, and consequences rather than predecessor situations (Creswell, 2015). Rather than focusing on approaches, in pragmatism; researchers put emphasis on the problem under study and employ all methods on hand to understand the problem (Creswell, 2015, Creswell & Plano Clark, 2011). It focuses upon a research problem in educational research and makes use of pluralistic approaches to develop knowledge about the problem. A convergent parallel mixed methods design that focuses on collecting, analysing and then merging the qualitative and quantitative data sets was used in this study. Combining the two methods would provide a better understanding of the research problem. Questionnaires and focus group discussions that collected both qualitative and quantitative data were used as the main data gathering instruments.

The participating in-service teachers were selected using stratified random sampling and research based recruitment. They were assumed to be information rich cases as all of them had taught geometry at ‘O’ level for two years or more and were professionally trained.

1.8 Significance of the study

First, the study provides useful information on instructional methods for curriculum developers, teacher educators, pre-service and in-service teachers, on how to ease the problem of geometry achievement not only in Zimbabwe, but globally. The research results suggests better and more improved teaching strategies that could help the teacher towards a more effective teaching of geometry in schools through the use of Ethnomathematics pedagogy.

Results of this study are useful to teachers in planning teaching activities in the classroom. Different stakeholders such as those who design the curriculum, make policies, authors of textbooks as well researchers might benefit from the findings of this study. Additionally, findings will inform the design of teacher training programmes. The training of teachers on ethnomathematics teaching approaches can be successful if the designers of the training programmes are aware of what teachers are doing well and where they are facing challenges.

Secondly, integration of ethnomathematics approaches into the school mathematics curriculum impacts positively on learners achievement in geometry, since ethnomathematical approaches are capable of bringing crucial learning benefits, such as, helping learners to reduce cognitive complexities in mathematics learning caused by the use of the traditional approaches (Orey & Rosa, 2007), while nurturing creativeness in solving geometry problems (D’Ambrosio, 2004; Massarwe et al., 2010) and improving learners’ motivation and curiosity to learn geometry (D’Ambrosio, 1985).

Thirdly, findings pave way for more pedagogical courses and topics that are based on ethnomathematical approaches in teacher education programmes in Zimbabwe and globally. Fourthly, findings of this study add to the existing knowledge on ethnomathematics teaching approaches in Zimbabwe and internationally. Research studies on Ethnomathematics in Zimbabwe have mainly focussed on the benefits of the inclusion of Ethnomathematics in the curriculum (Chikodzi & Nyota, 2010; Nyaumwe, 2004). This study focuses on how in-service teachers are prepared to integrate ethnomathematics approaches in geometry teaching that could enhance learners' achievement in mathematics. It is hoped that this research adds a different dimension of knowledge to the literature on ethnomathematics teaching approaches.

1.9 Purpose of the study

In an effort to improve the teaching and learning of geometry, teachers should have a deeper understanding of the different teaching approaches that improves the learners understanding as well as their performance in geometry particularly and mathematics generally. Several teaching approaches should be considered in the teaching and learning of geometry and how these approaches are used in the teaching of geometry. The purpose of this mixed method study is to find out teachers' preparedness to incorporate one of these approaches; ethnomathematics approaches in the teaching and learning of geometry.

1.10 Limitations of the study

One of the delimitation of this study is that it was restricted to one university in Zimbabwe, University of Mashonaland, (UM, pseudonym name) located in Mashonaland Central Province of Zimbabwe. The choice of this university was principally influenced by proximity, familiarity and accessibility to the researcher, who has been teaching at this university for at least 7 years. Therefore, the researcher is familiar with the area of study, as such, has easy access to needed information that makes it easy to efficiently collect data. The study was conducted with Ordinary Level, ('O' Level) in-service mathematics teachers at UM in Zimbabwe. The Ordinary Level teachers are those who teach learners between the age of 14 and 17 from Form one up to four. Furthermore, the study focused on a single mathematics topic, which is geometry.

1.11 Assumptions

The study assumed that teachers had a strong preparatory teacher education programme that allowed them to respond to the questions. In other words, it was assumed that the in-service teachers have had a strong and effective mathematics teacher education programme. It was also assumed that the in-service teachers had basic knowledge about Ethnomathematics, enough to enable them to respond appropriately and give useful information regarding this research study.

1.12 Definition of terms

Ethnomathematics

Ethnomathematics is the study of the relationship between mathematics and social backgrounds (Zhang & Zhang, 2010). Even though Ethnomathematics consist of several research areas in mathematics education (Zhang & Zhang, 2010), this study is interested in the inclusion of the cultural backgrounds, experiences, activities and environment as components of ethnomathematics approaches in the teaching of geometry. In this study, the term Ethnomathematics was used to refer to the association between all culturally-rooted geometry designs, activities and procedures that can be employed in teaching and learning situations designed to enrich deeper understanding of the prescribed geometry concepts taught in schools.

An ethnomathematics approach of teaching and learning mathematics includes learners' cultural background knowledge and prior knowledge as well as their past and present experiences of their environment (D'Ambrosio, 2001).

Geometry

Geometry is the study of shapes, their sizes as well as the position of two and three dimensional figures.

Social constructivism

The principle of social constructivism are based on the active participation of both the teachers and learners in knowledge construction. It put more emphasis on the significance of culture and context in construction of new knowledge. Social constructivism recognises the significance of using symbol systems like language, values, norms, customs and geometry ideas that are an integral part of the learners' culture.

1.13 Location of the study

The majority of Zimbabwean secondary school teachers are trained in teacher training colleges. The Department of Teacher Education (DTE) at University of Zimbabwe (UZ) is responsible for the running of the colleges. The university also trains teachers in the Faculty of Education. Each college designs its own curriculum for authorization by DTE. An additional ample number of teachers are trained through the numerous universities that offer Diploma in Science Education (DPScEd), Post Graduate Diploma in Education (PGDE) or other relevant degrees with an education element. The Zimbabwe Integrated National Teacher Education Programme (ZINTEC) and the Zimbabwe-Cuba Teacher Education Training Programme (ZCTTP) have as well been some of the conspicuous characteristics of teacher training education in Zimbabwe.

The study was conducted at MU in Mashonaland Central Province in Zimbabwe. In the mid-eighties Zimbabwe used to send students to other countries such as Cuba to train as secondary teachers. The programmes, like the ZCTTP, targeted 'A' level holders to train as teachers in mathematics and science subjects in Cuba. After 10 years, a college was set up which was run by UZ to train the teachers, instead of sending them to Cuba. In the year 2000, the college was upgraded to a university. Currently the university has four faculties, namely; Faculty of Commerce (FC), Faculty of Agricultural Science (FAES), Faculty of Science (FS) and Faculty of Science Education (FSE). This study targeted the undergraduate in-service mathematics teachers enrolled for a three year degree programme in the FSE. The university offers a Bachelor of Education honours degree in mathematics (3 years duration) for in-service teachers who are holders of diplomas/certificates in education from the various teachers training institutions, and who had two years teaching experience.

The university is located in Bindura the capital town of Mashonaland Central Province, which is approximately 87km north-east of Harare. Bindura is a small town of roughly 40,000 inhabitants.

After gaining independence in 1980, Zimbabwe witnessed an incredible growth in the education sector. In spite of the tremendous growth in education, political and economic factors have destroyed all gains that were achieved in education after independence. The university relies heavily on government funding, but the funds allocated to the university have been diminishing due to the economic meltdown. The university continues to face challenges due to economic meltdown. Staff retention at the university continues to be a major challenge. Academics are being lured to join other universities out of Zimbabwe because of poor remuneration and deplorable working conditions.

The economic meltdown in Zimbabwe was a result of the political instability in Zimbabwe. Mashonaland central province is endowed by natural resources and it used to be a commercial farming region that supported successful agriculture, until the politically initiated land restructuring programme that is in progress since the year 2000. The land distribution programme has contributed immensely to the economic meltdown and political instability in Mashonaland central province. The university has experienced problems emanating from both the political and economic situation in Zimbabwe.

1.14 Layout of the thesis

The thesis is organised as follows:

Chapter 1: Introduction and study background

The chapter reports on the background of the study, objectives of the study, statement of problem, research questions, significance and purpose of study, limitations of the study, the definition of terms and location of the study.

Chapter 2: Literature review

The chapter focussed on the literature that was reviewed in this study, which covered the nature of mathematics, nature of Ethnomathematics and teachers' views on integration of ethnomathematics approaches in geometry teaching.

Chapter 3: Theoretical framework

The chapter focused on the social constructivist theory as the theoretical framework.

Chapter 4: Methodology

The chapter focused on the research methodology comprising of the design, sampling techniques, reliability and validation of the data collection instruments and the ethical issues.

Chapter 5: Data findings, analysis and discussion

Findings that were gathered from the analysis of the results were presented in this chapter.

Chapter 6: Discussion of results, conclusion and recommendations

The chapter mainly focusses on answering the research questions and gives a summary and recommendations drawn from the study.

1.15 Summary

This chapter presented and discussed the introductory issues and the procedures that are expected on integrating ethnomathematics approaches in geometry teaching. Arguments for the inclusion of ethnomathematics approaches in geometry teaching based on what researchers say on learner performance were presented. The statement of the problem was developed and key concepts used in the study were introduced. The chapter concluded with the structure of the thesis. The next chapter focuses on the literature supporting this research.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

Chapter 1 introduced the study and gave background to the research problem. This chapter reviews literature on Ethnomathematics and mathematics knowledge with the aim of improving the learner performance in mathematics. It begins with a review of the stances on the nature of mathematics and the nature of Ethnomathematics as a context for the teaching of school mathematics. Thereafter, the chapter focuses on research on integration of Ethnomathematics in the classroom, teachers' preparedness to integrate ethnomathematics approaches in mathematics teaching, their views and challenges on integration of these approaches in teaching.

2.2 The nature of mathematics

It is not the aim of this research to deal with the nature of mathematics, however, conflicting views about the nature of mathematics affects the way mathematics is taught in the classroom. Ernest (2009) describes two conflicting views of the nature of mathematics which may be termed the traditional view and the humanistic view. By understanding the differences between these two conflicting views on how mathematics is viewed one can gain appreciation of the pedagogical implications of each to mathematics education. The pedagogical implications for mathematical education arise from the epistemological debate about the nature of mathematical knowledge; therefore, it makes it necessary to explore the nature of mathematical knowledge. Each of these views is outlined and discussed in relation to classroom practice.

2.2.1 The traditional view of mathematics

For several years, mathematics has been viewed as a discipline that is not related to culture and is disconnected from societal beliefs (D'Ambrosio & D'Ambrosio, 2013; Bishop 2004); and has been constantly imparted to learners as a culture-free subject comprising of content, facts and concepts that are universal. In other words, mathematics comprises of an assortment of information of realities, calculations, sayings and theorems, to be delivered to the learners by the expert who is the teacher.

The traditional view of mathematics is based on Plato's ideas in that mathematical knowledge is approached as a pure form of truth that go beyond cultures and time. Geometry is pigeon holed as the unbiased truth with correct and strict procedures that were discovered through logical systems or axiomatic systems (Roe, 2002). Teachers also view mathematics including geometry from a traditional view of mathematics as an absolute truth free from human bias (White-Fredette, 2010). According to Bishop (2004) the traditional view of mathematics is common in numerous mathematics classroom that do not include the learners' cultural background and prior knowledge that learners take along into the classroom. The traditional view of mathematics has made teachers to obediently believe that there is no association between mathematics/geometry and culture. As a result, the teachers would view mathematics as a culture-free irrelevant subject. (D'Ambrosio, 2001). According to Ernest (1988), it is impossible for instructional reforms in mathematics education to go on without changing the views held by teachers about the teaching and learning of geometry.

Mathematical knowledge is viewed as objective, abstract, rigid, fixed, logical, absolute, cold, universal and an inhuman subject (Ernest, 2004). It is regarded as pure isolated knowledge, which is handy because of its universal validity. Geometry is both abstract and consistent (Roe, 2002). Mathematics teachers also view geometry as an abstract topic. For instance, Ah-Choo, Mohamed Eshaq, Sian-Hoon & Samsudin's (2014) study on teachers' views of geometry and geometry teaching approaches, showed that the teachers viewed geometry as abstract and complex.

The objects of geometric knowledge are eternal (Roe, 2002). For this reason, geometric knowledge exists 'out there' and needs to be discovered and is separated from human activity and context-free. The traditional view, maintains that mathematical/geomety knowledge is value-free and culture free (Bishop, 2004; Ernest, 1991). Geometry is essentially viewed as disembodied and decontextualised. The traditionalist believe that geometry knowledge is culture-free and must imparted to the learners in its "pure" form.

The learners' practical geometric knowledge can be used to strengthen their understanding of difficult geometrical concepts. However, the traditional views of mathematics do not allow for the inclusion of social facets in the teaching and learning of geometry that can motivate the learners

(D'Ambrosio, 2001; Matang, 2009). They undermine learners' capacity to make vital geometrical links between the school geometry and their real-world application of geometry concepts. They focus on providing harsh systems to warrant the indisputable certainty of geometric knowledge. This mismatch between the learners' real-world experiences and prescribed instruction hampers their understanding of geometry (Paraide, 2015). This has numerous implications for classroom practice.

The traditional view of mathematics is linked to the behaviourist approach, which is communicated in the classroom through the use of repetition and drill of isolated skills, individual work, and an emphasises the use of routine procedures (White-Fredette, 2010). Teachers, who embrace traditional views of teaching mathematics favour instructional practices, for instance, lecturing, give paper-pencil activities to learners, predominantly use textbook resources and circumvent teaching using authentic life problems. Teachers provide learners with routine geometrical tasks that include the use of memorised procedures, deductive reasoning and they stress that each task has a single, static correct answer (Davision & Mitchell, 2008; White-Fredette, 2010).

The traditional representation of geometry is usually merged with a procedural teaching method, which pays attention on outcome that is the correct answer and the correct method of solving geometry problems. This implies that the teachers would expose learners to monotonous practices that lead geometry to be labelled as abstract and inappropriate to learners. Learning is perceived as gaining of knowledge which attaches pedagogy to the transmission of a given body of knowledge. This requires the teacher to lecture in a structured manner from prescribed textbooks (Kim, 2005). Jojo, Brijlall & Maharaj (2006) reported that geometry proofs are generally done from diagrams in textbooks, whose origins are not known to the learners, which diminish the learners to passive participants in the development of mathematics and its connections with experience. Furthermore, they argued that if mathematics is taught in purely abstract, symbolic ways that are not connected to learners' culture and experience, then its teaching is not only useless, but is also detrimental to the learners, society and mathematics. The teacher-centred methods may not be useful in understanding and influencing how learners acquire geometry knowledge, however, it is important for teachers to make connections to learners' prior and cultural experiences. This aspect of teaching requires ethnomathematics approach. Fundamental to ethnomathematics approaches is the idea that teachers should link geometry concepts taught in the classroom with the learners' cultural and background experiences. Hence, it is worth to explore how teachers were prepared to integrate ethnomathematics approaches in teaching geometry.

Tate (1995) notes that mathematics pedagogy in secondary schools is dominated by teacher-centred activities that require the learners to produce right answers to well-defined problems. The emphasis is on memorising procedures and set of rules, monotonous practice, learning geometry content and skills in isolation, and depend on the prescribed textbooks. Similarly, Fasheh (1983) points out that in developing countries, such as Zimbabwe, mathematics is generally imparted to learners as a set of procedures and formulas that learners have to learn by heart. However, this approach to geometry teaching does not meet the needs of learners from different societies; and with reference to Fasheh's point, it can be deduced that the rationale of teaching geometry in the developing countries is to get good grades in examinations, without considering whether the learners understand the content or whether the content is relevant to their daily activities.

Furthermore, teacher-centred approaches to geometry teaching hardly ever make links between applications and theory to culturally relevant matters in learners' day-to-day activities. This could be responsible for the causes of poor mathematics performance in secondary schools, where geometry is believed to be taught efficiently and meaningfully without connecting it to the cultures and experiences of the learners. The use of teacher-centred approaches that have their roots in traditional views of mathematics in teaching geometry is problematic because geometry is social and cultural, and learners bring to class different environmental and cultural experiences that influence their learning. Therefore, there is need for teachers to make use of the learners' experiences and background knowledge in the teaching of geometry. However, the question remains that how prepared are the teachers to integrate ethnomathematics approaches into the teaching of geometry.

Literature has indicated that even though the view that mathematics is a body of infallible and unbiased truth is currently questioned by several scholars, this view is generally accepted by the general public, teachers, and learners (Benn & Burton, 1996). Several teachers are still aligning their teaching methods with the traditional view, because of the numerous benefits associated with these approaches, for instance, their usefulness in situations where there are large numbers and limited resources. Nonetheless, an escalating number of scholars view mathematics as a product of social processes, which is discussed in the section below.

2.2.2 The humanistic view of mathematics

According to Paraide (2015), the humanistic view embraces the fact that mathematics is fallible in nature and is subject to change, and is an outcome of social creativity, hence it is a product of social processes. From the humanistic view, mathematics is value-laden and situated in social contexts, and is not a universal body of knowledge (Presmeg, 2007; Rosa & Orey, 2011). According to Rosa & Orey (2011) mathematics is a collection of culturally created metaphoric portrayals as well as processes which help in the operation of such portrayals. The development of the portrayals is a process that takes place in the cognitive systems of the learners which are culturally contextualised (Rosa & Orey, 2008). This implies that the geometry knowledge that is acquired in the classrooms is not built from complex cognitive structures, but, it results from the amalgamation of previously taught skills and knowledge in addition to the new social ideas. Mathematics is contextual and is affected by the social and historical factors (White-Fredette, 2010).

Geometry is a component of the humanity culture; it is at the center of every culture and is integral component of each human mind (Gerdes, 2008). This implies that geometry is a social product and a construct of the human mind that has been created by human beings in societies throughout the world. It is an essential element of the learners' cultural experience and is an important part of several facets of life from architecture to design (Jones, 2002). In the view of Jones (2002), geometry has a wide range of applications in real life. Geometry was used in construction of religious and cultural artifacts and in measuring land in ancient times, which nowadays is being practiced through surveying. Nowadays, architects and designers make use of the aspects of geometry in their daily activities, such as designing buildings and structures. Geometry is fundamental to all forms of design. According to Bishop (1988) geometry designs are used when creating objects, artifacts and technology and craft for home use, for business, for beautification, for war, for religious motives and games.

Fashion designers, interior designers, floral designers and cultural artifacts designers, they all use geometry when making decisions regarding shapes, sizes, positions, patterns and measurements. Stathopoulou, Kotarinou & Appelbaum (2015) report that research has shown existence of several rich geometry cultural activities in the world. For instance, Zaslavsky (1973) explained fascinating geometrical shapes from African traditions. In Zaslavsky's work, different forms of ornamental patterns, together with African designs portrayed on houses in the form of highly structured drawings, demonstrate difficult geometrical concepts. These wide ranges of geometry applications occur in almost all cultures and human activities and could be used in the classroom. These are numerous familiar examples that could be used as contextualised resources for teaching several geometrical concepts in the classroom. To do this, teachers should be prepared to integrate ethnomathematics approaches in teaching geometry.

The humanistic view is reflected in schools where geometry teaching is experienced as investigational, creative, collaborative, enjoyable, historical, cultural, and related to learners' real life situations (Davision & Mitchell, 2008). Teachers who hold the humanistic view are facilitators, who believe in participatory learning and learner-centredness. These teachers create learning environments that connect school geometry and learners' cultural experiences and their teaching focuses on making connections between learners' backgrounds, experiences and everyday practices and academic geometry. This can bring to light the link between cultural geometry and school geometry that enable them to fuse the practices of out-of-school cultural contexts and school geometry. Ernest's views of mathematics are shown in Table 2.1.

Table 2.1: Ernest's views of mathematics

Aspect	Traditional view	Humanistic view
Accessibility	Tough, unapproachable	Open-minded and approachable
Social dimension	Detached, impartial, complex and objective	Social, human and idiosyncratic
Cultural context	Non-representational tools useful in advanced cultures	Theories/concepts and procedures found in human culture and history

Fundamental features	Hypothetical complex theories	Hands-on problem solving and conceptual tools
Applications	Not components of 'real' (pure) mathematics. Applications work by chance or because mathematics explains the essential organisation of world	Mathematics is entrenched in applications providing creativeness for its theories and utility through modelling
Processes and techniques	Ultra-rational, rigorously following static rules in textbooks Teaching is viewed as banking geometrical knowledge in the learners' minds and culturally neutral. Geometrical knowledge is infallible and static	Innovative and supple application of knowledge to solve problems, creative investigative and cultural activities. Teaching uses learners' cultural knowledge. Geometrical knowledge is viewed critically and shared by both teachers and learners.
Focus	Concentrate on the correct answers and detached facts Transmission of geometrical knowledge	Focus on the processes of individual's inquiry and comprehension Facilitator of mathematical/geometrical knowledge
Problem solutions	One fixed correct answer exists for every single problem Merely place value on facts and ideas imparted by experts to the learners	Mathematical/Geometrical tasks/problems have numerous solutions techniques and many answers Values the geometrical knowledge learners bring to the learning environment

	View learners only in terms of individual characteristics, view achievement as means to escape the community	Helps learners to make connections between the academic geometrical knowledge to their personal lives, families and communities, through collaborative learning and inquiry mode of instruction
Source of knowledge and aptness	Specialists are sources of knowledge and all the answers	Everyone must be competent in solving problems/tasks and checking answers

Adapted from Ernest, 2009

In fact, if geometry is viewed as a static and complete body of facts, theories and concepts, and the teaching of geometry is viewed as the impartation of facts and theories from teachers to learners, then there is barely any chance for integrating ethnomathematics approaches into the teaching process. For example, the traditionalist who holds the opinion that geometry is the same everywhere and that the learners do not possess the geometry knowledge and the teacher's role is to pour the geometry knowledge into the empty minds of the learners are expected to implement teaching approaches that are teacher-centred. The responsibility of such teachers is that of specialists who possess all the geometry knowledge that must be taught to the passive learners using teacher-centred approaches (Khader, 2012).

On contrary, the humanistic view the teacher as a facilitator who makes every effort to create conducive learner-centred environments where construction of geometry knowledge by learners is encouraged (Schunk, 2014; Tuncel, 2009). The teachers actively engages the learners in the construction of geometry knowledge using their prior knowledge. The new geometric knowledge is built using the prior knowledge that the learners already possess. Kang's (2004) study revealed that teachers who embrace the humanistic view expected their learners to acquire good ideas about geometric knowledge through observing carpenters and brick layers without being taught.

According to Hersh (1999), teachers who hold the humanistic philosophy of mathematics, inspire learners to explore many representations of geometry concepts and different relations among them. Teachers tend to use whole class-discussions, collaborative work in groups or pairs and fieldwork in the classroom. In addition to this, they tend to create their own problems using a multiplicity of resources including those from both the learners and the teachers' own environments. For instance, Hunter (2013) suggested that some aspects of geometry could be taught by using different measurements from both the home and the classroom, for example, the area or perimeter of the walls, floors, windows, and living area. Teachers would encourage learners to be actively engaged in knowledge construction as well as applying the acquired knowledge in real life situation. They view application of geometric knowledge as successful learning. This implies that learning is complete if the learner acquires skills and practices that could be useful in future in solving different or similar geometry real life problems.

The humanists' view of geometry as a cultural product disagrees with the traditional views that geometry is universal, objective, and culturally neutral (Rosa & Orey, 2011). This implies that it is pointless to regard geometry teaching as conceptual and culture free on the grounds that the instructing and learning process can't be theoretical and setting free, that is, the teaching process cannot be free from the society and environment in which the learner lives. As a result, it is important to teach geometry in contexts that are relevant and important to the learners, especially their cultural backgrounds and experiences (Ernest, 2002).

This contradiction is an important issue influencing the ways in which mathematics is approached in the classroom. The pedagogical implications for mathematical education arise from the epistemological debate about the views of the nature of mathematics, as the teachers' views influences the way they interact with their learners and the instructional decision they make in the classroom. Correspondingly, Presmeg (2002) points out that teachers' views about the nature of mathematics either make it possible or impede the process of connecting learners' day-to- day practices and school mathematics.

The view adopted for this study is the humanistic view. That is, mathematics is characterised as dynamic, persistently increasing field of human construction and development and is a product of culture (Ernest, 2010). Barnes &Venter (2008) argue that the need for teaching mathematics using ethnomathematics approaches was called for by the change in mathematics education from a traditional model to a humanistic view which emphasises mathematics as a cultural product. This humanistic view provides an underlying principle, as well as a foundation for ethnomathematics approaches to geometry teaching (Ernest, 2002). The humanistic view is also connected to Ethnomathematics in its emphasis on the cultural aspect of mathematics. The next section discusses the nature of Ethnomathematics.

2.3 Nature of Ethnomathematics

The objective of this study is to explore how the in-service mathematics teachers were prepared to integrate ethnomathematics approaches in teaching geometry. The argumentation is that these approaches are anticipated to make the teaching and learning of geometry significant and relevant with regard to the improvement of the entire quality of the learners' geometrical experiences.

Ethnomathematics is a "broader view of how mathematics relates to the real world" (D'Ambrosio, 2002, p.1). Ethnomathematics has been defined as the relationship between culture and mathematics (D'Ambrosio, 2001; Zhang & Zhang, 2010; Izmirli, 2011); the study of mathematical ideas and activities rooted in cultural contexts (Gerdes, 2001; Rosa & Orey, 2010); the study of the connection between mathematics and culture (Izmirli, 2011); the everyday or social practices of mathematics of a specific ethnic group (Matang, 2002; Bose & Subramaniam, 2011) and the study of mathematics' association to culture and how culture affect the teaching and learning of mathematics (Bush, 2005). These definitions of Ethnomathematics give the impression that Ethnomathematics is as a result of the relations between culture and mathematics. This suggests that the study of mathematics has cultural connotations.

Contrary to a value-free or culture-free approach, Ethnomathematics integrates mathematical practices that are historically developed in diverse cultures (Massarwe, Verner & Bshouty, 2011). It is characterised as a contextualised living and dynamic body of knowledge, which is culture-bound and validated by individual's worldviews, intertwined into realistic societal knowledge and activities with principles and a specific technique of thinking in the person's society (Massarwe, Verner & Bshouty, 2011). The major idea of Ethnomathematics is the one that hubs on mathematics as a product of culture and its link to the mathematics that the learners develop in everyday life. Its focus on cultural practices that can be considered to be related to mathematics (Knijni, 2012).

Ethnomathematics is thought to “cultivate the idea that mathematics is a product of culture and is affected by cultural forces” (Kitchen, 2001, p.152 cited in Hunter, 2013, p.6). The cultural aspect of mathematics can refer to broad historical, traditional, or indigenous cultural practices (Hunter, 2013). Ethnomathematics is also concerned with the study of local indigenous knowledge of geometry rooted in the daily cultural activities and appreciation of the school geometry in connection to its day-to-day use. In an Ethnomathematics classroom teachers value and connect learners’ cultures to the teaching and learning process. According to D’Ambrosio (2001) the purpose of teaching geometry through ethnomathematics approaches is for the teacher to demonstrate to the learners that their culture and geometry are linked to each other. Thus there is need to explore how the teachers are prepared to integrate ethnomathematics approaches in teaching geometry.

One major characteristic of the cultural activities is that, the majority of the cases rely on the contextual reality to present the required conceptual meaning of several geometrical concepts officially taught in the classrooms, instead of relying on pensiveness which is inclined to the traditional views.

According to D’Ambrosio (2001) ethnomathematics presents us with an alternative view towards the teaching of geometry. Ethnomathematics gives insights to different geometrical methods that are contextualised and permits different ways of thinking to be investigated and authenticated (Parsons, 2015). For example, guided practice which are contextualised and personally applicable (Parsons, 2015), could be employed in geometry teaching. Mogari (2002) used cultural artefacts (wire cars) to guide the learners in geometry concepts. A variety of geometrical concepts such as symmetry and geometrical shapes were explored. Hunter (2013) noted that Ethnomathematics puts the geometry of the indigenous culture at the forefront of geometry teaching. The learner’s cultural background is taken into consideration when lessons and class activities are being developed by teachers (Hunter, 2013). Geometry should be taught using a familiar and useful approach that sanctions learners to achieve academic success while allowing them to practically understand the topic (Hunter, 2013). Thus, Ethnomathematics as a learner-centred approach, builds upon the learners' experiences, values and culture (Hunter, 2013). As a result, ethnomathematics approaches rests in the social constructivist views of teaching that are widely advocated for in mathematics education.

Meaney & Lange (2013) advised that the learners' backgrounds have to be considered when implementing an ethnomathematical approach, which makes it suitable to meet the learners' needs. The learners' cultural backgrounds play a crucial role in influencing the way they understand geometry concepts, as well as, in making the teaching of geometry more effective and meaningful. Through the use of culturally-relevant activities and context from learners' daily experiences, the mismatch that they view between school geometry and real life geometry can be reduced.

There is a belief that linking learners' experiences and cultures with school content, would enable them to remember and apply the content in real life situations. Thus, learners would be assisted in making sense of abstract geometric concepts through connecting them to familiar practical geometry tasks, thus preparing them for functioning well in various societies (Paraide, 2015). It is believed that Ethnomathematics might be a useful way of connecting everyday geometry and school geometry. However, it worth to find out how prepared the teachers are in integrating ethnomathematics approaches in teaching geometry.

Ethnomathematics incorporates the relevance of learning geometry concepts and relates the mathematics curricula to the learners' culture and interests (Rosa & Orey, 2015). It underpins the view that mathematics is considered as a social item which has been created subsequently from different cultural exercises (Bishop, 1988). Whilst mathematics is regarded as a cultural product (Gerdes, 1996), geometry in particular, offers a socially and traditionally rich environment to teach mathematics, since it is an essential component of cultural activities and experiences as well as a crucial part of various facets of life (Jones, 2002). This prevailing view makes geometry more pertinent to learners since they are from different cultural backgrounds with varying geometry cultural activities and experiences useful for the teaching and learning of geometry. Ethnomathematics approaches use cultural experiences, examples and activities that makes the teaching and learning of geometry more significant (Rosa & Orey, 2008). These views on the nature of Ethnomathematics have a bearing on the implementing of ethnomathematics-based activities in geometry teaching.

Table 2.2 shows a comparison of how ethnomathematicians D'Ambrosio, Gerdes, Ascher, and Lipka view Ethnomathematics as compared to mathematics.

Table 2.2: A comparison of ethnomathematicians' views of Ethnomathematics and mathematics.

Mathematics	**Ethnomathematics**
D'Ambrosio	*D'Ambrosio*
• Aprioristic: learning without understanding the concepts • Closed collection of information and changes through the actions of mathematicians • Imparted in university, colleges and schools • Rational and approved by specialists or experts	• Relative and transformative learning reliant on experience • Continuous collaboration with all individuals from society • Taught practically, casually • Value- - -bonded and approved by person's world views • Construction of all information
Gerdes	*Gerdes*
• Western world view promulgated	• Living and changing collection of information • Active recovering of a mathematical perspective as a major aspect of local culture • Mathematics in connection to society
Ascher	*Ascher*
• Closely defined category of knowledge particular to Western culture	• Closely characterized classification of learning specific to Western culture.

	• Intersection of mathematics and culture • Contextualised mathematics thinking and philosophy
Lipka • Logical set of ideas that symbolise a perfect world, i.e. in geometry a line. • Maths as a science and theory	*Lipka* • Integration of numerical ideas and practices from the objective culture to formal arithmetic. • Mathematical strings woven into social information and practices. • Routine "math" is hands-on

Adapted from Barton (1996, p.210)

Ethnomathematicians are of the view that the systems and truths of mathematics are a social item and they emphasis the effects of cultural activities and experiences on mathematics development as well as its teaching (Gerdes, 1996). To them, mathematics is always culturally embedded. Gerdes (1996) argues that the ethnomathematical paradigm comprises of the philosophies for instructional practice. For example, teachers need to search for social components, activities and exercises that may be useful and relevant in teaching geometry in the classroom. For instance, in the construction of circular huts, there are several geometrical concepts such as shapes and locus that could be employed to teach geometry from the cultural practices that are used in building huts in Zimbabwe.

The idea of locus is employed when setting a hut. The same idea could be used when introducing circle geometry. Similarly, Gerdes (1998) carried out a research on the sand drawings of the Tchokwe people in Angola and recommended a number of potential methods for using these in a geometry classroom. Gerdes (1998) identified geometrical concepts in the sand drawings such as geometrical symmetry and similarities, which could be used as a basis for introducing such concepts in geometry.

Teachers' views regarding the nature of mathematics affects their willingness to incorporate ethnomathematics approaches into the teaching of geometry. According to Gerdes (2005), geometry is at the centre of culture and Ethnomathematics. The view that geometry is a human construct provides a basis, as well as a rationale for ethnomathematics approaches to be incorporated in geometry teaching (Ernest, 2002). The ethnomathematics approach finds its way into the classroom through the humanistic view of mathematics that perceives geometry as a human product as well as being rooted in authentic life application (Ernest, 2009).

2.4 Using ethnomathematics approaches in mathematics education

In some countries, policy documents in mathematics and mathematics education (for instance the Zimbabwe Ministry of Science and Technology, Development Policy, 2010; South Africa curriculum, 2005) encourage inclusion of ethnomathematics teaching approaches in school mathematics curricula. In a similar vein, NCTM's (2000) guiding principle, Brazilian Ministry of Education and Culture (Brazil, 1997), and the Ministry of Public Education (Costa Rica, 2012) emphasise the significance of connecting mathematics to the learners' cultural backgrounds and environment. In other parts of the world, such as Mozambique, Hawaii and Canada; about a decade ago it was found that it was important to include Ethnomathematics in the school mathematics curriculum (Gerdes, 2005; Chin, 2007; Aikenhead, 2006). The foregoing discussions reflect the growing interest in Africa and elsewhere in integrating ethnomathematics approaches into the mathematics curriculum for improving learners' mathematics performance as one of the techniques of maximising the cultural relevance of mathematics education in these communities (Gerdes, 2005; Chin, 2007; Aikenhead, 2006).

However, given the nature of mathematics and that of Ethnomathematics, it was essential to consider the philosophical challenge of combining the two bodies of knowledge, since these are crucial to the incorporation of an ethnomathematics approach into the formal mathematics curricula. The various conflicting views regarding the nature of mathematics influence the manner in which mathematics is taught in schools. The pedagogical implications for mathematical education emerge from the epistemological argument about the nature of mathematical knowledge; therefore, it was mandatory to look at the nature of mathematical knowledge. According to

D'Ambrosio (1997) teaching mathematics from an Ethnomathematics viewpoint provides a chance to shed light on the nature of mathematical knowledge.

2.5 Incorporating Ethnomathematics into mathematics

Ethnomathematical approaches are likely to make geometry important and relevant to learners with an anticipation of improving the quality of mathematics education and performance in mathematics (Gerdes, 2001; Adam, 2004; Madusise, 2010; Rosa & Orey, 2015; 2016). Ascher (2002) stresses that connecting cultural activities, geometrical concepts and mathematics curricula can strengthen the learners' understanding of geometry. It is crucial to formalise such kind of knowledge into the school mathematics curricula (Battista, 2002) and to support it through adequate teacher training (Paraide, 2014).

Nevertheless, a major drawback of mathematical educational reform is the views of nature of mathematics prevalent among people, including teachers and policymakers (Atweh, Fogarz & Nebres, 2010). Mathematics is generally viewed as comprising basically the calculations and use of formulas that produce fixed correct answers, lacking applicability to real life problems, easily accessed by specialists, and not open to criticism (Atweh, Fogarz & Nebres, 2010). However, the teaching of geometry from an Ethnomathematics point of view presents a chance to explain in simple terms the nature of geometrical knowledge, as Ethnomathematics recognises that culture and mathematics coexist (Gregory, 2011). This implies that Ethnomathematics is not a substitute to school mathematics but could co-exist and work hand-in-hand in academic circles.

According to Izmirli (2011) an understanding that mathematics is a cultural product is rooted on the understanding of its epistemology, in addition to, the theoretical views of mathematics. Although, the views regarding the nature of mathematics are differing (Gold, 2011), it does not necessarily imply a disjunction between Ethnomathematics and mathematics classroom practice (Stathopoulos, Kotarinou & Appelbaum, 2015). There are areas of convergence and non-convergence between Ethnomathematics and mathematics. Most scholars agree that there are many areas of overlap between them. Gates (2002) and Orey & Rosa (2006), for example, identified various intersections of school mathematics and ethnomathematics. Ethnomathematics is considered as the intersection of diverse fields such as the history of mathematics with academic mathematics instruction (D'Ambrosio, 2001; Bishop, 2000); the anthropology of mathematics with academic mathematics instruction (Gerdes, 1988); mathematical modelling with academic mathematics instruction and cultural anthropology (Orey & Rosa, 2006; Rosa & Orey, 2013). The majority of the recurring parts are generally anthropology of mathematics and academic mathematics instruction, possibly due to the genesis of Ethnomathematics. The geometrical knowledge obtained in schools and the society is viewed as coordinated as opposed to discrepant. For example, the geometry learners learn from their elders' basket and mat weaving activities are connected to the geometry they learn in schools. The concepts of similarities and symmetry used in weaving are the same concepts that are taught in schools. The geometrical knowledge found in weaving has a place in geometry classrooms.

2.6 Research on integration of ethnomathematics approaches in the classroom

Adam, Alangui & Barton (2003) note that the cultural aspects of the learners' surroundings should be incorporated in the learning environment in a holistic manner, including the knowledge of geometry, its content, and its teaching approaches. They strongly advocated for the integration of geometric practices, experiences, activities and examples which originates from the learners' cultural backgrounds into the teaching and learning of geometry in schools. In other words, there is need to incorporate ethnomathematical approaches in the existing geometry curriculum and that teachers should contextualise the teaching and learning of geometry through connecting geometry concepts to the learners' cultural experiences and the real-world. The literature supports the use of culturally familiar materials, examples and problems as a means of facilitating learners' ability to access and understand school geometry (Rosa & Orey, 2011).

Studies that support integration of ethnomathematics approaches in mathematics classroom put emphasis on the need and benefits of associations in bridging school and social or ethnic mathematics (Rosa & Orey, 2009; Gerdes, 2011; Pinxten & François, 2007; Adam, 2004). Rosa & Orey (2009) investigated the symmetrical designs found in quilts, making associations that involved geometry and the craft and art of quilting. During their analyses of different symmetrical freedom quilts, Rosa & Orey (2009) developed a teaching unit for geometrical transformations.

The unit comprises of comprehensive work on symmetry, reflections, rotations and translations. These were captured in lesson plans that enable teachers to design geometry activities that would help learners to comprehend geometry, particularly concepts of transformations and symmetry Geometry concepts were viewed as abstract concepts by learners, however, analysing real symmetrical freedom quilt patterns, as in Figure 2.1**,** enabled them to change their views about geometry and to see the relevance of learning geometry (Rosa & Orey, 2009). Quilt are identified by their particular patterns, that bear them particular names, for instance, the quilt in Figure 2.2 is known as the *Bowtie*, while the other one in Figure 2.3 is called *Shoofly* (d'Entremont, 2015). These quilts may be used as models by teachers to teach numerous geometrical concepts such as shapes, perimeter, area, symmetry, measuring and transformations that include rotation, translations and reflection. On the whole, quilts provide "real world" examples of geometry concepts for the reason that they use symmetry, translations, rotations and reflections. This study demonstrated how to link school geometry to the learners' own environments and culture.

Figure 2.1: Freedom Quilt Displayed on Window-sill (Adapted from Rosa & Orey, 2009, p.58)

Figure 2.2: Bowtie
(Adapted from d’Entremont, 2015, p.2820)

Figure 2.3: Shoofly

Pinxten and François (2007) carried out a research involving Navajo Indians (in the U.S.). The researchers used the *hooghan* (traditional housing) project to teach geometry. The learners visited the *hooghan* site where they received clear descriptions of the hooghan. After visiting the hooghan site, learners were asked to build a *hooghan* model at a planetary scale, demonstrating Navajo concepts such as proportions and wind directions. Figure 2.4 shows a model of the traditional *hoogan* house.

Figure 2.4: A *hoogan* model (Scott, 1999)

The learners worked as a team in exploring all features of the *hooghan* such as notions of direction and proportion of hooghan models. The Navajo language was used in the groups. After the study, researchers found out that it was helpful for learners to start by learning the geometry that was rooted in the hooghan picturing the structures in it and then using graphical representations to grasp geometry concepts. The use of the Navajo language and team work in the study is in line with ethnomathematics approaches and the social constructivist views of the teaching and learning of mathematics.

Gerdes (2011) used examples from African Art such as decoration of handbags, hats, mats, and basket trays in Mozambique to present the geometrical ideas interwoven in these decorations such as the area of a circle, symmetry and transformation. Figure 2.5 and Figure 2.6 shows a basket tray and a hat respectively that could be used to teach geometry concepts such as the area and circumference of the circle. Gerdes (2011) advocated for the use of African Art in elementary schools' settings in teaching and learning of geometry. A teaching and learning lesson in geometry could make use of designs in the artistic decorations and connect the designs to geometrical activities in the classroom. The artefacts could make geometry real for the learners.

Figure 2.5: A basket tray (Gerdes, 2011, p. 15)

Figure 2.6: A Makhuwa hat (Gerdes, 2011, p.15)

In another study, Gerdes (1999) explored the cultural mathematical activities of the Tchokwe (Sona) people, from Angola. He illustrated geometry concepts in the ivory carvers, painters, potters, mat and basket makers, sand drawers, in the work of wood and weavers. He examined geometrical concepts in numerous crafts and explores their use in the classroom. He concluded that integration of the geometry concepts from the Sona people in the mathematics curriculum, both in Africa and elsewhere in the world might contribute towards the development of a more creative and more innovative mathematics education.

Adam (2004) carried out a research on the implementation of an ethnomathematical unit in Maldives with Grade 5 teachers and learners. The research was on measurement concepts such as perimeter, area and volume. Teachers and learners visited different places, for example, markets, carpentry and boat building sheds to search the mathematical features of these activities. Teachers and learners welcomed and appreciated the use of the ethnomathematical approach in teaching and learning of measurement.

Research evidence showed that both teachers and learners managed to recognise cultural activities and experiences in Maldivian culture displaying measurement systems, and they as well managed to connect the exhibitions to the academic mathematics in their school syllabus (Adam, 2004). The benefits resulting from such activities comprise motivation and interest, being able to link school concepts on measurement to real life situations and to understand that mathematics is developed by humans as a response to specific problematic situations. Adam's (2004) study showed that it is possible to integrate ethnomathematics approaches when teaching mathematics.

In Kanu's (2005) study, the teachers reported that they gathered Aboriginal curriculum resources, they even rewarded guest speakers and attended workshops on Aboriginal education to improve their understanding of Aborigian. Kanu (2005) also reported that, there were prominent exhibitions of Aboriginal cultural products, pictures and promotional material about Aboriginal occasions on the walls and on bulletin boards. Further, they were lively consultations of books and supplementary journals by Aboriginal and worldwide authors, use of sharing circles, and culturally responsive evaluation techniques such as observing the learners displaying their projects that were grounded on their social experiences and merits; in addition to, the constant incorporation of helpful content resources of Aboriginal populates.

In another study carried out by Anchor, Imoko & Uloko (2009) in Nigeria, they compared the conventional/traditional approach with ethnomathematics approach on learners' achievement in geometry. The study showed that learners taught with ethnomathematics approaches had a greater mean achievement in comparison to conventional/ traditional approach. The reason for higher achievement by learners who were exposed to ethnomathematics approach was attributed to the integration of their cultural background and experiences with the alien features of geometry learning. This might imply that ethnomathematics approaches could help in reducing the abstract nature of geometry.

A number of benefits have been identified for integrating ethnomathematics approaches into the teaching of mathematics. These include improving the learning of school mathematics content including geometry and promoting higher levels of intellectual skills; enable learners to be creative; improving learners' ability to solve geometry problems; improving learners' tactics for obtaining information; boosts learners' self-esteem; improving learners' ability to work with others in the classroom; helping learners to experience self-reliance; allowing learners' to make their own decisions; increasing learners' ability in making links between daily practices and school geometry; improving learners' ability in discovering important meaning to countless complex geometry concepts taught in schools (Gerdes, 1999; Adam, 2004; Anchor et al, 2009; Rosa & Orey, 2010; Izmirli, 2011).

The studies cited above highlight different ways that have been used in integrating ethnomathematics approaches in mathematics curriculum in different countries. Fundamental to the above studies is the significance positioned in identifying and embracing cultural-based practices, activities and experiences in the teaching and learning of geometry. Nonetheless, there are some challenges associated with the notion of incorporating ethnomathematics approaches into the teaching of geometry. This study was interested in finding out the in-service mathematics teachers' preparedness to integrate ethnomathematics approaches into the teaching and learning of geometry.

2.7 Challenges on integration of ethnomathematics approaches in the classroom

The integration of ethnomathematics approaches is not without challenges. Various reasons have been advanced for not integrating ethnomathematics approaches in mathematics teaching. For instance, Ukpokodu (2011), in Missouri studied both pre- and in-service urban teachers who were taking a graduate course that focused on cultural-based teaching approaches in mathematics. Data was collected using group discussions and structured in-class activities. For the structured activities, participants worked individually at first in completing different activities. They then worked in small groups sharing their ideas. The objective of the structured activities was to find out why teachers were not teaching mathematics using ethnomathematics approaches. Ukpokodu's (2011) study revealed five major challenges.

Firstly, teachers pointed out that the textbooks were convenience to use when teaching and the domination of textbook-based mathematics instruction are barriers to the use ethnomathematics approaches. They indicated that mathematics teaching approaches are teacher-centred and textbook-based and that there are prescribed curriculum materials that they must use religiously as failure to use them results in trouble. Furthermore, teachers are forced to teach for examination so that their learners score high marks in examinations.

Secondly, the study revealed that there were no models to emulate when using ethnomathematics approaches. For the participating teachers, it was their first time of hearing about teaching mathematics in culturally responsive methods. Teachers also reported that their previous college courses did not include teaching mathematics in culturally responsive ways let alone modelling it. The participants lack awareness of such approaches. Ukpokodu's (2011) study supports findings of an earlier research carried out by Kanu (2005) which pointed out that teachers had inadequate cultural knowledge and understanding necessary for the effective integration of ethnomathematics approaches.

Thirdly, the study showed that curriculum standardization and high-stakes testing were also a challenge to the integration of ethnomathematics approaches. This results from the fact that teachers are forced to teach for the examinations because their schools are rated basing on the learners' results and not on their understanding of the mathematical concepts. Therefore, teachers do not teach in the ways that allow them to meet the learners' needs. Similarly, Orey & Rosa (2006) observed that it has been problematic to merge the aims and idea of ethnomathematics, academic yardsticks, principles, and objectives associated with the passing of standardised examinations in formal schools. Teaching for examinations encourages rote, memorization and procedural learning that counter the humanistic and social constructivism views that advocates for learner-centred approaches.

Fourthly, the study showed that the view of mathematics as a culture-free product also poses challenges to integrating ethnomathematics approaches in the classroom. Teachers reported that mathematics is a complex subject, a "universal language," that numbers are the unchanged everywhere, and hence, mathematics teaching approaches are not concerned with cultural experiences and activities. This is also supported by Bishop (2004) and Paraide (2015) who reported that, in practice, mathematics teaching is rarely linked with the learners' cultural background because of it is viewed as universal.

D'Ambrosio (2001), Bishop (2004), Matang & Owen (2004), and Matang (2009) reported that this is due to the traditional view that regards mathematics as both culture- and value-free facts, D'Ambrosio (2001) argues that the traditional view has made the teacher to believe that there is no link between mathematics and culture and that mathematics is acultural. Consequently, the application of culture has been drastically omitted from school mathematics and its teaching. This traditional view of mathematics has contributed to the nonexistence of the inclusion of cultural activities in the teaching process.

Lastly, most teachers did not make use of the affluent cultural diversity their learners bring to the learning environment so as to make the teaching of mathematics interesting and significant for all learners (Ukpokodu, 2011). Instead, several teachers view the variations in culture as sources of problems in the classroom. The findings of Ukpokodu's (2011) study corroborates earlier research by Barnes &Venter (2008) who identified the multiplicity of cultures and practices within the world as factors that create problems to relevant and culture-sensitive ways to use contexts in the classroom. It is not possible for a single task to offer a universal application that is familiar and relevant to all the learners due to cultural diversity (Boaler, 1993). Moreover, the cultural examples that might be used could either be unfamiliar to the learners or their cultural and environmental experiences might not include such examples (Nawesab, 2012). This implies that there are several methods to contextualise the same content, which may pose problems to the teacher in deciding on appropriate everyday contexts that would guarantee learners' participation and meaningful learning of concepts through ethnomathematics approaches.

Nawesab (2012) used various methods of data gathering such as open-ended questionnaires, observation, and interviews to undertake an investigation in Namibia, focusing on how junior secondary school teachers used everyday contexts to facilitate a meaningful understanding of the mathematics concepts. The guiding theoretical framework of his study was social constructivism. Inductive data analysis was used in the study. The findings of the study showed that a lack of teaching materials for particular topics that could bring out the practicality, significance and usefulness of mathematics to the learners was a major challenge.

In the same study, teachers pointed out that at times a topic needs specialised instruments. For instance, they mentioned the use of mathematical sets that are required for the teaching of geometrical concepts. Nevertheless, in the absence of such instruments learners will not understand the concepts and the use of ethnomathematics approaches would be very difficult. Furthermore, pertaining to the issue of resources, Orey & Rosa (2006) observed that there were very few textbooks and other instructional resources about ethnomathematics approaches that were being used in schools.

Naweseb (2012) reported that some topics in the mathematics syllabi such as those associated with geometry were perceived by teachers to be too difficult and could not be connected to the learners' everyday experiences, thus, hindering the use of ethnomathematics approaches. He points out that it is possible for teachers to connect to the environment the topics that they view as easier than those that they view as abstract or demanding to teach. Similarly, Makari (2007) recognised the nature of mathematics as a stumbling block which does not permit contextualization to take place at secondary school level. Makari's (2007) study supports findings of an earlier research carried out by Akpo (1999) which pointed out that secondary school teachers find the same topics, for instance, algebra, graphs, trigonometry, indices, polynomials and geometry difficult to teach and therefore problematic to link to learners' cultural backgrounds. The abstract nature of geometry that has its origin in the traditional views of mathematics imposes challenges on the integration of ethnomathematics approaches in teaching and learning of geometry.

Although some teachers identified pre-knowledge and interests of the learners as essential features in deciding on the use of ethnomathematics approaches, however, recognising them before a topic was taught was not easy (Naweseb, 2012). Mogari (2014) in South Africa also noted that teachers were not able to use the ethnomathematics approaches because of difficulty in preparing ethnomathematics lessons. This challenge emanates from how ethnomathematics activities are chosen from the learners' cultural experiences or activities. The selection of mathematical content from the learners' environment depends on situational activities that are fascinating to learners themselves because inspiration and inventiveness are major elements in the ethnomathematics approaches.

In order to implement the ethnomathematics approaches, teachers ought to be both supple and conversant in geometry content since they are the ones who choose the cases which are connected to learners' cultural backgrounds and environment. Stears, Malcolm & Kowlas (2003) argued that the recognition of everyday contexts and their meaningful incorporation entails unique teacher skills in relation to the learners' interest. Venkat, Bowie & Graven (2009) reported on some experimental research in mathematics classrooms in which teachers that were trying to incorporate contextualised mathematics teaching, showed lack of skills that resulted in loss of focus on mathematical aspects. Teachers' cultural knowledge may enable them to understand how learners learn mathematics and may help them to select and to use the learners' cultural knowledge and experiences to build on when teaching in schools (Paraide, 2009). Teachers also felt that overcrowded classrooms affected their ability to contextualise mathematics content meaningfully (Naweseb, 2012). Ethnomathematics is a learner-centred approach, hence, is not perfect for large classes (Mogari, 2004).

In South Africa, mathematics instruction in schools is rarely linked to learners' cultural backgrounds and societal experiences (Mosimege, 2012). It does not make links between mathematics and culture in instructionally informed ways. Jojo, Brijlall & Maharaj (2006) also reported that teaching that provides opportunities for learner to struggle with problems of conceptualising and communicating their diverse and personal intuitive mathematical thought and builds on this knowledge to construct notations, proofs, definations and the appreciation of geometry as a whole takes time and planning. Jojo, Brijlall & Maharaj (2005) observed that whenever learners are invoved in practical activities the learning environment becomes chaotic and the learners make noise. The same authors also noted that a large number of learners in a class could therefore be a barrier to the integration of cultural activities into the teaching and learning of geometry. Mosimege (2012) pointed out that mathematics teachers were not able to make relations in their teaching of mathematics. According to Madusise (2015) in South Africa, mathematics teachers' ethnomathematical content knowledge is shallow.

In another study in South Africa, Madusise (2015) explored how academic mathematics was used to understand cultural experiences and activities. Teachers were interviewed on their views of connecting mathematical knowledge to cultural experiences and activities. Learners were interviewed and at the same time they completed the questionnaire. The study noted that efficacious integration of cultural experiences and activities requires sufficient and appropriate mathematical content knowledge and that inadequate knowledge of mathematics concepts acts as a hindrance on the use of academic mathematics in reading and understanding of various cultural activities. The research also revealed that teachers' own subject knowledge also hinders the integration of ethnomathematics approaches in the classroom. In Nigeria, Telima (2011) reported that the foundation of most mathematics teachers in geometry was poor. This concurs with Ponte and Chapman (2006) who reviewed several studies that show consistently that geometrical knowledge is generally challenging in view of what the teachers know, and how they understand geometry. Their summary showed that teachers lack ability to connect geometry to real-world situations and difficulty to process geometrical information and in addition they do not have basic geometrical knowledge, skills and analytical thinking ability. The teachers ought to have a deep understanding of geometrical concepts so that they provide help to the learners in various investigations. The teacher should have adequate geometrical knowledge to identify exciting, relevant geometrical problems, in addition to, the skills to assess various methods of solving the problems that learners present (Wilding-Martin, 2009). The implication here is that if the teacher does not have either the requisite knowledge or pedagogical understanding of teaching geometry, then an Ethnomathematics learning environment can easily lead to disorder.

In another study, Cherinda (2012) reported that teachers in Mozambique do not make links between mathematics and the real world or historic features in their classroom for the reason that time is limited and the topics in the syllabus are too comprehensive for the teaching time assigned. He also reported that teachers were of the view that they will be wasting time if they concentrate on issues that are not examined. This tends to force teachers to resort to the traditional methods of teaching, which are not time consuming in both lesson preparation and during presentation.

The traditional mathematics curriculum may not allow implementation of ethnomathematical approaches which are culturally rooted and more often than not there are no traditional syllabus or assessment standards for such an approach (Orey & Rosa, 2006; Paraide, 2009). In addition, teachers are not permitted to work away from the binding textbooks and curriculum, nor are they adequately equipped or encouraged to be able to link geometry and culture (Orey & Rosa, 2006). Furthermore, another challenge, teachers need to overcome is that schools are bound by a system of assessment with official syllabus of topics to be covered and usually a standardised or required examination structure (Shirely, 2006). Anything that seems to deviate from the approved curriculum may appear superfluous, time wasting, or even counterproductive in terms of achieving good results and scores (Shirely, 2006). Indeed, this restricts the likelihood for an Ethnomathematics perspective to enter into the classrooms in schools.

In addition, Van den Heuvel-Panhuizen (1999) cited by Beswick (2010, p.377) reported that if learners are given contextual/cultural problems, they may not pay attention to the mathematical content involved or they may perhaps concentrate on the contextual/cultural facets without considering the mathematics rooted into the contextual/cultural situations. Beswick (2010) is of the view that contextualising mathematical problems is not intended to form a connection between mathematics and the outside classroom world, however, it for the understanding and development of mathematical concepts that are relevant and can be useful in different situations.

Nutti (2013) reported that some teachers highlighted that their roles as teachers and working system were challenges to the implementation of ethnomathematics approaches. The role of a teacher in ethnomathematics approaches would be mainly that of a facilitating the teaching-learning activities instead of being an expert who imparts knowledge to the learners (Matang, 1999). Teachers are epitomised as mentors, mediators and facilitators of the teaching and learning process (Orey & Rosa, 2006). This change of roles from the expert in the traditional view to a facilitator in the humanistic and Ethnomathematics perspective may pose difficulties to the teachers. In ethnomathemtaics approaches teachers are supposed to acknowledge learners as equal partners, who must as well have a say in all teaching-learning activities that take place in the classroom. As a result, learners are actively involved in all class activities; they are not inactive empty vessels where teachers need to pour geometry knowledge.

Naresh (2015) pointed out teachers' lack of professional development and limited models of cultural resources as challenges to the implementation of ethnomathematics approaches. Several course activities required teachers to make clear links between the cultural activities and the mathematics teaching and learning principles prescribed the mathematics syllabus. Naresh (2015) also indicated the absence of cultural and historical activities from the mathematics curriculum as an obstacle to the integration of ethnomathematics approaches in the classroom. Consequently, several teachers recognised that such activities that are a component of ethnomathematics approaches required a deeper and richer examination of mathematics content.

Even though, there are several challenges associated with the implementation of ethnomathematics approaches, this does not imply that these approaches should be evaded absolutely, for when they are properly implemented the benefits are great (Lipka, 2002).

2.8 Teachers' preparedness to integrate ethnomathematics approaches in the classroom

One of the most influential determinants of whether ethnomathematics approaches prosper or dither in the geometry classrooms is how much the individual teachers comprehend the idea of Ethnomathematics. Without the sort of working comprehension, it could not be anticipated that teachers would be able to use ethnomathematics approaches to their specific classroom settings. Hence teachers' understanding of the Ethnomathematics and ethnomathematics approaches is of great significance before putting into practice the approach in all learning environments. Shirley (2001) reviewed several researches on the field of Ethnomathematics and concluded that the approaches are essential to the process of teaching and teaching instruction. For this reason, Shirley pointed out that it is important for ethnomathematics approaches to be incorporated in mathematics teacher education programs. Rosa (2013) reported that it is important to comprehend both culture and its link to mathematics teaching as this could be a source of knowledge for teachers that would assist them to adjust and modify their instructional practices so as to support positive learning prospects of learners.

In a "Geometry of Ornaments workshop" in Israel (Massarwe, Verner & Bshouty, 2011), on pre-service teachers' experience and their way of thinking regarding the teaching and learning of geometry using cultural examples and context before and after the workshop (Massarwe, et al., 2011, data was gathered through group discussions, questionnaires and observations. In the workshop, pre-service teachers in the experimental group designed instructional units and lesson plans that they used to teach geometry using ornaments that their learners were familiar with. Pre-service teachers in the investigational group were exposed to the significance of incorporating the cultural aspect into activities towards geometry teaching. Discussions focussing on how teachers had taught using ornaments were held after teaching. The results of their study showed that the pre-service teachers had not been exposed to links of geometry with culture and art prior to the workshop. Furthermore, the study showed that the pre-service teachers in the investigational group had managed to acquire skills that were required to teach using cultural context and ornaments. However, this was done once for the teachers, which is a limitation for the study.

In another study, perhaps picking on their earlier study Massarwe, Verner and Bshouty (2012), developed, implemented and evaluated another methods course "Issues in Ethnomathematics: Teaching Geometry in Socio-Cultural Context" to both to pre-service and in-service teachers with the aim of developing competence of teaching multicultural groups in Israel. The course concluded with a workshop in which each teacher taught the examination as well as ornament construction from a particular culture to different learners in Israel.

The authors framed their study within social constructivist framework. They taught the geometry concepts from a social constructivist perspective by involving the teachers in analysing ornaments with regard to geometrical transformation and symmetry. Researchers collected data using questionnaires, observations and through the analysis of the teacher designed posters. The study showed that the course helped the teachers to meaningfully improve their mastery of geometry content and how to teach it, in addition to comprehending the significance of ethnomathematical learning activities linked to the learners' own cultural backgrounds.

Harding-DeKam (2007) carried out a two semester study in Colorado involving first year trainee teachers for the purpose of equipping them with foundational knowledge of Ethnomathematics that might be useful in the classroom. The study was done whilst the teachers were doing a methods course in mathematics. It was a forty five contact hour course done in five weeks, which was framed within the constructivist views, where the teachers were taught problem solving skills, how to design problems of their own as well as encouraged to arrange for supportive learning environments and numerous solutions for mathematics problems.

The teachers were also taught to make links between mathematics and the learners' prior knowledge, introduce the concepts from simple to complex, connect mathematics to the learners' real life situations, culture and history. Afterwards pre-service teachers were placed at schools for teaching practice for eleven weeks. Questionnaires and thematic unit lesson plans were used to gather both qualitative and quantitative data. Data was analysed separately but was never merged.

Findings of the study showed that the teachers used various instructional methods to tap into the learners' prior content and cultural knowledge. Harding-DeKam (2007) recommended a need for

Ethnomathematics to be introduced to pre-service teachers before looking at diverse techniques of integrating ethnomathematics approaches in in the classroom for the purposes of equipping them with the knowledge on Ethnomathematics and its importance a classroom. Nonetheless, it was worth exploring how the in-service teachers were prepared to integrate ethnomathematics approaches in teaching geometry.

Luitel & Taylor's (2005) study showed that teachers lacked knowledge on how to develop activities that were culturally contextualised that could be used in the teaching and learning of mathematics. Teachers are unaware of the link that exist between mathematics and culture not aware of the connection between mathematics and culture for the reason that culture is not a component of the mathematics content and instruction in the classroom (D'Ambrosio, 2001; Bishop, 2002). In addition, several teachers are not acquainted with the relationship that exist between geometry in particular and mathematics in general with other subjects, specifically, its interdisciplinary nature, which is one of the requirements when integrating ethnomathematics approaches in the classroom (Orey & Rosa, 2006). The interdisciplinary nature of geometry inspires lifelong education from a variety of experiences.

In an exploratory study in New Zealand, Averill, Anderson, Easton, Maro, Smith, & Hynds (2009) investigated trainee teachers' views of a bicultural mathematics content course, their views on the use of cultural examples and activities in the mathematics content course and on the effect of integrating cultural approaches in the classroom. Questionnaires, course evaluations and focus group discussions were used as data gathering instruments. The pre-service teachers pointed out pedagogical advantages of incorporating cultural approaches in mathematics teaching such as practical hands on approach, a technique of showing that mathematics is not just a school or text-based subject and a method to incorporate teaching across other curriculum subjects.

Averill et al's (2009) study showed that the pre-service teachers' awareness of teaching mathematics using ethnomathematics approaches improved after the course and that before taking the course they were not likely to use such approaches in mathematics teaching. The researchers noted that a once off integration of cultural teaching strategies in the teaching programme was not enough to make teachers aware of such strategies. This view was supported by Ukpokodu (2011) who reported that a single course on methods or a once off course ethnomathematics approaches would not guarantee a complete change on teachers' views of teaching mathematics using cultural examples or activities. Averill et al's (2009) study indicated that if teachers possess the required knowledge for teaching mathematics in a cultural context, they are likely to use ethnomathematics approaches in the teaching and learning of mathematics. Although, findings from Averill et al's (2009) indicated that the teachers were offered a course that integrated cultural teaching strategies in teacher training programme, a single course was not sufficient to enable them to use ethnomathematics approaches.

Adler (2005) reported that mathematics teachers predominantly display mathematical and teaching practices emphasised in their teacher training programme. She noted that teacher training programmes predominantly emphasised procedural skills that have their origins from the traditional view of teaching mathematics. The ability to demonstrate mastery of procedures does not necessarily guarantee underlying conceptual understanding.

Shulman (2004) argued that successful integration of contextualised activities and examples in the classroom is centred on the deeper conceptual comprehending of mathematics and relevant pedagogical content knowledge. Teachers are not able to successfully use everyday context in their geometry teaching if the training they received did not adequately equip them to use contextual teaching (Adler, 2005; Gainsburg, 2008; Venkat, et al., 2009). According to Adler (2005), it is not realistic to anticipate that teachers would use teaching instructional approaches that they have not been exposed to during their training or have not personally experienced.

In another study, Velasquez (2014) used narrative stories and interviews to investigate teachers' opinions of teaching using a mathematics national syllabus that was culturally based. Data was gathered after the implementation of the mathematics national syllabus. The study showed that teachers were not professionally trained to use mathematics syllabus that focussed on teaching mathematics using cultural activities and examples, nonetheless, they were of the view that having such examples and activities would enhance their instructional approaches in the teaching of mathematics. According to Massarwe, et al., (2012), the models of Ethnomathematics courses for pre-service teachers are very few, the famous courses are "Ethnomathematics" (Presmeg, 1998) in

United States and “Ethnomathematics and the Teaching of Mathematics in Secondary School” (Gerdes, 1998) in Mozambique.

The lack of Ethnomathematics courses in teacher training programmes might imply that teachers are not prepared to integrate it in schools (Orey & Rosa, 2006). Correspondingly, Katsap & Silverman (2008) observed that a majority of teacher education institutions were training teachers for mathematics content without any cultural context. Therefore, nearly all the teachers do not employ ethnomathematics approaches for the reason that they do not have the adequate training that allows for its implementation along with fixed school curriculum (Rosa & Orey, 2013). This scenario influences teachers to view mathematics as universal and culture free (D'Ambrosio, 2001) and these teachers who persistently hold this traditional view of mathematics would continue to use teacher-centred methods in the classroom.

In Sweden, Nutti (2013) investigated teachers’ views of the Indigenous School transformation and their work to acclimatise teaching using mathematics instruction that is culturally based. Before, during and after teaching using culturally based instruction, the teachers held discussions with the researcher. The research findings showed that teachers lacked both the knowledge of mathematics and ethnomathematics approaches. Although, ethnomathematics approaches would make the teaching of geometry relevant to the learners, numerous mathematics teachers are not aware of ethnomathematics approaches or they have insufficient knowledge to put it into practice.

In another research, Makari (2007), in Namibia, revealed that teachers were exposed to ethnomathematics approaches during their training, especially during microteaching. Nevertheless, they were quick to point out that the exposure was inadequate and that nearly all mathematical concepts, geometry included, were abstract and hence, not always easy to contextualise. The abstract nature of geometry rooted in the traditional view of mathematics might perhaps imply that the teaching of geometry could be teacher-centred.

In South Africa, Mogari (2014) used an in-service mathematics programme to introduce ethnomathematical approaches. The programme comprised of cluster meetings held monthly, classroom visits and three workshops. The purpose of the in-service programme was to introduce teachers to the concept of Ethnomathematics and ethnomathematics approaches, to educate teachers about mathematising as well as training teachers to use ethnomathematics approaches. The study revealed that teachers cherished the significance and applicability of in-service program especially in regard to the knowledge they acquired during the programme. The study also showed that although the teachers were able to repeat some of the activities from workshops when teaching, they were not able to design new ethnomathematics activities for their own use.

Katsap & Silverman (2008) carried out a two-semester study that involved the implementation of an Ethnomathematics programme with the aim of examining possible effects that were likely to accrue for the trainee teachers from being exposed to ethnomathematics approaches. The teachers in the Ethnomathematics programme prepared and presented study units combining ethnomathematical contents in academic mathematics. After their presentation the participants were involved in class debates and discussions. Geometry concepts served as one of the mathematical content for the implementation of the program. The findings of the study showed that the classroom presentations on the topic were a thrilling learning experience for the teachers. Thirty six participants agreed on the importance of linking the mathematics teacher's preparation with cultural perspectives of mathematics and with the benefit of integrating ethnomathematical approaches in geometry teaching.

Katsap & Silverman’s (2008) study showed that the teachers valued ethnomathematical approaches and acknowledged that mathematics rooted in the culture and their living and teaching environments should not be separated from the school mathematics. Thirty two participants highlighted the following as some of the important features of incorporating ethnomathematics approaches in mathematics teaching: richness of learning of content taught, prolonging the learners’ "world of knowledge", creating positive views about mathematics, creation of inter-disciplinary amalgamation; and changing the monotonous and boring structures of the mathematics experiences.

Findings demonstrated that the pre-service mathematics teachers assigned nearly all the benefits to the fact that incorporation of ethnomathematics approaches in academic mathematics can improve their learners’ comprehending of mathematics as well as their quality of learning. They reported that the ethnomathematical experiences prepared them for modelling, which is non-existent in several mathematics textbooks (Katsap & Silverman, 2008).

In another study, Naresh (2015) designed and implemented a mathematics content course that was based on an Ethnomathematics curriculum in United States. The course was a 38 contact hour course for prospective teachers. In designing the classroom materials Naresh (2015) consulted a variety of sources that included online content, print media, textbooks and video materials. Prospective teachers were required to examine an independently significant practice, which show that mathematics is indeed a cultural product. Every teacher designed a geometry activity and was involved in geometry content investigations and its pedagogy. Data were collected using small group discussions and the teachers' evaluations and reflections on the course.

Figure 2.7: Kolam patterns (Naresh, 2015, p. 464).

Naresh (2015) introduced the teachers to *kolams* (see Figure 2.7) and were requested to find out the mathematics embedded in the *kolams*. Teaching concepts like polygons, symmetries and transformation in geometry, patterns and sequences and combinations were identified by the teachers. *Kolam* comprises quite a number of horizontal and vertical reflections, translations, symmetries and rotations. The teachers found joy in these cultural activities.

In light of their introduction to *kolams*, teachers were eager to search for and identify different types of mathematics that exist outside the domains of the classroom mathematics. The research also revealed that it has positively impacted the teachers' views of mathematics and its teaching. The course challenged their views on mathematics, improved mathematical understandings, and presented a pointer to the mathematics that exist in different cultures and societies. With globalization *kolam* has come into the realm of computer science (Ascher, 2002), which has been overlooked by the mathematics education sector.

2.9 Views of teachers on integrating ethnomathematics approaches in the classroom.

Teachers' views of what mathematics is have philosophical and psychological underpinnings of their teaching of mathematics and geometry specifically and consequently on their conceptions of Ethnomathematics. These views shape their perceptions of what ethnomathematics approaches are.

Researchers, for instance, (Ernest, 1989; Handal, 2004; Meena, 2009; Zheng, 2009) believed that teachers' views of the mathematics influence their classroom practices in different ways. According to Handal (2004) so many educational innovations have been unsuccessful because teachers' beliefs, feelings and views about teaching were not considered during the development of the programmes. The role played by the views held by teachers' when deciding on teaching approaches is very crucial.

Jorgensen, Grootenboer, Niesche & Lerman (2010) used questionnaires and observations, to investigate the mismatch concerning teachers' views and their classroom practices.. The survey data that were collected in the early stages of a 3-year project, focusing on the teaching of mathematics in schools in Western Australia, indicated that the teachers were of the view that their learners' cultural activities and experiences were crucial in the teaching of mathematics and they pointed out that they make use of cultural activities and examples when they plan and implement their mathematics activities. Nonetheless, the video taped lessons showed otherwise, the teachers were not practising what they claimed were doing, which might indicate their lack of skills in planning and implementing such activities.

Furthermore, their study showed that even though teachers had positive views about the use of ethnomathematics approaches in the teaching of mathematics, this does not mean that they would integrate ethnomathematics approaches into the teaching and learning of mathematics. Ferner (2013) also had similar sentiments as a lecturer in a teacher education program when he observed that both in-service teachers and prospective teachers had challenges when trying to implement learners' cultural background to mathematics teaching. It became clear to him that even though those teachers believed that ethnomathematics approaches could be useful to their learners, they were dither to make use of them in mathematics teaching.

Massarwe, Verner & Bshouty (2010) developed and evaluated a pilot curriculum on geometry through ornament analysis and construction. The underlying principle for developing such a curriculum was to make the teachers aware of the geometry that exist outside the classroom and its relation to the real world. The curriculum consisted of a formal class and a workshop. Data was gathered using observations, group discussions and questionnaires. The curriculum was taught by the teachers guided by the researchers. Before the implementation of the curriculum the study revealed that both the teachers and the learners were not aware of the connection that exist between real life practices and geometry.

The study showed that the learners were astonished that geometry has a connection to the real world that could be used in geometry class. This motivated the learners to search for additional geometry decorations, embedded in their own culture and environments. The study also revealed that learners were interested and motivated to study geometry with the use of ornaments. After piloting the curriculum both the learners and the teachers perceived the teaching practice with geometrical ornaments as an enjoyable experience of discovering geometrical properties. Similarly, Katsap and Silverman's (2008) study showed that pre-service mathematics teachers held the belief that the excitement that they experienced throughout the Ethnomathematics course would as well be experienced by their future learners when geometry is taught using ethnomathematics approaches. The teaching of geometry using ornaments stimulated the teacher' emotions, encouraged dialogue, as well as motivating them to learn. The study also revealed that the use of the ethnomathematics approach helped the teachers to view mathematics as a product of human and social creation (Katsap & Silverman, 2008).

In Cameroon, Kang (2004) investigated teachers', learners' and teacher educators' receptiveness to an Ethnomathematics curriculum. The author framed his study within the social constructivism views. Collection of data was done through the use of observations, interviews and questionnaires. Data was analysed through inductive process by letting for common themes, patterns and recurring expressions to emerge. Kang's (2004) research showed that teachers were of the view that relevant learners' daily experiences and cultural background were important when planning their lesson instructions. Teachers also reported that they were able to connect learners' prior and background knowledge to the teaching of mathematics. Teachers favoured the incorporating of ethnomathematics approaches in the mathematics' classroom with the hope that it will improve mathematics learning.

Kang's (2004) study also showed that teachers viewed Ethnomathematics as mathematics teaching based within a cultural background and its people and race, mathematics practiced in a particular culture, which differs from culture to culture and mathematics knowledge passed down orally from generation to generation within an indigenous community, for instance, traditional mathematics used in different cultures in their daily activities which is not documented such as weaving and thatching. In addition, the same study revealed that teachers viewed ethnomathematics as relating mathematics to cultural values and showing the role of culture in mathematics settings.

Similarly, the teachers in Katsap & Silverman's (2008) study did not make use of the word Ethnomathematics in their presentation instead; they referred to it as the "mathematics in people's culture" or "mathematics in everyday life". Gerdes (1994) stated similar descriptions under titles such as informal mathematics, out-of-school mathematics as well as everyday mathematics. These different types of mathematics are rooted in cultural activities, namely everyday mathematics, for instance, hunting, fishing and house building are components of Ethnomathematics (D'Ambrosio, 1993).

The everyday mathematical (Ethnomathematics) knowledge of learners has been studied by Bose & Subramaniam (2011) in India. They believed that such knowledge is capable of improving and supporting the teaching and learning process of mathematics. The everyday mathematics is shaped by the learners' everyday experiences and their cultural practices (Bose & Subramaniam, 2011). According to Bose & Subramaniam (2011), uniting everyday mathematical knowledge with school mathematics may help in developing problem solving skills and motivate the learners to learn mathematics. Everyday mathematical activities nurture effective situational problem solving skills that could be useful in the teaching and learning of mathematics and have a potential of dealing with barriers that are involved in teaching mathematics in schools. However, Bose & Subramaniam (2011) suggested that it is worth exploring how much the teachers are aware about the extent of their learners' everyday mathematical knowledge and how such knowledge can be brought in the classroom so that the teaching and learning process would improve.

In Katsap & Silverman's (2008) study, pre-service mathematics teachers reported that their understanding of mathematics content and pedagogy improved. For instance, prior to the Ethnomathematics program, the pre-service mathematics teachers viewed symmetry as an abstract geometry concept, and they were not able to link the abstractness in symmetry to any daily forms of symmetry in the environment. However, their views on the abstract nature of symmetry changed as they were exposed to geometry embedded in cultural context, for example, symmetry was evidenced in Bedouin women's dress embroidery, their carpet weaving, and also in the designing and making of Jewish kippahs. Each of these instances demonstrated the sophisticated use of symmetry, in simple terms that were used to come up with the different products and with the different views of geometry. Their views of geometry changed from what Ernest (2009) described as a traditional view to what he described as a humanistic views.

Those pre-service mathematics teachers reported that in the initial phase of examining their selected topics, they expected that the minimalism exemplified by the realistic mathematics in the chosen topics would be unsuccessful in bringing forth a great deal of respect from their colleagues for the mathematical concepts in the activities related with various topics (Katsap & Silverman, 2008). Nevertheless, the class activities and dialogue showed that ethnomathematics approaches, indeed, stimulate inquisitiveness.

It is believed that the learning and teaching of mathematics is a process that takes place in schools settings, hence, mathematical knowledge, skills and concepts were learnt by those who went to school (Rosa & Orey, 2011). This concurs with Mutemeri & Mugweni (2005) who suggested that early childhood teachers in Zimbabwe in their study viewed academic mathematics as something that is detached from learners' cultural lives and were not aware of how to deal learners from various cultural backgrounds. On the contrary, the pre-service mathematics teachers in Katsap & Silverman's (2008) study stated that mathematics is all over and is a component of their culture. A research of learners' mathematical knowledge has revealed to scholars that mathematical knowledge is as well gained outside the mathematical learning environments, for instance, in learners' homes and other cultural environments (Rosa & Orey, 2010; 2011).

Orey (2000) pointed out that mathematical knowledge is as a result of social interactions, where important notions, proofs, theories, ideologies, and expertise are developed through cultural context. Therefore, Ethnomathematics compels teachers to be acquainted with the idea that mathematics exist in almost everything, not only in textbooks and schools (Rosa & Orey, 2011; 2016). According to Rosa & Orey (2016) it is important to carry out investigations which focus on the teaching and learning of geometry and how the process of teaching and learning is influenced by cultural aspects. Therefore, this study focuses the how the teachers were prepared to integrate ethnomathematics approaches into the teaching of geometry.

In Namibia, Kapenda, Kasanda, & Naweseb (2015) investigated teachers' understanding of the use of everyday contexts in the teaching of mathematics. The social constructivist theoretical framework underpinned their study. Data was collected using questionnaires and interviews. Inductive data analysis technique was employed to interpret the data collected. Data were coded and organised into categories and then the coded categories were combined in order to search for repeating ideas and larger themes relating the codes and the summary results were connected to the research questions.

The study revealed that teachers were of the view that learners would not learn mathematics if everyday context were incorporated in the teaching process. Teachers may not integrate this approach if they are not able to see how this would allow them to do well in improving learner performance. If the teachers are to integrate ethnomathematics approaches in their teaching, they have to believe that such approaches support the learning process. Mutemeri & Mugweni (2005) observed that, regardless of the fact that teachers agreed that learners bring mathematical experiences into the classroom and that teachers should build from their learners' experiences, the teachers did not see the mathematical knowledge learners have from their cultural experiences outside the school as useful or valid. They reported that the integration of cultural activities in the teaching process would slow down learners 'progress and concept development in mathematics.

Kanu's (2005) study used observations, journals and interviews to find out teachers' perceptions on integrating Aboriginal culture into the high school curriculum (all subjects). Whilst Kanu (2005) focused on all subjects offered in the school curriculum, the focus of the current study is on how in-service teachers are prepared to integrate ethnomathematics approaches in geometry teaching only. Kanu's (2005) study revealed that teachers were of the view that the integration was vital and they regarded integration as sometimes including Aboriginal viewpoints, where appropriate, to a Eurocentric curriculum.

In Namibia, Hara-#Gaes (2005) carried out a research on the mathematics entrenched in the cultural activities of Damara people. Data was gathered through questionnaires, observations and interviews. Findings of the study revealed that teachers were of the view that school mathematics expressed Western cultures, and that, incorporation of the learners' own cultural activities and objects into the teaching and learning processes of mathematics might be of great value towards developing learners' problem solving skills and positive attitudes in mathematics.

Teachers viewed use of learners' cultural experiences in the teaching of mathematics as a method that would reveal the relevance of mathematics to learners thereby improving their performance in mathematics (Makari, 2007). Teachers also pointed out that they make connections between the learners' cultural experiences and mathematics in the teaching process. Nonetheless, they claimed that some of the topics, such as geometry in the secondary school mathematics curriculum were rather complex and abstract, making them difficult to connect to learners' cultural backgrounds (Makari, 2007). The complex and abstract nature of geometry is rooted in the traditional view of mathematics that might perhaps lead to teacher centred approaches.

Mutemeri & Mugweni (2005) further observed, through lesson observations, that learner' out-of-school techniques of solving mathematical problems and even their out-of-school experiences were not included in the teaching and learning process. They reported that teachers believed that problem-solving in mathematics involved routine procedures and that the learners should be taught how to apply such procedures correctly rather than teaching them through everyday contexts which might impede the learning of those procedures. They further reported that teachers felt that they were supposed to teach formal methods without complicating them with learners' out-of-school experiences and informal problem-solving techniques. In support of that argument, Gainsburg (2008) points out that several teachers fear that confronting learners with the complicated activities from real world situations through ill-structured problems will contribute to misunderstandings, disorder and slow down the learning process. As a result, teachers apply everyday contexts primarily to teach procedures and not to develop higher-order or mathematical ways of thinking.

Nutti (2013) who carried out a research in Sweden reported that teachers viewed the teaching of mathematics based on culture as crucial. Teachers' motivation for culturally based teaching was stimulated by their belief that it was useful because as learners will be involved in culturally based activities they would sense that they were working with practical knowledge. As a result, the teachers were eager to adjust mathematics teaching to learners' everyday lives and for this reason they considered that mathematics teaching in perspective was indispensable (Nutti, 2013).

Findings from study by Velasquez (2014) showed that the participating teachers had a positive attitude toward culturally-based mathematics teaching. Teachers held the view that ethnomathematics approaches are useful in the teaching and learning process because of the link between the cultural experiences and mathematics, to the extent that they promised to share it with others and to carry on using these approaches themselves. However, it was noted that teachers' lack of knowledge and familiarity with these approaches hindered their efforts to make use of them in the classroom (Velasquez, 2014).

In California, Rosa (2013) carried out a study to find out teachers' views about the connection between mathematics and culture. The study used a mixed method design with questionnaires and semi-structured interviews. The study used concurrent data analysis in which qualitative and quantitative data were analysed concurrently and then merged. Inductive data analyses procedures were used for qualitative data from interviews and questionnaires. Descriptive data analysis was used for the quantitative data. The study showed that the teachers did not agree that mathematics is connected to culture. These teachers held the traditional view of mathematics, where mathematics has no link with culture, in other words mathematics is culture-free. However, the finding contradicts ethnomathematicians such as D'Ambrosio (2001) who points out the existence of the connection between mathematics and culture. Therefore, the views held by the teachers' regarding the nature of mathematics influence their teaching, understanding and how they implement different teaching approaches (Ernest, 1991) including the ethnomathematics approaches during the teaching and learning process.

2.10 Summary

The view in mathematics education that perceives mathematics as a cultural product, and proposes that its teaching should integrate ethnomathematics approaches is still being deliberated in the literature. The views held by the teachers regarding the nature of mathematics influences the way mathematics is taught in the classroom. The reviewed literature has revealed two opposing views regarding the nature of mathematics and how they influence the teaching and learning of mathematics in addition to the integration of ethnomathematics approaches in the classroom. The traditional views mathematical knowledge as objective, abstract, absolute and incorrigible body of knowledge which is culture and value-free. In contrast, the humanist views mathematics as connected to cultural activities is culture and value-laden. This study is located within the humanistic view of mathematics.

Discussions from the reviewed literature point out that research has been carried out in Ethnomathematics in learning teacher education institutions, involving pre-service teachers and in secondary schools with in-service mathematics teachers (Kang, 2004; Katsap & Silverman, 2008; Naweseb, 2012; Madusise, 2015; Cherinda 2012; Nutti, 2013; Rosa, 2013). These studies debated on issues connected to linking the teaching of mathematics to learners' prior knowledge and their cultural activities and the environment.

With regard to the integration of ethnomathematics approaches in the classroom, a number of challenges faced by teachers such as, insufficient resources, lack of training, the medium of instruction used in teaching of mathematics and the nature of mathematics (Ukpokodu, 2011; Mogari, 2014; Naresh, 2015). Nonetheless, studies that explored the in-service teachers' readiness to incorporate ethnomathematics approaches into the teaching and learning of geometry are limited.

Furthermore, there are numerous researches in areas of Ethnomathematics in Africa and even outside Africa (Gerdes, 1995; D'Ambrosio, 2001; Matang, 2009; Adam, 2004), but there are very few studies carried out in Zimbabwe. Few studies have been conducted on Ethnomathematics primarily because of the belief that mathematics is universal, a view which is being questioned by ethnomathematicians (Zhang & Zhang, 2010).

Against the above, additional researches are required to explore the in-service teachers' preparedness to integrate ethnomathematics approaches into the teaching of geometry in Zimbabwe. There is no research that centres on how in-service mathematics teachers are prepared to integrate ethnomathematics approaches in geometry teaching. Research is, therefore, required that deals with this problem. Despite this, the insight obtained from the reviewed literature helped in guiding the direction of this study. Theories that help in appreciating the social and humanistic nature of mathematics in the classroom are mandatory. Chapter 3 presents social constructivism being the theoretical framework employed in the current study.

CHAPTER 3: THEORETICAL FRAMEWORK

3.1 Introduction

The preceding chapter reviewed literature related to the in-service mathematics teachers' preparedness to integrate ethnomathematics approaches in geometry teaching. The current study attends to the following sub-research questions:

1. What instructional approaches have in-service teachers experienced during training and have used in their teaching and learning of geometry?
2. What are the in-service teachers' understandings of ethnomathematics approaches to geometry teaching and learning?
3. How are ethnomathematics approaches being integrated into the teaching and learning of geometry?
4. How does the integration of ethnomathematics approaches into the teaching and learning of geometry impact the teaching and learning of geometry?
5. What are the in-service teachers' views of ethnomathematics approaches?
6. What concerns do the in-service teachers have towards the integration of ethnomathematics approaches into the teaching and learning of geometry?

According to Jones (2001) studying geometry helps learners in developing skills of imagining, critical thinking, problem-solving, inferring, logical reasoning, valid argument and proof. Therefore, it fosters innovative and creative thought, which are essential requisite skills in a developing country such as Zimbabwe. For the learners to acquire such skills teachers have to implement teaching approaches such as ethnomatheamtics approaches, which according to Ferner (2013) are rooted in the social constructivist perspective and would enable learners to be innovative, autonomous and become critical thinkers. These approaches should empower the learners by making sure that there is appropriate gaining of geometry knowledge and skills, implying that teachers should desist from confronting learners with ready-made geometry subject matter, which ultimately turns out to be irrelevant and meaningless to their everyday essentials and challenges. Instead, teachers should resort to ethnomathematics aparoaches that put more emphasis on geometry processes by which content is developed or constructed. New geometry knowledge should be built on the geometry knowledge that the learners already have. This can be achieved if learners are involved in the process of developing geometry knowledge. The process of geometry knowledge development can either be done cooperatively by the teachers and learners where the teachers play the leading role of posing problems or learners working in groups to solve problems posed. Teachers should understand that the learning and teaching of geometry do have a social dimension.

Research on teachers' preparedness to incorporate ethnomathematics approaches into geometry teaching would inescapably bring to the surface teaching and learning theories. The theoretical facets on teaching and learning shapes the hub of the framework of this study. A social constructivist theoretical framework guided and shaped this study since it is apprehensive with what takes place in the classroom and the need to improve the geometry understanding and application. Nonetheless, before the discussion explores more into the ideas of social constructivism, it is necessary to deliberate on the philosophy of constructivism, in addition to, its fundamental ideologies.

3.2 Constructivism

According to Wilding-Martin (2009) constructivism is an ideology that focuses on matters that deal with the geneses and understanding of knowledge. From the original word, to "construct", constructivism is concerned with the formulation of knowledge by learners individually (Goldin, 1990). According to Makonye (2013) constructivism epistemology explains the nature of knowledge and how this knowledge is acquired during the teaching and learning process.

The procedures of knowledge formulation entails making sense from practices in terms of prevailing knowledge. Particularly, learners connect known patterns of geometry knowledge to new ones and this result in the creation of new geometry knowledge. Constructivism maintains the opinion that learners should be actively involved in knowledge construction using previous knowledge information or experiences. Constructivists believe in the learners' ability to construct knowledge through interaction with their surroundings (Schunk, 2014). This implies that constructivism has to do with creation of new ideas that emanates from the learners' experiences. Therefore, there is a need for teachers to search for tasks that would enable the learners to choose a variety of strategies to solve everyday problems with minimum supervision from teachers (Woolfolk, 2010). Genuine learning is attained from experiences that stimulate learner's inquisitiveness and give them the opportunity to work out their own answers. This implies that learners are guided by the teacher so that they acquire knowledge or skills without being told.

According to Loyens, Rikers, & Schmidt (2009) the idea of constructivism has four major features which are; knowledge construction, collaborative learning, meta-cognition in learning, and realistic learning activities. Firstly, learners are responsible for knowledge construction through the use prior knowledge using procedures of transforming, discovering, and testing information, and by revisiting procedures that might be irrelevant in their situations. Secondly, the construction of knowledge can be promoted when the learners interact with others, acknowledging the idea that social mediation and collaboration are essential in knowledge construction.

Thirdly, metacognition (knowing about our own thinking) plays a vital function in the teaching and learning process, whereby learners preferably gain new knowledge through self-regulated learning. Fourthly, realistic learning tasks, comprising of solving problems that are related to real life situations that the learners would come across in future and encourage meaningful learning.

Thus, the most important idea in constructivism is that learners actively construct knowledge in social settings using their past experiences rather than being passive recipients of information. The teachers' engagements of learners in utilising these characteristics in construction of knowledge would imply they are using constructivist principles. According to Tuckman & Monetti (2011) and Schunk (2014) constructivism constitutes several versions such as the exogenous, endogenous and dialectical. These are discussed in the next section.

3.2.1 Exogenous constructivism

Tuckman & Monetti (2011) defined exogenous as the acquired knowledge which reflects the reality of the external world through teaching and experiences. In this perspective, the external world influences the construction of knowledge. According to Applefield, Huber & Moallem (2001) the exogenous constructivism views knowledge as something that is recreated to exemplify an outside truth; hence, a learner's intellectual constructions grow to reflect the system of an unbiased world. An exogenous constructivist method of teaching and learning believe that the manner in which learners understand geometry concepts are correct depending on the degree to which it mirrors the reality (Schunk, 2014). It is believed that knowledge is gathered from external sources. According to Schunk (2014) the effect of the outside world on construction of knowledge may possibly be as a result of experience and training.

An exogenous constructivist method of teaching accepts the importance of direct instruction whilst supporting that learners must have a choice over the content and the sequencing of the content, in addition to being actively involved in knowledge construction. While using direct instruction, it is essential to encourage learners to use their knowledge in realistic environments. By placing emphasis on the learner's ability to construct knowledge, constructivists advocate for instructional approaches that enables the learners to improve their comprehension, retention and their knowledge construction (Schunk, 2014).

3.2.2 Endogenous constructivism

In the endogenous perspective, new knowledge develops out of earlier knowledge through the process of cognitive development of the structures into which knowledge is organised (Tuckman & Monetti, 2011). This was proposed by Piaget, who was of the idea that the construction of knowledge by learners is through cognition utilising processes such as assimilation, accommodation and equilibration (Woolfolk, 2010). Tuckman & Monetti (2011) defined assimilation as a process that is used in incorporating new knowledge in the existing schemata. The process of assimilation takes place when new knowledge is integrated into the prevailing knowledge structures without altering its basic system. This enables the learner to easily and clearly understand the information as it matches with the learner's current understanding and makes the task of understanding less difficult. The term schemata was used by Piaget to refer to knowledge constructions and methods of knowing, and understanding, the world. Accommodation is a process of learning that is used to alter an existing knowledge structures in order to enable the recognition of new knowledge that would be incomprehensible with features that already exist in the knowledge structures. The process of restructuring the existing knowledge structures when challenging information is received or when the added new information does not controvert with already existing information is called equilibration.

In geometry, for instance, a leaner could have the common information that a square is a quadrilateral with completely identical angles and sides. In the event that the learner comes across different shapes which have the same trait and definition yet unique dimensions, the learner would add it to the knowledge that is already existing as the definition would not have changed. This process is known as assimilation.

In the event that the same learner, comes across a quadrilateral with equal sides but different angle sizes through experience/experimentation, the learner becomes confused as this new shape does not have the characteristics of a square. This results in cognitive conflict. The learner would then modify the existing pattern of squares keeping in mind the end goal to enable the new knowledge to be included by making sub schemas in the schemas of shapes with equal dimensions. This is referred to as accommodation.

Through rearranging the existing knowledge structures once contrasting data comes in or even when new knowledge is added that does not negate with the knowledge that already exist, the learner attains equilibrium. In other words, a constructivist teaching and learning environment comprehends the assimilation of new information as well as accommodation of such information in existing schemas, in which the learners are actively involved in the assimilation of new information (Barrett & Long, 2012).

According to Tuncel (2009), Piaget proposed four stages of development through which off springs develop, which include the sensori-motor stage, the preoperational stage, the concrete stage and the formal operational stage. Whilst learners are developing from one stage to another, their thinking also develops and they become more organised. However, Piaget’s four stages of development may possibly imply that teachers would wait for all the learners to reach a particular developmental stage before introducing specific geometrical concepts. This means that teachers should assist learners in the classroom through a proper selection of geometry content that fit within their cognitive levels of development.

On the other hand, in the classroom the actual practice is that the teachers introduce the same geometrical concepts to learners from different developmental stages. Teachers who embrace Piaget's views might spend more time dealing with each individual learner as he\she constructs his/her own geometrical knowledge. This kind of situation poses difficulties for the teacher. The implementation of Piaget's views entirely is challenging when teaching geometry since geometry learning is by nature social and cultural, and the learners bring to class different cultural and environmental backgrounds as well as their prior knowledge. Therefore, teachers need to revise their application of Piaget's views so that they accommodate learners' prior knowledge or experiences in teaching geometry. Piaget's constructivist view is based on an individual perspective, which is influenced by the effect of the learner's physical and social environment on his/her internal cognitive processes (Fetherston, 2006). Piaget's views were useful in defining the constructivist view of teaching and learning which outline the point of view that transpire behind reasoning, processing, and comprehension (Thompson, 2013).

3.2.3 Dialectical constructivism

In the dialectical perspective knowledge comes from the interactions between learners and the environment, as well as with peers and with teachers (Tuckman & Monetti, 2011). According to Applefield et al., (2001) dialectical constructivism views knowledge construction as the social intersection of people, associations that incorporate sharing, looking at and discourse among the learners and the teachers. In a dialectical constructivism class learners are capable of establishing their meanings, whilst assisting others to find meaning. As a result, knowledge is jointly created. This notion has its roots in Vygotsky' social constructivism theory, which focuses on the idea that social interaction facilitates learning, that is, learners work together to construct knowledge. This basic idea can be used by teachers to help learners construct meaningful understanding of geometrical concepts.

Two levels of development were considered by Vygotsky's social constructivist theory. The first of which is referred to as the *actual level of development* (Woolfolk, 2010; Tuncel, 2009). In this level, the learner is able to execute and display geometry knowledge without being assisted by the teacher or peers (Woolfolk, 2010; Tuncel, 2009). Vygotsky's second level of development is identified as the *Zone of Proximal Development* (ZPD), which is the difference between what the learners can do without anyone else's input and what they can do with the support from the more knowledgeable peers or teachers through interaction. The learner is helped through a process of *scaffolding*. Although teachers could help learners acquire knowledge in a number of ways, scaffolding applies only when assistance is applied in the learners' ZPD. The teachers' part in this point of view is to recognise every learner's ZPD and to offer in every lesson the level of motivation expected to progress through the zone and subsequently augment the rate of learning. The help offered in that zone should match the learner's prior knowledge (Tuncel, 2009; Woolfolk, 2010) and facilitate the learner's development to the new acquired knowledge and skills. This implies that proper interaction among the learner and the teacher could facilitate problem solving abilities and an understanding of geometrical concepts. The role of social interaction in the knowledge construction is vital in the teaching and learning of geometry using ethnomathematics approaches as this leads to the importance of incorporating cooperative and collaborative instructional approaches.

The above perspectives share the common view that geometry knowledge must be constructed by the learners for it to be meaningful to them, which could be achieved through active involvement of the learners. An elemental principle of constructivism is that learning and thinking take place in a context or an environment, not in vacuity (Schunk, 2014; Tuckman & Monetti, 2011). Meaningful learning of geometry takes place when the learners' cultural experiences and their environments are taken into consideration. Therefore, constructivism guides teaching and learning processes of geometry in the classroom. Although, there are numerous views about constructivism, the current study on in-service mathematics teachers' preparedness to integrate ethnomathematics approaches into the teaching of geometry is primarily contained within the social constructivism theoretical framework.

3.3 Social constructivism

Mathematical knowledge, including geometry, has been for a long time viewed as an infallible body of knowledge (Ernest, 1991; Gerdes, 1995; D'Ambrosio, 1991). Nevertheless, social constructivists challenge the traditional view of mathematics which claim that mathematical knowledge is infallible. Ernest's (2009) two classifications of the nature of mathematics change from a traditional, inflexible, static view of mathematics to a humanistic, social constructivist, social, reform-based perspective mathematics. Such views of the nature of mathematics in Ernest's (2009) categories impacts the instructing and learning of the geometry.

The traditionalist view mathematics as a set of a supreme facts, which emphasises hard work, memorisation, drill and practice, and the lack of learners' cultural and prior knowledge in the classroom (Ernest, 2009). In contrast, social constructivism involves an active teaching and learning process, not simply the memorisation of proofs and the practicing of processes, but the active participation of the learner in geometry activities. On the other hand, humanistic and social constructivist view mathematics as a cultural and societal product, accepts the humanistic nature of mathematics, and believes in the recreation of mathematics knowledge in each learner's mind that is relevant and worthwhile to him /herself.

As indicated by Ernest (1999) social constructivism is a theory of mathematics that perceives mathematics as a cultural creation. Scholars have come to acknowledge that mathematics is a social product which is culturally embedded and culture-bound (Ernest, 1991). Similarly, Vygotsky (1978) cited in Woolfolk, 2010) referred to social constructivism as a movement where construction of knowledge is done by learners using their past information in addition to their cultural and background knowledge.

The prevailing view is that learners do not exist in solitude, but they exist and learn in cultural environments where learning is shared and understanding is created with others (Woolfolk, 2010). Each learner's existing information is a potential springboard to move to higher levels of learning (Vygotsky, 1978). Vygotsky's (1978) work acknowledges the importance of social collaboration throughout the academic learning process. According to Vygotsky (1978) knowledge is actively created in social environments and that the development of such knowledge is cultural. The most important idea governing Vygotsky's (1978) social constructivist theory is the concept that learners acquire geometry knowledge from the individuals who have more understanding and information especially teachers through interaction in an environment that is culturally-based.

Social constructivism refer to learning as a human item that is culturally and socially built (Ernest, 1991). Additionally, scholars who advocates for social constructivism believe that culture and environment are essential components in understanding and accepting what happens in the society, and knowledge construction must be founded on this understanding (Kim, 2001).

Culture finds itself in the philosophical discussion about mathematics due to the prevailing stance that mathematics must be viewed as a human product (Ernest, 1998; Bishop, 1991). In particular, the humanists and social constructivists consider mathematics to be a cultural product and they also accept that knowledge is a human invention, which is culturally and socially created.

In addition, social constructivists believe that the teaching and learning procedures are cultural processes, and that the learner's participation in cultural activities results in meaningful geometry learning (Kim, 2001). Vygotsky (1986) acknowledged that culture provides learners with the cognitive tools that are required for development. This implies that it is through culture that learners construct, exemplify, nature, and understand their own realities (Schunk, 2014). From the social constructivists' point of view it is not possible to separate the learner from the societal influences because the sociocultural environments in which educating and learning take place are crucial to the learning procedure itself, since learning is regarded as socially and contextually specific.

Vygotsky (1978) is of the idea that the use of cultural tools, norms, experiences and values is an important element in the teaching and learning process of geometry. According to Vygotsky (1978) learning occurs in cultural and historical contexts. For instance, the social background, culture and history of the learners should be taken into account when planning for classroom instruction, since these would impact on how learners acquire geometrical knowledge. In other words, the essentials of culture and history have a great impact on the teaching and learning process of geometry.

Social constructivism put accentuation on the social idea of learning as it is believed that the information is built through the procedure of social connection and the utilisation of language. The social constructivist believes that learning occurs as a result of social communication that is facilitated by dialect that happens in a particular context (Doolittle, 1999). According to Barton (1996) a number of ethnomathematicians researchers use language as a pivotal aspect of culture and an essential element of the teaching and learning process. Ernest (1991) is of the view that mathematical learning is grounded on etymological information, conventions and rules, and that dialect itself is a cultural product. The language of instruction is also a factor that affects the teaching and learning of mathematics including geometry in African schools (Shizha, 2007).

From Vygotsky's (1978) social constructivism, language is important in the early stages of learning and this is attained through interaction and cultural heritage. The dialect of the social setting and cultural communications help in the academic development procedure. Dialect is regarded to be essential in the social procedure of meaning making and social associations are situated in shared and helpful educating and learning conditions that support scaffolding and basic reasoning among the learners (Gordon, 2009). Such learning conditions are relevant for both ethnomathematics approaches and social constructivism. The Zimbabwean mathematics curriculum encourages the integration of learners' ethnomathematical language and knowledge into the teaching and learning of mathematics (ZIMSEC, 2015). Hence, this study explores in-service mathematics teachers' preparedness to integrate ethnomathematics approaches into the teaching of geometry.

Furthermore, ethnomathematics approaches are founded on the notion that the teaching and learning of geometry is relevant and meaningful if it is linked to familiar mathematical activities that originate from the learner's cultural background, experiences, activities as well as the environment (Matang, 2009). This as well supports the opinion that teaching using a language that learners are familiar with might result in meaningful learning since knowledge is rooted in their languages (Paraide, 2015). Teaching geometry in a language that learners know best is in support of both ethnomathematics approaches and social constructivism views which counters the view that mathematics is culture- and value-free (Bishop, 2004).

Vygotsky's (1978) idea that knowledge is socially constructed in social situation have implications to the teaching and learning process of geometry. This implies that the teaching and learning of geometry concepts should be contextualised and is influenced by the interaction of learners with their environment (Banks, 2008; Kincheloe, 2008). Learning is seen as a related procedure in which the learner can effectively make individual meaning of the information acquired through social experiences (NCTM, 2000; Vygotsky, 1978).

In a social constructivist classroom, the role of the teacher is to guide, facilitate, coach, provoke, and co-explore in manners that enable the learners to take part in basic and imaginative reasoning, examination and union of thoughts amid the teaching and learning process of geometry (Tuckman and Monetti, 2011). The teacher undertakes the role co-learner who urges learners to address, challenge, and outline own views, conclusions, carry out projects, make their own comparisons, and make valid conclusions (Sunderman, 2006). In addition, the teacher's role is to assume the role of an expert learner who guide the learners into accepting intellectual strategies, for example, self-testing, articulating understanding, making inquiries, and reflection (Sunderman, 2006). The teacher needs to organise information about activities that are interesting to the learners, to help them in developing new intuitions, and to relate these with the learners' prior knowledge.

Furthermore, teachers need to assess and make constructive use of the learners' prior knowledge and also to organise and structure discussions between learners. Social constructivism instruction focusses on active learning that results in higher learner activity as compared to the presentation of material in the teacher-centred classroom (Alessi & Trollip, 2001). Social constructivist ideologies deject teaching practices that just transfers information, passively to the learners and supports the use of resources that encourage the active participation of learners through hands on activities and social interaction (Alessi & Trollip, 2001; Schunk, 2014).

From the social constructivist perspective, active learning includes investigation, experimentation, making inquiries and looking for answers. The teacher is responsible for facilitating and presenting the learners with a chance to actively construct knowledge. The role of teacher is not that of dispensing information but to be an umpire, who works with the learner in order to construct geometrical knowledge using the approaches that are activity-based, through cooperation and scaffolding within the ZPD.

The teacher, therefore, has the responsibility of bringing into the classroom geometry situations, activities and problems that encourages communication, flexibility, imagination and problem solving skills (Alessi & Trollip, 2001; Matang, 2002; Schunk, 2014). It is through these processes that geometry concepts are learnt in the classroom. In other words, learning occurs when the learners create knowledge through active participation in all leaning activities. Learners are motivated and guided to construct meaning through the use of techniques that include, for instance, exploration and inquiry based problems, where they generate multiple methods of solving geometrical problems in groups (Schunk, 2014).

Various school reflect diverse and multicultural societies that they serve (Rosa & Orey, 2013), the Zimbabwean schools are not an exception. A geometry classroom is indeed a component of the environment, and learners should be urged to solve real-life geometry problems using several approaches to enable them to comprehend the geometry concepts (Rosa & Orey, 2013).

In such an environment, teachers need to learn to value the different ways of learning and thinking, adjust the teaching approaches, and plan accordingly. Hence, there is no need for the teachers to concentrate on the aptness of the final answer, but on the procedure used by the learners (Hensberry & Jacobbe, 2012), and this is due to the fact that the solution to a problem involves a chain of steps that each learner builds on as he/she settle on a different method when working out the problem. If teachers do not concentrate on the aptness of the answer then they tend to embrace Ernest's (2009) humanistic or social constructivist views of mathematics.

According to Vygotsky (1978), learners become autonomous with geometrical skills after they have been directed, taught and guided by the teacher. The ZPD put emphasis on the need to have teachers in the learning process, particularly when introducing new geometrical concepts to the learners. The teachers' role is to help the learners to progress to their individual zone of learning as they are challenged by a more knowledgeable personnel so that they enhance their understanding of geometrical concepts. Vygotsky's (1978) ZPD of social constructivism maintains the essential view that learners require social interaction, scaffolding instruction, and a chance to mingle with more knowledgeable learners or peers. Crook (1994) identifies two educational implications that are dealt with in the ZPD. Firstly, the ZPD deals with an assessment of the learner's level of understanding in a specific area. Secondly, it provides solutions to questions such as, what happens throughout the process of teaching and learning. These two educational issues emanating from the ZPD could inform teachers' teaching of geometry.

Despite the fact that previous knowledge and realistic resources are crucial in social constructivism, the role of the teacher of assisting learners in solving geometry problems is also crucial. This implies that even though social constructivism enables the learners to construct knowledge through their own understanding and experiences, learning is as well exceedingly reliant on the teachers' capability to scaffold learners during the knowledge construction process. According to Alessi & Trollip (2001), this is different from pure discovery environments, because it is a requirement for the teachers to guide and become partners in the teaching and learning process. Hence, it is worth to explore how the teachers were prepared to integrate ethnomathematics approaches into the teaching geometry.

According to Fetherston (2006) the social constructivist view has several implications to teaching and learning of geometry including the designing of the learning environments. Social constructivists value the educational context and the conditions of learning mathematics as intrinsic to the teaching and learning process. From the social constructivist view, a learning environment is seen as "construction of the individuals in a given social setting; an individual's socially mediated beliefs about the opportunities to learn and the extent to which the social and physical milieu constrains learning" (Lorschback & Jinks, 1999, p. 158). Although learning can be regarded as personal, each learner's intellectual constructions are influenced by the activities of others in the cultural settings and the features of the culture in which learning occurs. Social constructivists maintain that learning activities must be rooted in problems solving situations that are meaningful and appropriate to learners (Fetherston, 2006). In addition, it is important to plan for conducive learning environments that would allow learners to construct knowledge.

Social constructivist learning environment, put more emphasis on learners' construction of knowledge. Teachers embracing the constructivist principles create learning environment where learners have sufficient chances for the social negotiation of their understandings. Teachers are required to plan for tasks and activities that are epitomised by active engagement, authentic learning, situated learning, experience based, inquiry-based, problem-based learning and research projects, in which learners create and test their notions, make deductions and conclusions with others in shared learning environments (Sunderman, 2006). In this view, social, historical and cultural contexts are crucial to the learner-centred teaching and learning processes of geometry. It is in this sense that social constructivism is amenable to ethnomathematics approaches through using learner-centred activities in contextualised problems and situations (Ferner, 2013).

In addition, social constructivists encourage designing of learning environments that are cooperative (Alcantara, Hayes & Yorks, 2009). Cooperative learning enables the learners to work together, sharing different ways of thinking and perfect the way in which one clarifies ideas. Cooperative learning increases learner involvement and socialization skills. Cooperative learning is a social procedure that comprises of group establishment, sense-making and making of decisions (Alcantara et al., 2009).This implies that, all teaching and learning activities are collaborative.

Even though social constructivists encourages construction of knowledge in collaborative settings, this can only become meaningful if the cooperative learning activities allows learners to incorporate their developed ideas, notions, and principles into real-life situation (Alcantara et al., 2009). When working in groups to solve geometrical problems, learners are symbiotic and are motivated to solve the problems. The more able learners have the chance to support others and, if duties are assigned, all the learners participate actively. By making use of the social constructivism, teachers might scaffold instruction and learning to encourage group processes that augment and enhance learners' cognitive development. Through working and communicating together in groups quite a number of meaningful geometrical connections could be made so that learners would be able to make useful connections and constructions during their process of learning geometry.

Furthermore, in designing learning environments that fit into the social constructivist views, teachers are anticipated to prepare lessons by choosing suitable teaching materials and approaches, in addition to, practical assessments that would encourage learners' construction of knowledge. With the intention of improving geometry learning environments, scholars suggested the use of a diversity of teaching approaches that would result in effective teaching and learning (Golashani, 2013). Active teaching comprises teaching geometry for understanding, improving geometry concepts and the use of better methods such as ethnomathematics approaches to teach geometry (Friesen, 2005). This suggests that teachers should be facilitators of geometrical knowledge construction for the learners instead of transmitting knowledge to them (Golashani, 2013). For example, teachers' use of multiple teaching approaches including ethnomathematics approaches could benefit the learners, as every classroom comprises of learners with diverse levels of ability to comprehend geometry concepts (Golashani, 2013). To accomplish this, teachers need to have the knowledge and skills for actual execution of ethnomathematics approaches that encourages construction of knowledge by learners in conducive learning environments. Hence, it is worth to explore teachers' preparedness to integrate ethnomathematics approaches in teaching geometry.

Social constructivism and its associated instructional strategies for teaching and learning reviewed in this section have implications for the current study. Social constructivism underscore the significance of understanding the social and cultural contexts of teaching and learning geometry in the classroom. The in-service teachers' preparedness to integrate ethnomathematics approaches in geometry teaching being explored in this study incorporates many of the ideas derived from social constructivism.

Viewing teaching of geometry through the social constructivist lens, enables teachers to utilise learners' previous knowledge, everyday activities and their cultural environments to develop their understanding of geometry. Social constructivists and ethnomathematics approaches share common views regarding the teaching of geometry as they both believe that learners effectively take part in the construction of geometry knowledge in their sociocultural setting (Cobb, 1994; Eglash, 1997). The social constructivist ideas integrated in the current study include:

- Teachers use a variety of resources from the environment, cultural and everyday knowledge in geometry teaching that enable learners to solve real life geometry problems.
- Teachers utilise the learners' background and prior knowledge in geometry teaching.
- Creating authentic, collaborative and scaffolding learning environments in which learners are supported by the teacher and more knowledgeable peer in meaningful and interesting geometrical activities.

- It is essential for teachers to do extremely well in facilitating, guiding and in creating learning environments in which learners are motivated to construct geometry knowledge.

The construction of new knowledge entails active and basic reasoning abilities on the part of the learner as new information is merged with prior knowledge. The deepness and number of links made impacts on the extent of acquiring new learning. Acknowledging the role played by prior experiences in learning new geometry concepts might lead teachers who embrace social constructivist views of teaching not to simply question whether a learner understands a concept, but how he/she understands it and what ideas to which the learner is connecting it (Van de Walle, 2007). The purpose of the social constructivist classroom is to encourage interactions of learners' previous and new knowledge and understanding that would lead to new knowledge being applied to both school activities and out-of-school activities as well. The transmission of geometrical knowledge is an important component in social constructivism. The acquisition and use of geometry knowledge are not isolated from social activities and are often elicited as a result of being involved in a particular situation.

The social constructivists focus on using learners' interests and prior experiences as a spring board for acquiring new knowledge, as well as encouraging discussion about understandings, questions, and experiences (Alessi & Trollip, 2001). Social constructivist ideas in teaching geometry results in effective teaching that rely on how familiar the geometry concepts are to the learners and how these concepts are taught shapes the manner in which the material is understood (Schunk, 2014). It is these understandings on social constructivism that point to the relevancy of exploring teachers' preparedness to integrate ethnomathematics approaches in teaching geometry. The approaches allow the teacher to discover learners' experiences and encourage learners' involvement with geometry learning by actively linking school geometry to out-of-school life and out-of-school life to school geometry. The social constructivists believe that geometrical knowledge is produced socially and culturally by learners with the help of teachers and it requires an effective informative procedure, not just the remembrance of facts, and rehearsing of methodology, but through the commitment and engagement of the learners in learning geometry. Following the ideas of social constructivism, ethnomathematics approaches places geometrical teaching and learning in a setting in which knowledge is actively produced in meaningful interactions.

3.4 Social constructivism and the present study

Inclusion and emphasis of the learners' cultural context and experiences that are in line with ethnomathematics approaches makes social constructivism appropriate as a theoretical framework in terms of this specific study. The social constructivist view of teaching requires another perspective of mathematics, the humanistic view that centers on the context and understanding of mathematics for the learner and on critical thinking aptitudes (Lerman, 1990). Thus, effective teaching and learning of geometry has shifted from the traditional comprehension of geometry as isolated facts and rules to inserting geometry in situations and move towards a learning approach that integrates effectively the construction of knowledge among a network of learners. It encourages the contextualisation of geometry in the classroom, acknowledges that the teaching and learning of geometry requires various learning modes such as visual and verbal, in addition to, integrating cultural experiences into the teaching of geometry (Schunk, 2014). Along these lines, there is a growing comprehension in mathematics education literature of the need to take into consideration cultural and social background of the learners in planning for the teaching of mathematics.

3.4.1 The humanistic nature of mathematics and social constructivism

The view that mathematics is a cultural product is associated with several fundamental developments in the history, philosophy and social investigations of mathematics, particularly, the humanistic view of the mathematics (Ernest, 1999 cited in Prediger 2004). According to Hersh's (1999) humanistic view of mathematics, mathematical knowledge is fallible and mathematics is human. The prevalent view is that mathematics is a component of and fits well into the social culture and it has been developed through empirical evidence and numerical experimentation.

According to Ernest (1991) the social constructivists' derive from the quasi-empiricism their fallibilist epistemology which take account of the view that mathematical knowledge and its concepts develop and change. Mathematics as a body of knowledge is not static, neither is it a fixed body of knowledge, but, rather it is dynamic and is subject to change (Ernest, 1994). Ernest (1994) and Makonye (2013) reported that social constructivism originated from the fallibilist epistemology, which views knowledge as lived and constructed socially and they advocate for learners' own construction of mathematics knowledge. According to Ernest (1994) the social constructivist point of view in mathematics considers it as a corrigible, and altering cultural construct, that is, as a social product that is fallible like any other form of knowledge.

Thus, the entire mathematical knowledge is a product of human construction. Fallibilism considers the socio-cultural and historical development of geometry as vital in elucidating the nature of mathematics and divulges geometry as human, historical, and corrigible. Corrigible in this context, refers to the fallibilist views that geometrical knowledge could be revised, improved and even corrected. Social constructivist believes that mathematics is as a result of human creation, made by human beings to solve the real-world and theoretical problems they come across in day-to-day living (Makonye, 2013).

In the same way, humanists view mathematics as fallible (Ernest, 2009). As a result, mathematics is viewed as a human invention rather than a discovery, therefore, it is fallible, corrigible, and eternally open to revision and corrections (Ernest, 1991). This implies that the humanistic view mathematics as corrigible, revisable, changing, with new inventions in mathematics made by human beings. Social constructivism is related with the humanistic perspectives of mathematics, in which mathematics is viewed as a cultural product which is value laden, socially determined, and open to correction (Ernest, 1991, 1994, 2009; Makonye, 2013). One vital ramifications of the humanistic position of mathematics is that if mathematics is a human product then this must also apply to the teaching process. The humanists are of the view that geometrical knowledge is not gained through rote memorisation from the expert. Instead, they regard it as societal knowledge that must be interpreted meaningfully to the learner through authentic problem solving activities. Therefore, the humanistic view to mathematics aligns itself well with the instructional method consistent with social constructivist theories that advocate for problem-based learning, genuine application, cooperative learning, and an accentuation on process rather than product (Threlfall, 1996 cited in White-Fredette, 2010). Social constructivism is related with the humanistic perspectives of mathematics, in which mathematics is viewed as a social product which is esteem loaded, socially decided, and open to correction (Ernest, 1991, 1994, 2009; Makonye, 2013).

Similarly, Ferner (2013) reported that the humanistic view to mathematics is more often than not attached to the social constructivist teaching approaches. In addition, the humanistic viewpoint of the nature of mathematics and social constructivists' practices were found to be analogues. According to Aikenhead (2006), the humanistic and social constructivist accentuates on enculturation of newly taught geometrical concepts into the learners' cultural experiences and their local context. A humanistic view to mathematics opens the door to ethnomathematics approaches since it perceives mathematics as rooted in real life application (Ernest, 2009).

Pedagogically, teachers who hold a humanistic view of the nature of mathematics usually follow social constructivist instructional strategies (Chan, 2011). The teacher would use geometry activities that were designed to put learners in situations that would help them to construct geometrical concepts that may be new to them, in addition to, hearten reasoning and creativity. Teachers who held a humanistic view of mathematics as culture- and context-dependent, focus on solving relevant situational problems that encourages diverse thinking, diverse solutions, and collaborative learning are more likely to plan for the teaching of geometry from a social constructivist view.

These teachers may perhaps allow learners to be autonomous and may possibly treat mistakes as learning opportunities for individual learners and the class as a whole. If teachers concentrate on learners' cultural and their distinct social knowledge, they are likely not to become a "sage on the stage" and perhaps become more of facilitators of learning (Chan, 2011). Be that as it may, despite the fact that there are various calls to change and adjust instructional methods in line with the constructivist epistemology, little has been done to find out how the teachers are prepared to integrate ethnomathematics approaches into the teaching of geometry.

3.4.2 Ethnomathematics and social constructivism

Ethnomathematics and its approaches are situated in the conception of culture (Mogari, 2014). Its epistemology, according to Lakatos (1978 cited in Makonye, 2013), is based on fallibilist quasi-empiricism that considers the empirical and historical aspects of mathematics within the development of mathematical knowledge. The empirical and fallible nature of mathematical knowledge made it possible for the differences in mathematical cognition, which are visible in different cultures to be included in the mathematics curriculum (Barton, 1998). Fallibilists' ideas of mathematics include enthomathematics and are even more influential in the teaching and learning process (Boaler, 2003 cited in Makonye, 2013). They take into account the historical and cultural uniqueness of learners, which imply that learners' diversities are essential and could be incorporated in the classroom (Makonye, 2013). In addition, fallibilists acknowledge that not only is academic mathematics utilised in a variety of applied practices, but also that both Ethnomathematics and school mathematics have been appropriated and recontextualised in academic mathematical practices (Greer, Mukhopadhyay, Powell & Nelson-Barber, 2009).

Ethnomathematics and social constructivism contradict the view that mathematics is value-free and culture free (Bishop, 2004). Ethnomathematics approaches integrates philosophies of social constructivism in the teaching and learning process that uses learners' prior knowledge, experiences, activities and interests to make links between academic concepts and their application in life. The social constructivist aspect of Ethnomathematics is based on the connections between previous knowledge and collaborative learning environments. Social constructivism emphasises that meanings and understandings grow out of social interactions. Ethnomathematics and the social constructivist point of view are associated to a certain extent in the sense that they both can be construed as procedures of enculturation since their founders assume that the whole lot of what should be learnt or taught is found in both the learners and teachers' cultural environment. Woolfolk (2010) contends that what is learnt is particular to the settings in which it is learned.

Ethnomathematics approaches and social constructivism share similar views on two major enlightening assumptions that influences how mathematics is taught in schools (Matang, 2009). Firstly, learners socially construct knowledge through their social interactions with the immediate environment and, secondly, learning occurs through realistic and contextualised activities that provides the appropriate contextual meaning to what is being learnt or taught in the classroom. This has some implications to geometry teaching in the sense that teachers should connect their teaching to the learners' experiences and environments and this view is supported by both ethnomathematicians and social constructivists. These implications may have beneficial effects, if suitable instructional approaches are utilised in tapping into the ethnomathematical knowledge that might be used as starting point in the teaching and learning of geometry/mathematics (Matang, 2009). However, it is important to find out how prepared the teachers are to integrate ethnomathematics approaches into the teaching and learning of geometry.According to Ernest

(1991) social constructivist teaching is rooted in the humanistic paradigm. It perceives teaching as actively engaging learners with mathematics, posing and resolving problems, deliberating on the mathematics rooted in learners' lives and background (Ethnomathematics) in addition to broader cultural contexts (Ernest, 1991). It promotes a pedagogy which relies on the knowledge that the learner brings into the classroom from his/her daily experiences. The pedagogy through which Ethnomathematics finds its way into the classroom is rooted in social constructivism, which advocates for learner-centred approaches based on negotiation, mediation and scaffolding and that promotes active learning (Ferner, 2013; Mogari, 2014).

Ethnomathematical approaches to the school mathematics curriculum and social constructivist approaches are expected to make academic geometry relevant and significant to learners. Such approaches should improve the quality of mathematics education on the whole and geometry in particular. Furthermore, ethnomathematics approaches incorporate philosophies of social constructivism that make use of the learners' experiences and interests in developing links between school geometry concepts and real world applications. The social constructivist facet of Ethnomathematics is based on the associations between prior knowledge and collaborative learning environments as well as placing emphasis on situated and contextualised teaching.

The major problem of both social constructivism and ethnomathematics approaches is on the designing of learning environments. These learning situations are the settings in which information building instruments and the way to make and manipulate artefacts of comprehension are given through which learners cooperate and encourage each other as they make use of different tools and learning resources in their quest for geometry learning objectives and problem-solving exercises. Essential characteristics of such settings consist of both high anticipations and an exposure to materials, resources, and methods that are culturally significant to the learners (Orey & Rosa, 2016).

The greatest common concern of the mathematics teachers is how ethnomathematics approaches could be integrated into the existing mathematics syllabus in the school (Ness & Lin, 2015). Kitchen and Becker (1998 cited in Ness & Lin, 2015) point out that this issue is rarely addressed adequately. One of the most vital themes connecting Ethnomathematics and school geometry involves the teachers' skills to help learners to be aware of how school geometry could be linked to their everyday geometrical activities (Ness & Lin, 2015). To do this, teachers need to accept the social constructivist point of view that every day or informal geometry exist.

In accepting this view the teacher has the role of identifying each learner's every day geometry. After identifying the learners' everyday geometry, the teacher must find techniques of fostering conducive learning environment in which learners would connect their everyday geometry to school geometry. Thus, an ethnomathematics approach to geometry teaching is a pedagogical tool for attaining such an objective. In this study, teachers' preparedness to integrate ethnomathematics approaches in teaching geometry is explored through the lens of social constructivism.

Ethnomathematics approaches fits well within the social constructivist theory, where learners construct and understand knowledge using what they have previously learned and been exposed to earlier or before (Brandt & Chernoff, 2015). Ethnomathematics approaches subscribe to the social constructivist view that emphasises situated and contextualised teaching and learning process. In a geometry classroom guided by social constructivism, learners are encouraged to solve problems that resemble those in the real life situations. Instead of solving geometry problems that are out of context learners are challenged with contextualised problems that enables them to link previous geometrical knowledge with new knowledge and transfer the new knowledge and understandings to real life situations.

Ethnomathematics approaches are grounded in the social situation of the learner, therefore, it is based on the life experience of the learner and relies on the theory of social constructivism (Ferner, 2013; Mogari, 2014). Ethnomathematics emphasises and analyses the effects of cultural aspects in the teaching, learning, and construction of mathematical knowledge. Ethnomathematics approaches are capable of developing learners' capacity of working in groups, allocating tasks, be able to accept both criticism and conflicting views, valuing the verdicts of group members and facilitate learners' interactions that help in understanding mathematical content (D'Ambrosio, 1993; Gerdes, 1988; Zaslavsky, 1998). Ethnomathematics approaches encourage cooperative socialization among the learners, taking into consideration their collective educational goals, at the same time valuing cooperation. This approach to mathematics teaching is in the dominion of

Vygotsky’s (1978) social constructivism. Teachers who embrace ethnomathematics approaches aim at developing learning activities that are linked to the learners’ daily lives.

Vygotsky’s (1978) social constructivist theory is connected to the ethnomathematics approaches, which put more emphasis on the role of culture and the environment in geometry teaching, in addition to the significance of the learners’ interaction with social beliefs and features in order to obtain geometry knowledge.

3.4.3 Linking humanistic view of mathematics, Ethnomathematics and social constructivism

From the reviewed literature, humanistic view of mathematics, Ethnomathematics and social constructivism are connected as illustrated in Figure 3.1.

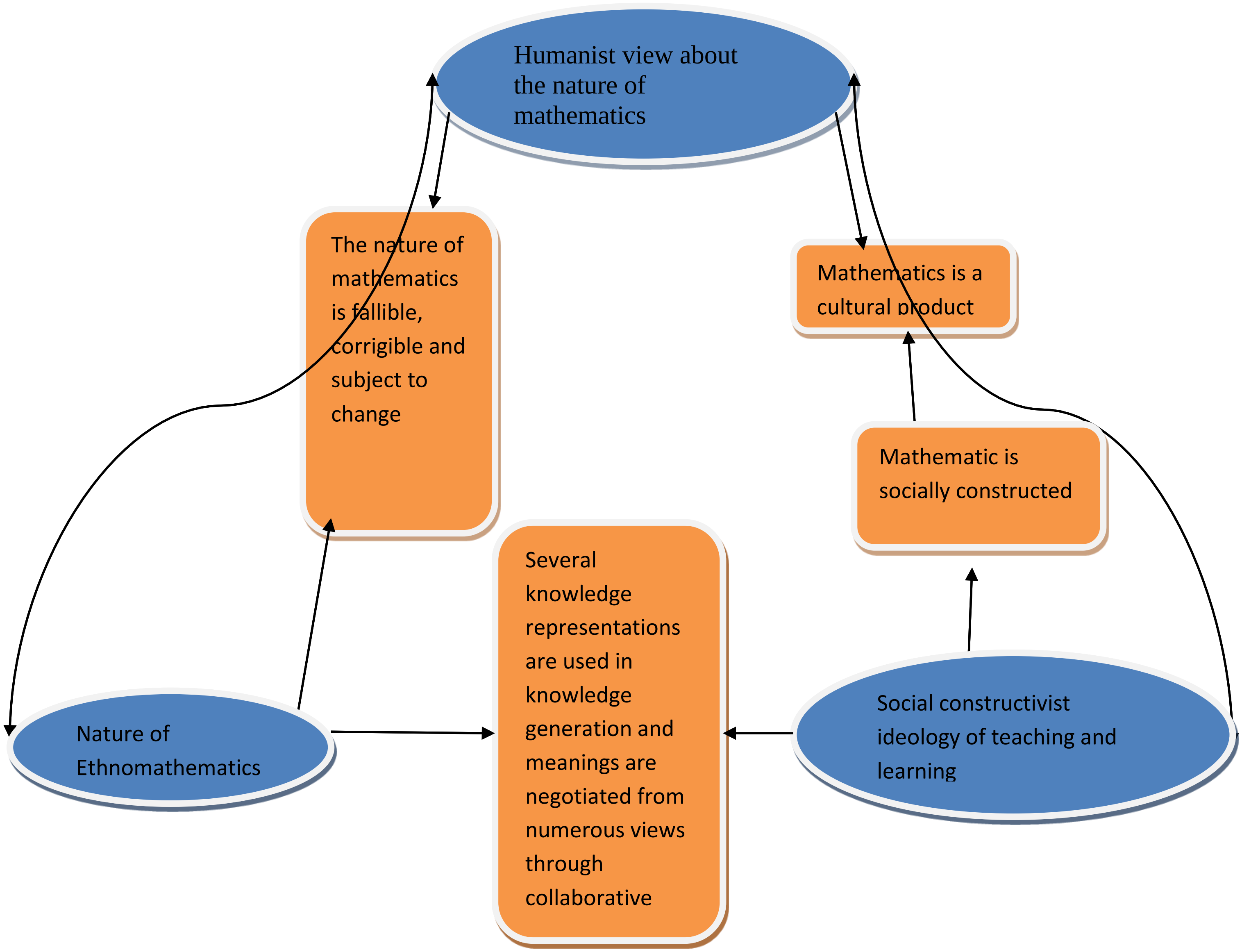


Figure 3.1: Linking humanist view of mathematics, Ethnomathematics and social constructivism

There are three interlinking aspects within this study:

- Humanist view about the nature of mathematics.
- Nature of Ethnomathematics.
- Social constructivism ideology about teaching and learning.

These three aspects share proverbial views about the nature and the methods of teaching mathematics. For instance, there is a consensus on the nature of mathematics, for example, that mathematics is fallible and is a product of human construction. Similarly, there seems to be a consensus on the teaching approaches that must be used in teaching mathematics, such as active learning, construction of knowledge (rather than passively absorbed) and effectual learning that involves analytical; open-ended, tricky authentic problems for the learners to solve. The most important change for teachers is to develop more open-ended tasks to make sure that learners are capable of reasoning critically, of solving complex problems, and of applying their geometrical knowledge in real-world situations. These suggests a learner-centred instruction that has implications on the cognitive, motivational and affective factors essential to the learner's personalities in the classroom.

In addition, learners could generate multiple solutions to the problem as they work together in groups. Teacher-learner and learner-learner collaborations are at the heart of these three aspects. Vygotsky's (1978) social constructivism put forward that learning takes place when learners interact among themselves when dealing with geometrical activities. Social constructivism put more emphasis on the role more knowledgeable learners play when guiding the learning process of their peers by interacting with them in their zone of proximal development (Pritchard & Woollard, 2010). The interactive learning through collaboration benefits both the learners that are receiving support and those providing the support. Learning takes place as learners elaborate and explain their understanding of geometrical concepts to group members instead of just providing answers and procedural information. Collaborations are also believed to improve learners' levels of motivation as well as their intellectual skills (Alessi & Trollip, 2001).

From the reviewed literature it was feasible to generate a set of assumptions to guide this study. These assumptions were categorised into two epistemological and instructional strategies.

Epistemology

The following set of epistemological assumptions come from the reviewed literature on social constructivism.

- Geometry is humanistic in nature
- Geometry is a product of human creation
- There are various ways of knowing geometry

Instructional assumptions

Social constructivism has some important implications for the integration of ethnomathematics approaches in the teaching and learning of geometry. Firstly, the view that learners construct new geometrical knowledge using their prior knowledge. Learners bring to the geometry classroom the geometrical knowledge gained from prior experiences in their environments or cultural backgrounds. Their previous knowledge and experiences influences the new geometrical knowledge they would construct from the new learning practices. Hence, if learning is focussed on learners' previous geometrical knowledge, then teachers need to take note of that knowledge when teaching and provide learning situations that exploit irregularities between learners' existing knowledge and the new experiences beforehand.

The second is that teaching and learning of geometry is an active process rather than passive. Learners remain active during this process. Therefore, geometry teaching cannot be regarded as the process of imparting knowledge to the learners by the expert, the teacher. The teacher, therefore, becomes a guider in the learning environment.

Thirdly, teaching and instruction in geometry class should emphasis on making connections with the learner's everyday activities, the learner's prior knowledge and their familiar contexts both within and outside the learner's school, meaning making and construction of geometrical knowledge. The construction of geometry knowledge requires familiarity with the environment, learners' prior knowledge and their cultural activities. Multiple resources from learners' environments must be utilised in geometry teaching.

Fourthly, the application of learners' existing geometrical knowledge in different circumstances is important in life. Therefore, teachers should create learning environments that enables learners to solve problems that are found in life by providing them with challenging and contextualised geometry activities. Teachers could also provide geometry tasks that are relevant to the learners, not those that are required for them to pass examinations.

Social constructivists hold the view that learners construct new geometry knowledge by connecting it to their prior experiences and they are acquainted with the learners' earlier geometry knowledge gained during informal and official activities at home and schools that is brought in the classroom. This complements Ethnomathematics' goal of recognising connections between school geometry and everyday experiences that led the current study to explore the in-service teachers' preparedness to integrate ethnomathematics approaches in geometry teaching.

Employing the social constructivist theory as a framework was ideal as it recognises the uniqueness of experiences of learners and allows for their background to be the beginning point for geometry instruction. Knowledge construction and conceptual understanding in geometry is valued more than memorising procedures and using them in solving routine tasks. This helps to reduce a detachment between geometry instruction in the classroom and the learners' environment.

In the current study, concepts such as the geometry teaching, in-service teachers' views of ethnomathematics approaches, and teacher training were understood by making use of social constructivist ideas that has its cornerstone as building on new knowledge using prior knowledge. In view of that, social constructivist theory was suitable for the present study that explored the in-service teachers' preparedness to integrate ethnomathematics approaches in geometry teaching in a Zimbabwean context. The social constructivists' ideas that learners construct new knowledge by linking it to earlier experience counterparts ethnomathematics approaches' objective of pinpointing links between school geometry and cultural prior experiences, led the researcher to explore in-service teachers' preparedness to integrate ethnomathematics approaches in teaching geometry.

3.5 Previous studies and social constructivism

Social constructivism has turn out to be a leading theoretical position in mathematics education (Ernest, 1993; Tobin, 1993). Social constructivism offers a credible, practical framework for interpreting and understanding practices of teaching and learning, in this manner social constructivism is an important theoretic referent to shape classroom that take full advantage of learners' learning (Tobin & Tripping, 1993). Social constructivism has consequences for the development of teaching approaches such as ethnomathematics approaches that focus on the learners' conceptual understanding of geometry concepts.

Most researchers and scholars have progressively grounded their studies on social constructivism as a hypothetical outline as it acknowledges the significance of cultural and individual features of learning (Microbe & Tobin, 1997). The learner's individual characteristics of learning govern how he/she constructs knowledge as new knowledge interacts with his/her prior knowledge (Microbe & Tobin, 1997). The social constructivist view of teaching and learning is founded on the construction of knowledge that is socially mediated through cultural experiences and collaboration with others within the classroom (Microbe & Tobin, 1997). Although learning can be regarded as personal, each learner's psychological constructions are influenced by the activities of others in the cultural situation and the features of the culture in which learning occurs. Thus, it is important investigate how the teachers were prepared to integrate ethnomathematics approaches in teaching geometry using social constructivist as a theoretical framework.

Some scholars have successfully applied the social constructivism in their researches. For example, Naweseb (2012) was guided by social constructivism in his study that involved secondary school teachers' ability to use everyday contexts in teaching mathematics. Social constructivism influenced the connections of the learners' every day and cultural experiences to classroom mathematics and real world applications. The social constructivism enabled him to focus mainly on incorporation of everyday context and cultural activities into the teaching of mathematics. In this study, social constructivism was employed to enable the study to focus on the integration of previous knowledge and cultural experiences in geometry teaching and gain a better understanding of in-service mathematics teachers' preparedness to integrate ethnomathematics approaches in teaching geometry.

More recently, Kapenda et al. (2015) applied the social constructivist theoretical framework in their research, arguing that social constructivist aspect of contextual teaching and learning is grounded on the links between prior knowledge and collaborative learning environments. The social constructivist theoretical framework enables the researchers to focus on the idea that learners construct knowledge through their interaction with the environment. Thus, social constructivism puts emphasis on that meanings and understandings of mathematical concepts grow out of social interactions. The authors grounded their understanding of the problem investigated on the ideas of social constructivism in order to understand the Basic Education Teacher Diploma (BETD) mathematics teachers' use of contextualised mathematics problems in the classroom.

Kang (2004) carried out research involving secondary school teachers, learners, teacher educator and pedagogic personnel to assess their receptiveness to a curriculum built on an Ethnomathematics foundation. His framework was grounded in the social constructivist views. The social constructivist views enabled him to connect Ethnomathematics pedagogy to social constructivist views, arguing that learners should be engaged in contextualised problems that mirror those in the real world using their cultural experiences, activities and previous knowledge from their real life. He contended that there is a link between Ethnomathematics and social constructivism views. Additionally, the social constructivism theoretical framework allowed the author to comprehend and specify important features of the practical role of the teacher to construct and create conducive learning environments that makes the learners to understand geometry concepts. These explanations support the perspective that social constructivism fits well within the current study.

3.6 Summary

The chapter outlined the theoretical framework that guides this study. The reviewed literature on social constructivism, Ethnomathematics and the humanistic view about the nature of mathematics concurs with the idea that the teaching and learning of geometry could be improved by choosing instructional techniques that enables the learners to construct geometrical meaning from their cultural and social environments. Social constructivism is consistent and interlinks with the humanistic philosophy nature about mathematics and Ethnomathematics. The ethnomathematics approaches as used in this dissertation can be categorised under the humanistic view of mathematics and social constructivism.

Social constructivism was relevant to this study as it contributes to the teachers' understanding of learner's geometry knowledge construction as they interact with the environment, and the contributions of culture to mental development, that could impact on how they are prepared to integrate ethnomathematics approaches in geometry teaching. In the context of social constructivism, it was necessary to view geometry as a cultural product, basing on the literature that considers the use of learners' cultural and background knowledge in their construction of knowledge (D'Ambrosio, 2001; Vygotsky, 1978).

Fundamental to the current study, the social constructivist theoretical framework affords a wider opportunity to show and deliberate ideas and aspects of the research question. In the current study, aspects of in-service teachers' preparedness to integrate ethnomathematics approaches in geometry teaching were understood by making use of social constructivist theoretical framework.

In this way, social constructivism not just provides an outline to inquire about practices in mathematic instruction, yet in addition a sound hypothetical foundation for educating and learning mathematics in the classroom (Duit and Tregust, 1998). By embracing the social constructivist hypothetical outline in this study it was trusted that geometry knowledge is socially developed and one of the objectives of the current research was to understand how in-service the teachers are prepared to integrate ethnomathematics approaches from their own point of view

CHAPTER 4: METHODOLOGY

4.1 Introduction

This chapter presents and explains the research methodology that was used in this study. The study was guided by a mixed method approach and a pragmatist philosophical paradigm. "A pragmatist paradigm entails that reality and science are socially constructed such that research must engage in reflexive and self-critical discourse where aspects of both qualitative and quantitative methods must complement each other as the rationale of research is to divulge hidden truth" (Gray, 2011, p37). The study design, paradigm, population and sampling techniques, data gathering methods and procedures, data analysis, as well as ethical considerations, were discussed in this chapter.

4.2 Mixed methods research

This research employed a mixed method research (Creswell, 2015; Gray, 2011) to explore in-service mathematics teachers' preparedness to integrate ethnomathematics approaches in the teaching and learning of geometry. The research questions under study required a research design that went beyond straightforward numbers in quantitative data or simple words in a qualitative data hence an amalgamation of both quantitative and qualitative data in a single study that affords a more complete analysis of the research problems (Creswell & Plano Clark, 2011; Angell & Townsend, 2011; Creswell, 2015). Additionally, in this study the use of mixed methods enabled the researcher to gather both qualitative and quantitative data simultaneously. According to Cohen, Manion & Morrison, (2015) a research question cannot be answered sufficiently by drawing only on one method, but requires data from both qualitative and quantitative methods for a complete understanding of the research problem. Therefore, it can be pointed out that use of the two methods was better than one in exploring in-service teachers' preparedness to incorporate ethnomathematics approaches into the teaching and learning of geometry.

The rationale for amalgamating qualitative and quantitative methods was to gain an in-depth understanding of how in-service mathematics teachers were preparedness to integrate ethnomathematics approaches into the teaching and learning of geometry, where each of the methods is not connected to a specific paradigm (Gray, 2011). The qualitative data helped to provide rich explanations of not only contradictory views of the in-service teachers, but also the other themes emerging from the qualitative findings. In addition, the qualitative data were expected to confirm, where possible, the quantitative data findings and also to provide additional insights on the findings.

Gray (2011) also notes that the main purpose of combining quantitative and qualitative methods was to triangulate the data. According to Mertens (2005) the idea of triangulation comes into sight from the pragmatists, as a method of improving the trustworthiness of the interpretation of the research findings. Some researchers consider the utilisation of triangulation as a mixed method approach by which qualitative and quantitative methods are utilised as an in-depth way for checking the legitimacy of an interpretation (Bergman, 2008). Triangulation in the current study refered to the combination of qualitative and quantitative methods.

In spite of referring to triangulation, as a straightforward amalgamation of qualitative and quantitative methods, the current research also utilised data triangulation that makes use of several data gathering techniques, for example, focus group discussions and questionnaires to ensure the validity of the research findings. Mixed methods research provides “researchers with techniques to improve the capacity of their methods and enrich the quality of the research results, complementarity, validity, flexibility, credibility and generalizability of findings” (Sarantakos, 2013, p54). In this study the research findings could be generalised from the sample to the population which is one of the aspects of the quantitative research. The most important idea is that the consolidated utilisation of qualitative and quantitative methods offers a way to authenticate the research findings.

In spite of the benefits associated with mixed methods research, there are some methodological weaknesses associated with this research method. The major disadvantage is linked to “incompatibilities of the methodology, ontology, epistemology, paradigm and ideology of qualitative and quantitative research which cannot lead to valid and acceptable research findings” (Sarantakos, 2013, p56). Despite the fact that, “mixed method is a process that uses both qualitative and quantitative methods and strategies in the same study, mixing does not change the structure and the identity of each methodology” (Sarantakos, 2013, p50). Each of the methods used in mixed methods is guided by its epistemology, therefore, utilising both qualitative and quantitative methods ensures reliability and validity the collection of data as well as in data interpretation. This also helped in making stronger and accurate inferences of the research findings.

Furthermore, expertise is mandatory in both qualitative and quantitative methods, predominantly for the reason that data is collected concurrently and with an equal weight. In the current study, this was addressed by the fact that the researcher is an expert in both quantitative and qualitative research methods.

Additionally, the quantitative and qualitative results may not agree. In this case, the reasons for the differences could be provided through re-examining the quantitative and qualitative data and or pointing out the limitations in one of the data sets or the other.

4.2.1 Convergent parallel mixed methods design

Creswell (2015:219) identified three categories of mixed methods design which are the explanatory sequential, exploratory sequential and convergent parallel mixed methods designs.

- *Explanatory sequential mixed methods design*: It entails a two-phase study in which involves the collection and analysis of quantitative data in the first stage. The research findings are then used to plan for the second qualitative phase.
- *Exploratory sequential mixed method design:* In the first stage qualitative data is collected and analysed and then use the results in the second quantitative stage. Similar to the explanatory sequential design, the second database builds on the results of the initial database.
- *Convergent parallel mixed methods design:* It involves the collection of both qualitative and quantitative data simultaneously, and then the findings are compared to see if they confirm or disconfirm each other.

This study employed a convergent parallel mixed methods design (Creswell & Plano Clark, 2011; Creswell, 2015; Bryman, 2016) to explore teachers' preparedness to integrate ethnomathematics approaches in teaching geometry. According to Creswell & Plano Clark (2011), in a convergent parallel mixed methods design, the gathering of quantitative and qualitative data is done both simultaneously and then the findings are amalgamated in the analysis and in the interpretation phases. The rationale of this convergent parallel design was to extrapolate conclusions from both qualitative and quantitative data gathering methods that are legitimate and acceptable about the teachers' preparedness to incorporate ethnomathematics approaches into the teaching and learning of geometry.

The quantitative and qualitative data complement each other as they measure a single complex phenomenon in different ways and were combined to enhance a deeper understanding (Creswell & Plano Clark, 2011) of how the teachers were prepared to integrate ethnomathematics into the teaching and learning of geometry. Creswell (2015) argues that mixed methods designs provide an inclusive solution to every single research question in the study and that the mixed method design that combines various techniques is prone to generate better findings with regards to scope and quality.

The rationale for collecting both quantitative and qualitative data was to gain a deeper understanding on how teachers' were prepared to incorporate ethnomathematics approaches into the teaching and learning of geometry through this form of methodological triangulation. In so doing, this study comprised of focus group discussions with open-ended questions (qualitative data) and a questionnaire, which contains both qualitative open-ended questions and quantitative Likert type questions. The qualitative component in both the questionnaires and focus group discussions add contextual meaning to quantitative numerical data on how the in-service teachers were prepared to integrate ethnomathematics approaches in the teaching of geometry.

In the current study, the trustworthiness of the results was enhanced since several data gathering methods and different forms of data collected made triangulation feasible. For instance, qualitative data from the focus group discussions extended on the quantitative data from the questionnaires. Creswell & Plano Clark (2011) suggested a methodological diagram of the convergent parallel mixed methods design to put across the intricacy of a mixed methods design. Figure 4.1 presents the stages within the mixed methods convergent parallel design used in this study.

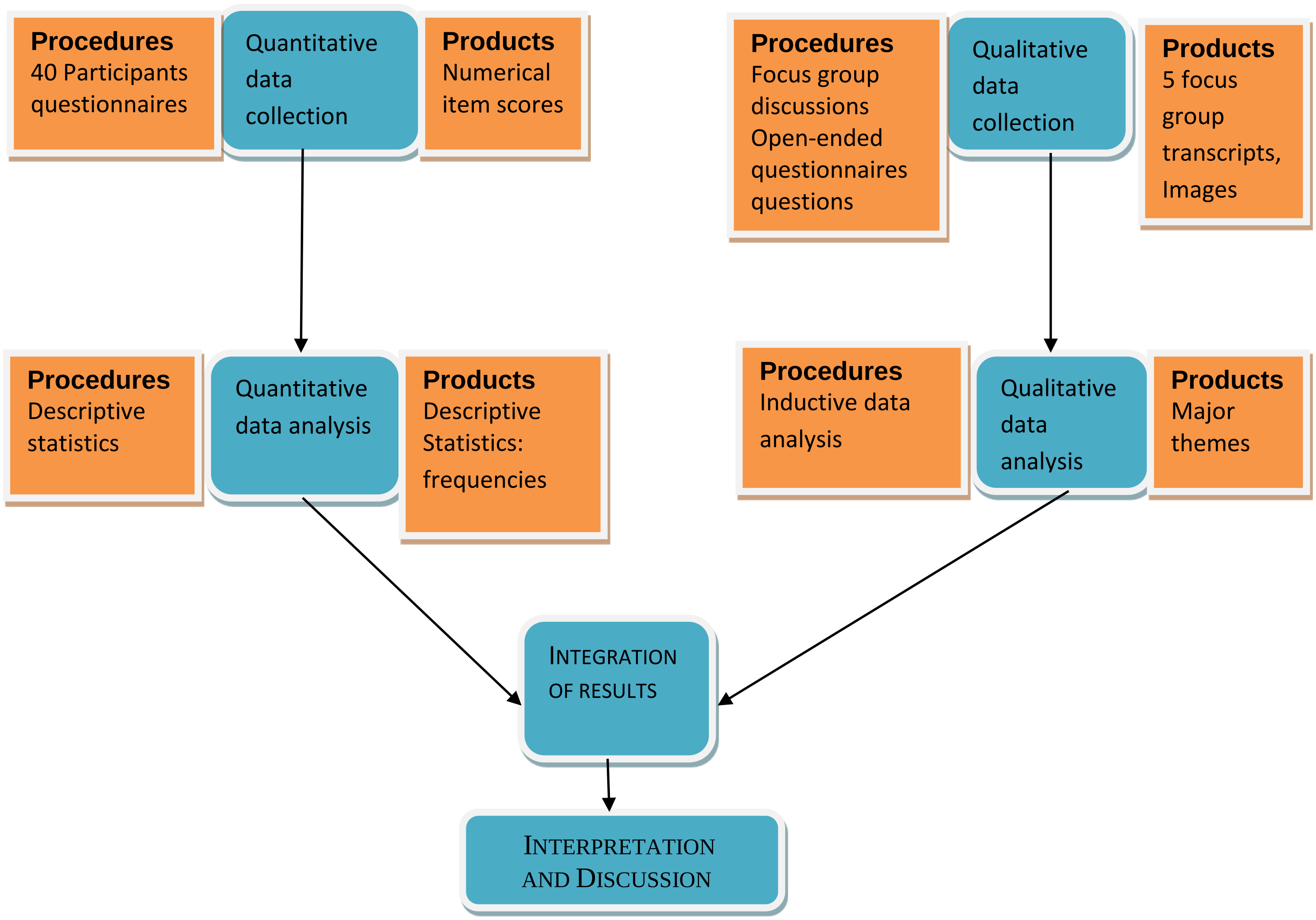


Figure 4.1: Methodological diagram (Creswell & Plano Clark, 2011, p. 79)

Figure 4.1 shows the four key phases in the convergent parallel mixed method design. In the first phase both qualitative and quantitative data about the in-service teachers' readiness to incorporate ethnomathematics approaches into the teaching and learning of geometry were collected. These two types of data were equally essential in addressing the research questions. The second stage involves the analysis of both qualitative and quantitative data separately using distinctive qualitative and quantitative analytic techniques.

As soon as both sets of preliminary findings were available, the results of the two data sets were merged in the third phase. In this study, quantitative and qualitative data was merged in both the analysis and interpretation phase in order "to answer the research questions and to provide a comprehensive analysis" (Creswell, 2015, p44) of the teachers' preparedness to incorporate ethnomathematics approaches into the teaching and learning of geometry. In the current study, integration was achieved by first reporting the quantitative numerical findings followed by qualitative quotations that supported or contradicted the quantitative findings (Creswell & Plano Clark, 2011). In that way, the merged results were used together to answer the research questions.

4.3 Research Paradigm

Scholars in mathematics education argue for a worldview that does not approach mathematical issues and teaching in an instrumental way. Problems faced by mathematics educators are complex and cannot be resolved by divorcing understanding of how society, economic and individual factors intermingle to produce the type of conditions that prevails in geometry classrooms. These problems have enthused the integration of different worldviews to support mixed-methods methodologies for scholars to engage in mathematics education research.

Within the "mixed methods design, pragmatism is recognised as the guiding theory" (Biddle & Schafft, 2015, p323). According to Cohen et al. (2015) pragmatist paradigm draws on, and combines, both qualitative and quantitative methods to meet the needs of the study and to provide complete answers to the research questions. It is fundamentally practical and oriented to the solution of practical problems in the real world (Creswell & Plano Clark, 2011). Pragmatists judge research by whether it has enabled the researcher to find out what he/ she wants to know, irrespective of the methodologies used, whether they are quantitative or qualitative (Cohen et al., 2015). Pragmatism suggest that "what works to answer the research questions is the most useful approach to the problem" (Cohen et al, 2015, p23) under study, be it a combination of focus group discussions, questionnaires as was done in this study so as to enhance the quality of the research (Creswell & Plano Clark, 2011). Pragmatism has its standards of rigour, and these are that the research must provide answers to the research questions (Cohen et al, 2015).

Methodological pluralism is an important component in pragmatism as it enables errors in a single approach to be rectified. It enables meanings in data to be probed, corroborated and triangulation to be practiced and rich data to be collected (Cohen et al, 2015).

On pragmatism, as a theoretical foundation for mixed methods designs, Morgan (2007) and Tashakkori & Teddlie (2010) state its relevance for concentrating on the research problem in mathematics education and then utilising several methods to generate knowledge from the problem. Pragmatism "applies to mixed methods research in that inquirers draw liberally from both quantitative and qualitative assumptions when they engage in their research" (Creswell, 2015, p39).

Philosophically, "mixed methods research adopt a pragmatic method and system, based on the view of knowledge as being socially constructed and based upon the reality of the world we experience and live" (Gray, 2011, p204). Pragmatists believe that research always take place in historical, social and other contexts (Creswell, 2015). The social nature of pragmatism point to the essential role of group effort in focus group discussions with an emphasis on communication and shared meaning-making in order to understand the teachers' preparedness to integrate ethnomathematics approaches into the teaching of geometry. The focus group discussions were used in this study so that the participants could share their views in a social setting. The collective responses of the teachers would enrich the study. This view aligns well with the social constructivist theoretical framework that guided this study.

In addition, "pragmatists do not see the world as an absolute unity" (Creswell, 2015, p39), rather they believe it offers a practical and utilitarian view of knowledge that supports the role of knowledge in mathematics education. The pragmatism paradigm is needed in this study, which focusses on how the teachers are prepared to incorporate ethnomathematics approaches into the teaching and learning of geometry.

This study explores teachers' preparedness to integrate ethnomathematics approaches into the teaching and learning of geometry. Like humanists, such as Presmeg (2007) and Rosa & Orey (2011), they view mathematics as value-laden and situated in social contexts. This study considers research to be value-laden. The pragmatism paradigm employed in this study acknowledges that knowledge is theory and value-laden and capable of shaping human values.

Similarly, mixed methods researchers rely on several methods for gathering and analysing data instead of using a single method, for instance, quantitative or qualitative. Subsequently, "for the mixed methods researcher, pragmatism opens the door to multiple methods, different worldviews, and different assumptions, as well as different forms of data collection and analysis" (Creswell, 2015, p40). The pragmatic paradigm suggests that the general approach to research is that of integrating data gathering methods and data analysis techniques in a particular study (Creswell, 2015).

In applying the pragmatism paradigm, the current study combined both quantitative and qualitative research techniques that consisted of various methods of gathering data such as questionnaires and focus group discussions that also utilised different data analysis procedures to explore the teachers' preparedness to integrate ethnomathematics approaches in teaching geometry. In this study questionnaires with closed and open-ended questions were employed as well as focus group discussions which generate both quantitative and qualitative data.

4.4 Study Population

To explore in-service teachers' preparedness to incorporate ethnomathematics approaches into the teaching and learning of geometry, the participants were drawn from a group of potential informants whom the researcher expected to offer relevant information (Silverman, 2011). The participants for the study were second year Bachelor of Science Education Honours in-service mathematics teachers at the university under study. In-service mathematics teachers are admitted into the university with minimum teaching qualification, such as diplomas/certificates in education attained from teachers' colleges or universities and a minimum of two years teaching experience. The in-service mathematics teachers have the requisite knowledge in the teaching and learning of geometry, since they were all trained to teach mathematics up to Ordinary level. The choice was made in this way so as to get a complete picture of the in-service teachers' preparedness to integrate ethnomathematics approaches in teaching of geometry. During the study period there were 80 teachers (50 males and 30 females).

4.5 Study sample and sampling techniques

This section focusses on sample and sampling techniques as Cohen, et al. (2015) pointed out that it is feasible to study the entire population for the purposes of gathering data, therefore, there is need for sampling.

4.5.1 Quantitative sampling techniques

Stratified random sampling was employed to select 40 in-service teachers. In "stratified sampling, the population is divided into mutually exclusive groups called strata and then a random sample is selected from each of the groups" (Christensen, Johnson & Turner, 2015, p154). According to Christensen et al, (2015) there are two different kinds of stratified sampling. These are proportional and disproportional stratified sampling techniques. In the proportional stratified sampling employed in this study, the number of participants selected from the two groups was proportional to their sizes in the population (Christensen et al., 2015).

Proportional stratified random sampling was employed in the current study to assure the in-service mathematics teachers' proportional representation in the sample and each in-service teacher had the same chances of being selected so that the research results could be generalised from the sample to the population (Christensen, et al., 2015). Stratification made it possible for the researcher to stress some control over the choice of the sample so as to assure inclusion of vital participants. For this study, gender was the stratification variable, in-service teachers were divided into a group of all females and a group of all males. The sample was then drawn separately from each group in proportion to the gender balance in the population (Curtis & Curtis, 2011). Based on this view, random samples of in-service mathematics teachers were drawn from each of the two groups (female and male groups) using simple random sampling technique with the aim of exploring how prepared were they to integrate ethnomathematics approaches into the teaching and learning geometry.

The lottery method employed in the current study, is one of the ways used to draw simple random samples (Sarantakos, 2013). Each in-service teacher within the female group and the male group was assigned a unique number. The numbers were placed in boxes (one for males and the other one for females), where they were thoroughly mixed. Then a blind-folded researcher selected twenty five numbers from the male box and fifteen numbers from the female box. The female and male in-service teachers assigned to the selected numbers were included in the sample. The compilation of the two random samples constitute the stratified sample of 40 in-service teachers (25 male and 15 female combined). A random stratified sample is a valuable combination of randomisation and categorisation that allowed both qualitative and quantitative methods of research to be employed (Cohen et al., 2015), in order to explore in-service teachers' preparedness to integrate ethnomathematics approaches into the teaching and learning of geometry.

4.5.2 Qualitative sampling techniques

According to Hennink (2014) research based recruitment is a qualitative sampling method that is employed in studies that make use of several research methods in a particular study. It is a qualitative sampling method whereby participants for the research are chosen from those who were previously drawn in the study, but were selected for another part of the study through a different selection method (Hennink, 2014). In the current study, the participants who were recruited to complete the questionnaires through stratified random sampling techniques were requested also to participate in qualitative focus group discussions. This is in line with Creswell (2015) who suggested that in the convergent parallel mixed methods design data can be gathered from the same number of participants on both the qualitative and quantitative methods, so as to resolve the issue of sample size in these two methods.

Classically, this convergent parallel mixed methods design incorporated the quantitative participants in focus group discussions, for the reason that eventually the two data sets would be compared and merged and the more they are analogous, the better the merging and the comparison. In order to gain more information on responses to research questions and to gain richer data, the forty in-service teachers who completed the questionnaires were recruited for the focus group discussions (Curtis & Curtis, 2011). This kind of selection was useful as the study was seeking a greater depth of understanding and information from participants who were previously drawn in the study. Recruiting for the focus group discussions after in-service teachers had already completed the questionnaires helped to build rapport with them (Hennink, 2014).

According to Seale (2012), three to five focus groups are sufficient in a study. Ideally, focus group discussions consist of six to eight participants (Hennink, 2014). In this study, five groups were considered, each group consisted of three female and five male in-service teachers. A group of eight was sufficient to allow the moderator/facilitator to gather enough information and to initiate a discussion. The recruitment of the participants for the focus group discussions was done randomly. The emphasis of the focus group was on small-group interaction and in-depth discussion among the participants about the issues being studied.

4.6 Methods of data generation

Data for the current study were collected using the mixed methods approach (Creswell, 2015), which included questionnaires and focus group discussions. According to Creswell & Plano Clark, (2011) a convergent parallel mixed methods design ought to address the same topic in both the quantitative and qualitative data. Mixed methods have been defined as the gathering of both qualitative and quantitative data concurrently (Gray, 2011), for instance, the use of questionnaires and focus group discussions in the current study.

Different data collection methods such as questionnaires and focus group discussions were employed to address the same research questions or focus on the same aspects of the research (Gray, 2011), that is, exploring the in-service mathematics teachers' preparedness to integrate ethnomathematics approaches into the teaching of geometry. This is a methodological form of triangulation which combines qualitative (focus group discussions and questionnaire-open ended questions) and quantitative (questionnaire-closed questions) methods on a single case (Gray, 2011), in which the same participants (in-service teachers) who completed the questionnaires were then included in the focus group discussions (Curtis & Curtis, 2011). Questionnaires were used in conjunction with focus group discussion so as to be thorough in addressing all possible aspects of the topic and to overcome the deficiencies of a single method (Sarantakos, 2013), as well as to gain richer data and contextualise the findings (Curtis & Curtis, 2011).

The association between the method of data generation and the research questions is shown in Table 4.1.

Table 4.1: Link between research questions and method of data generation

Research question	Data gathering method
1) How are in-service teachers prepared to integrate ethnomathematics approaches into the teaching of geometry?	Questionnaire Focus group discussion
Sub-questions	
a) How were the in-service teachers trained to teach geometry?	

	b) How were in-service teachers trained to integrate ethnomathematics approaches into the teaching of geometry?	
	2) How do in-service teachers view the integrating of ethnomathematics approaches into the teaching of geometry? Sub-question **a)** How do in-service teachers view ethnomathematics approaches? **b)** What are the views of the in-service teachers regarding the integration of ethnomathematics approaches into the teaching of geometry?	Questionnaire Focus group discussion
	3) Why are in-service teachers not integrating ethnomathematics approaches into the teaching of geometry? ***Sub-question*** **a)** What do in-service teachers perceive as challenges to the integration of ethnomathematics approaches into the teaching of geometry?	Questionnaire Focus group discussion

4.6.1 Questionnaires

Collection of both quantitative and quantitative data for the purpose of the current study, which seeks to explore in-service teachers' preparedness to integrate ethnomathematics approaches in teaching geometry, comprised the use of questionnaires. Questionnaires are data gathering tools through which participants are requested to provide answers to identical set of questions in prearranged order (Gray, 2011). They supply self-reported data about the views held by the participants on a variety of issues under investigation (Johnson & Christensen, 2012).

The questionnaires were employed because they were the best instrument to provide information about views, attitudes, motivation and opinions about how the teachers were prepared to integrate ethnomathematics approaches into the teaching and learning geometry (Gray, 2011). In this study, questionnaires comprising of a five-point Likert scale (quantitative data), and yes-no questions (quantitative data) and open-ended questions (qualitative data) were used. Questionnaires were ideal for this study because they generate both quantitative and qualitative data (McMillan & Schumacher, 2010), which is one of the major elements of this convergent parallel mixed methods research.

Open-ended questions have no definite responses and answers were recorded in full. The advantage of open-ended questions is the potential for richness of responses, some of which might not have been anticipated by the researcher (Sarandakos, 2013). The open-ended questions enable the participants a chance to include a comprehensive description on how prepared they were in integrating ethnomathematics approaches into the teaching and learning of geometry. The use of a questionnaire in this study made it feasible to use different categories of items that are open and closed on the same questionnaire, thus facilitating the researcher to get rich data as well as obtaining both quantitative and qualitative data.

Closed questions have an advantage that they can be pre-coded and this makes data analysis easy, and they also require less time to complete (Sarandakos, 2013). However, closed questions force participants to choose between the answers provided. In the current study this was surmounted by asking for more information, for instance, where participants were asked to indicate yes/no this was followed by explain or give reasons (Gilbert, 2009). Furthermore, response choices in closed questions reduce ambiguity, and participants are more likely to answer questions that the researcher really wants them to answer.

An essential benefit of using questionnaires in research is that they are commonly self-administered and can be given to large groups of participants at the same time. This makes them an efficient instrument to gather data from a large group. As a result, questionnaires are less expensive as compared to interviews. Furthermore, data gathered using questionnaires is more homogeneous and standard as all participants read and answer the same questions, in so doing, consistency is guaranteed in the demands of what participants had to provide as responses. The standard data generated from questionnaires enabled the easier processing of responses, in addition to, increasing reliability and validity of the results. In addition, because questionnaires were administered to all participants at exactly the same time, the data was more reliable for the reason that there were diminished probabilities of the conditions that bear on the participants' reactions. Finally, questionnaires were faster to complete and were more efficient, as a result they produced quick results.

In addition, a number of questionnaires have been used in studies that focused on ethnomathematics approaches and its integration in the classroom due to the advantages associated with them. These include the teachers' views on integration of ethnomathematics approaches in teaching geometry and mathematics in general, challenges of integrating ethnomathematics approaches in the classroom and teachers 'preparedness to integrate ethnomathematics approaches in teaching geometry and mathematics in general (Kang, 2004; Hara-#Gas, 2005; Harding-DeKam, 2007; Averill et al, 2009; Jorgensen teal, 2010; Massarwe et al, 2011; Naweseb**,** 2012; Rosa, 2013, Kapenda et al**,** 2015).

Consequently, taking into consideration all these advantages and that they have been successfully used in other studies for similar purposes, when designing the current study, questionnaires were considered to be the most appropriate data gathering method that enables an understanding of how in-service teachers are prepared to integrate ethnomathematics approaches in geometry teaching.

Although, the questionnaire as a data gathering method has advantages, it also has some disadvantages. According to Sarantakos (2013), some of the disadvantages are that questionnaires do not allow probing, prompting and clarification of questions. In addition, they do not provide an opportunity to collect additional information while they are being completed. To overcome these shortcomings, questionnaires were complemented with focus group discussions.

Additionally, questionnaires in research are affected by a low response rate particularly with mailed questionnaires, thus influencing validity of findings (Cohen, et al, 2015). According to Gray (2011) this situation is even worse if the questionnaire is too long. In the present study, this disadvantage was counterbalanced, firstly through self-administering of the questionnaires and secondly by limiting the length of the questionnaire to six pages as recommended by Gray (2011). For a highly educated participant and a salient topic, using a questionnaire of fifteen pages may be possible (Neuman, 2000). It was feasible and not very exorbitant to disseminate the self-administered questionnaires because the sample (40 participants) was not too large particularly in light of the fact that all in-service teachers were at the university under study. Questionnaires demand a certain level of literacy, nevertheless, in the present study, it was not inappropriate to use them because the participants in the sample, being teachers, were literate.

The questionnaire was insufficient to accumulate complex data identified with views and practices of how teachers were prepared to integrate ethnomathematics approaches in teaching geometry. Utilised all alone it is named as prohibitive, restricted in its ability to provide in-depth clarifications from pre-coded answers. Scholars who utilise questionnaires tend to force their perspectives and sentiments onto the participants, by outlining the reaction choices on the premise of their insight and perspective, which don't really mirror those of the participants. Since the questionnaire is less useful for examinations concerning unobtrusive practices and views among participants, qualitative instruments such as focus group discussions were utilised to address these issues in the current study.

Questionnaires were delivered by hand to each in-service teacher in a lecture room. This had several advantages, for instance, shorter period of gathering data, response rate was high, and this enabled the researcher an opportunity to explain verbally the rationale of the research and to provide answers to participants' questions (Gray, 2011). A box near the exit to the room for collecting questionnaires helped to assure confidentiality and to maximise the response rate (Gray, 2011).

4.6.2 Focus group discussions

Under the qualitative research methods, the researcher used focus group discussions, to collect data, in which participants were interviewed in a group-discussion setting that enabled them to put across their views comfortably, with the purpose of gaining a wide range of views on how in-service teachers were prepared to integrate ethnomathematics approaches in the teaching and learning of geometry. A focus group discussion is an interactive discussion, where a focus group facilitator keeps a small and homogeneous group of 6-12 participants concentrated on the debate of a research matter (Christensen et al, 2015).

In this study, five focus group discussions comprising of eight participants (five male and three female) were conducted. Curtis & Curtis (2011) state the merits of focus group discussions that incorporates the strengths of qualitative research methods in terms of gathering rich data, contextualised material and generating extra views and insights through the interactions of the group participants. The idea was that group involvement would assist participants to reflect on and to clarify views as combined. The interactive nature of the data gathering method allowed it to create additional insights on the research questions. In the current study, the discussion focused on teachers' understanding of terms ethnomathematics and ethnomathematics approaches, challenges and on their views on how they were trained to integrate ethnomathematics approaches into the teaching of geometry. The data collected complemented the quantitative data from questionnaires by providing additional comprehensive information on the teachers' preparedness to integrate ethnomathematics approaches in teaching geometry (Hennink, 2014).

Furthermore, group interaction was an important aspect in this study for two major reasons. Firstly, each participant was able to probe other group members for additional information, explanation and justification on questions raised during the discussion (Hennink, 2014). This resulted in a deeper understanding of questions and hence produced richer data. Generally, probes of a group member are more natural as compared with those from the moderator/facilitator. Secondly, the interactions between group members have the potential to divulge other aspects of understanding that more often than not remain untapped by questionnaires (Hennink, 2014).

Additionally, focus group discussions allowed for a variety of views on teachers' preparedness to integrate ethnomathematics approaches in geometry teaching to emerge (Gray, 2011). The focus group discussions were not only useful in gathering data on views and attitudes, but also in finding out the underlying context in which they occur, enabling explanations on why certain phenomena persist (Hennink, 2014). As indicated, the purpose of this study was to explore the in-service teachers' preparedness to integrate ethnomathematics approaches in teaching geometry, therefore, the researcher concentrated on making sense of the teachers' views and how they understand and use ethnomathematics approaches in their cultural context.

In addition, focus group discussions provide a greater coverage of issues than questionnaires and avail useful information to answer the research questions with the related contexts and various insights (Cohen et al., 2015). Focus group discussions were also useful in quickly gathering rich and detailed materials on teachers' preparedness to integrate ethnomathematics approaches into the teaching of geometry (Seale, 2012).

Focus group discussions brought out cooperative reasoning, which enhanced the quality of the participants' responses, and activated forgotten details (Maree, 2007). Social constructivism puts more emphasis on the importance of shared interaction, collaboration and negotiated meaning (Groundwater-Smith, Ewing & Le Cornu, 2011). The strength of focus group discussions is based on the development of ideas during the interaction and discussion process amongst the teachers. Focus group discussions model the elicitation phase that is central in the teaching approaches informed by social constructivism, because they imitate the procedure through which meaning is constructed in everyday situations. Finally, data from focus group discussions was helpful in explaining and interpreting the data from questionnaire (Neuman, 2000).

Domination of the discussion by some group members could have affected the direction and result of the discussion (Sarantakos, 2013). However, as suggested by Gilbert (2009) the researcher avoided eye contact with the dominant members and she acknowledged their contribution and then asked the other group members to contribute. Some group members might not participate in the discussion; they might be shy or reluctant to join the discussion. These members were drawn in the discussion, for instance, by directing a question to them (Gilbert, 2009), by means of cool, calm and collected probing, open body language and eye contact to welcome their views.

There may be attempts to go along with the researcher for many reasons, for instance, to please the researcher who holds an important position in the participants' professional life. In such situations, Gray (2011) advises that the moderator/facilitator should be firm and direct, while remaining friendly and calm. On the same issue, (Hennink, 2014) suggested the moderator/facilitator should desist from sharing their own point of view so that group members are not cognizant of the moderator/facilitator's standpoint on the issues under discussion. Finally, the findings may not be representative of the group's views if some members dominate the discussion (Sarantakos, 2013).

Despite the disadvantages of focus group discussions, they have been used for related purposes in other studies (for instance, Katsap & Silverman, 2008); Averill et al, 2009; Massarwe et al, 2011; Ukpokodu, 2011; Nutti, 2013; Naresh, 2015). For the current study, questions were prepared beforehand and participants were asked the same questions. This was envisioned to increase the validity of the research findings. Probes were also used to obtain more complete data about teachers' preparedness to integrate ethnomathematics approaches in geometry teaching.

Audio-taping that produces data by recording contextualised verbal data (Creswell, 2015), were employed to record the focus group discussions, whilst the researcher also documented the participants' body language and facial expressions that cannot be captured by audio recording. These details were essential as they had the potential to provide important insight in the analysis and interpretation of data. The aim of recording the focus group discussions was to allow the researcher to play again the tapes throughout when presenting and analysing the data (Sarantakos, 2013), as a way of confirming the views of the in-service mathematics teachers on their preparedness to integrate ethnomathematics approaches in geometry teaching. In addition, audio-tape recording had an advantage of offering a permanent record that is comprehensive and they are easier to use and more efficient (Sarantakos, 2013). The focus group discussions were carried out consecutively and were scheduled at the participants' best possible convenient time.

Audio-taping the focus group discussions had its own challenges, for example, most of the examples or illustrations on integration of ethnomathematics approaches could not be captured through audio-taping, and hence sheets of papers were used to capture the examples in this study. However, video recording could have been ideal because it would have recorded both participants' body language and facial expressions and examples on integration of ethnomatheamtics approaches. Nonetheless, its use could have been interfering and could divert the attention of the participants, and is also very costly.

4.7 Data Analysis

This study used a convergent parallel mixed methods design where quantitative and qualitative data were gathered simultaneously and then merged (Creswell, 2015). Further, in a convergent parallel mixed methods design, analysis of the combined data is used to describe the divergence and convergence of the results from each method (Creswell, 2015). The areas where data converges indicates compelling connections between the measured components. For areas where data diverges, there were reasons that, if determined, provided a greater understanding of the measured components.

Qualitative data analysis in this study involved selecting sorting, categorising, synthesising, summarising and interpreting data from focus group discussions and open responses from questionnaires. There are many qualitative analysis techniques (Adams & Lawrence, 2015). In the current study, inductive data analysis procedures were employed. Focus group discussions were tape recorded and transcribed. An "inductive" (Creswell, 2015, p238) analytic data procedure, where themes were generated was used for qualitative data from both the questionnaires and focus group discussions. Inductive analysis is a process of classifying patterns, categorises and themes in the data rather than deciding, prior to data collection or analysis what the precise categories or themes will emerge (Patton, 2002 cited in Curtis & Curtis, 2011, p.43). For open ended questions, in the questionnaire and focus group discussions, a coding frame was devised after data collection (Cohen et al., 2015). The data from focus group discussion and questionnaires were coded and gradually reduced into few important groups of major themes and sub themes. Inductive analysis was employed to note patterns and themes which emerged from the study. The developed themes were interpreted and discussed in this study. This was necessary because open ended questions were used in both focus group discussions and questionnaires. Focus groups produced qualitative data, which were analysed qualitatively, taking into account the group context and looking for themes that arose at group level and not simply from individuals within the group.

For the quantitative component, descriptive statistical visual strategies were employed to analyse as well as to interpret the data (Cohen et al., 2015). In the current study, the quantitative data was presented as frequencies (Cohen et al., 2015). Data from questionnaires were also pre-coded, for the closed questions. Responses were coded numerically for instance, no = 0 and yes = 1. An interpretive data analytic process was employed in the current study to provide meaning to the quantitative data. Interpretive data analytic process provides meaning that goes further than the straightforward depiction of the data (Thomas, 2003). According to Flick (2011) interpretations are important in quantitative analysis because they provide explanations for the numerical data.

4.8 Validity and Reliability

Reliability and validity are crucial requirements for any research process because they enhance the precision of the measurement and assessment of any study. However, they encompass diverse connotation under the quantitative and qualitative methods (Creswell, 2015).

4.8.1 Validity in mixed methods research

Validity is the degree to which any measuring instrument measures what it purports to measure. Validity in a convergent mixed methods approach should be based on ascertaining validity strategies for both quantitative and qualitative methods (Creswell, 2015). Different types have been identified that comprises of criterion validity, construct validity, content validity and face validity. Two main categories of validity are internal and external validity. According to Cohen et al. (2015) the two research methods, namely, quantitative and qualitative addresses both internal and external validity.

External validity in qualitative methods focuses on the extent to which th**e** research results can be applied to the world. It is concerned with how research findings can be generalised to other situations.

Even though, the goal in qualitative research is not to generalise the results, generalisability in qualitative methods refers to the comparability and transferability of the findings. Within the qualitative methods, external validity can be achieved by the level of honesty, depth of the inquiry, scope of the data collected, and triangulation (Cohen et. al., 2015). Within this research external validity was ensured by selecting a representative sample for the research, collecting adequate data for the research questions and through an amalgamation of data gathering methods (focus group discussions and questionnaires).

Internal validity focuses on the degree to which research approaches impacts on research findings (Sarantakos, 2013). In other words, it seeks to make sure that the results of the research have not been influenced by the instruments or the research process. With the aim of strengthening the validity of the research results, the current study gathered data through questionnaires and focus group discussions since collecting data through a single instrument could have been questionable, biased and weak. On the other hand, the data gathered through questionnaires and focus group discussions also helped to confirm the research results in this study.

Legitimation in mixed methods design

Despite the fact that each of the mixed methods design (qualitative and quantitative) have to adhere to their particular validity requirements, Cohen et al. (2015) ague for particular validity requirements for the integrated qualitative and quantitative methods. The aim is to make justified qualitative, quantitative and incorporated claims. Scholars for example, Onwuegbuzie and Johnson (2006) argue that the expression "validity" ought to be restored by "legitimation" in mixed methods research to mirror the parts of validity instigating from qualitative and quantitative research. The scholars pointed out that this would surmount the problems of representation, legitimation and integration. Onwuegbuzie and Johnson (2006) identified nine types of legitimation in mixed methods, outlined and summarised in Table 4.2.

Table 4.2: Legitimation in mixed methods design

Type of Legitimation	**Description**
Sample integration	The degree to which the link between the qualitative and quantitative sampling strategies produces quality results and conclusions.
Inside–outside legitimation	The degree to which the investigator precisely acquaint with and suitably uses the insider's view and the outsider's view for purposes, for example, explanation and clarification.
Weakness-minimisation legitimation	The degree to which the shortcoming from one methodology is repaid by the qualities from the other methodology.
Sequential legitimation	The degree to which one has reduced the likely challenges in which the findings and conclusions could be influenced by reversing

	the order of the qualitative and quantitative stages.
Conversion legitimation	The degree to which the quantitating or qualitising produces quality research findings and conclusions.
Paradigmatic mixing legitimation	The degree to which the investigator's ontological, methodological, epistemological, axiological, and explanatory convictions that underlie the qualitative and quantitative methodologies are effectively (a) joined or (b) mixed into a usable package.
Commensurability legitimation	The degree to which the meta-inductions made mirror a varied worldview based on the intellectual procedure of Gestalt switching and amalgamation.
Multiple validities	The degree to which tending to legitimation of the qualitative and quantitative aspects of the investigation result from the utilisation of qualitative, quantitative and blended legitimacy types, produces quality meta-deductions.
Political legitimation	The degree to which the users of mixed methods research design value the meta-inductions coming from both the qualitative methods and quantitative methods of a research.

Source: Onwuegbuzie and Johnson (2006, p.57)

Sample integration is the "degree to which the relationship between the qualitative and quantitative sampling techniques enables high quality inferences" (Onwuegbuzie & Johnson, 2006, p57). These researchers suggest that the same or similar samples must be used in mixed methods design to allow for transferability or generalisability of the results, despite the fact that the qualitative small sample size may negatively affect the transferability of findings. In this study, sample integration was achieved by using the same participants in both qualitative and quantitative data collection methods, in addition to, randomly selecting the participants for quantitative research.

Inside–outside legitimation alludes to perspective of individuals' inside and additionally an outsider's view. Despite the fact that it is impractical to have outsider's perspectives all the time Onwuegbuzie & Johnson (2006) call for reviewers. The inside-outside legitimation was accomplished, as proposed by Onwuegbuzie & Johnson (2006), by subjecting each research instrument to reviewers who were mathematics educators and also seeking views from the supervisor during data gathering, analysis and interpretation.

Weakness-minimisation legitimation refers to "the extent at which the weaknesses from one method are counteracted by the merits of other method" (Onwuegbuzie & Johnson, 2006, p57). Mixed methods research is in the optimum position for making the best use of this type of legitimation just because the investigator is able to design a research that conglomerates two or more methods. The larger the "degree that the weakness from one method is compensated by the strengths from the other method, the more likely that merging a weak inference with a strong inference will lead to a superior or high quality meta-inference" (Onwuegbuzie & Johnson, 2006, p57). This was achieved through the use of focus group discussions to pick up on what the questionnaire failed to determine.

Sequential legitimation is concerned with the timing of the administration of the quantitative and qualitative instruments. It is assumed that meta-inferences occurring from a sequential mixed methods design could be as a result of the sequencing itself (Onwuegbuzie & Johnson, 2006). Consecutively, to curb such sequence-driven challenges, it is significant to make up for the sequential effect, as was done in this study, by "applying concurrent parallel designs that switch, in terms of timing, the qualitative and quantitative data collection periods" (Onwuegbuzie & Johnson, 2006, p57), to explore the teachers' preparedness to integrate ethnomathematics approaches into the teaching and learning of geometry.

Conversion legitimation is of importance to this study, as it is concerned with the translation of "qualitative data into quantitative data, and vice versa, and the conversion procedures used would produce sound and interpretable quality results" (Onwuegbuzie & Johnson, 2006, p57). To achieve conversion legitimation, in this study the data analysis and interpretation was conducted in an iterative and looping style between qualitative data into quantitative data.

Paradigmatic mixing is the degree to which the combination of the epistemological, ontological, axiological, methodological, and views about mixed research were useful in yielding the research results. From the different "beliefs systems, such as epistemological (objectivity vs. subjectivity), ontological (single reality vs. multiple reality), axiological (value free vs. value-bound), methodological (deduction vs. induction), and rhetorical (formal vs. informal writing style) that leads to a dualistic position that requires precise acknowledgement of the value ladedness of mixed methods study" (Onwuegbuzie & Johnson, 2006, p57). Onwuegbuzie & Johnson (2006) pointed out that it is essential that the quantitative element is explicitly combined with the qualitative element, which was also catered for in this study.

Then again, there ought to be a continuum along which every single double point of view must be united (Onwuegbuzie & Johnson, 2006) for each piece of the continuum to convey its qualities to the issue under investigation. In this study, epistemological, ontological, axiological, methodological, and expository convictions that underlie the quantitative and qualitative methodologies were dealt with in isolation as suggested by Onwuegbuzie & Johnson (2006).

Commensurability legitimation discards the incommensurability proposition and prepares the technique for the amalgamation of results and perspectives (Onwuegbuzie & Johnson, 2006). As examined by Onwuegbuzie & Johnson (2006), the investigator ought to suitably switch amongst qualitative and quantitative methods, consistently attracting from one method in order to improve the comprehension of the other method, and the other way around, indicating how both methods are complementary in providing additional investigational evidence on the problem under investigation. In this study that was achieved by moving back and forth from the qualitative and quantitative data sets to obtain a complete picture of the teachers' preparedness to incorporate ethnomathematics approaches into the teaching of geometry.

Multiple validities is the degree "to which all relevant research approaches are used and the research could be considered high on the several relevant validities" (Onwuegbuzie & Johnson, 2006, p57). For instance, while addressing legitimation of either the quantitative or qualitative element, the relevant quantitative or qualitative validities are attended to. This study achieved multiple validities by using various data gathering techniques, for instance, questionnaires with both closed and open-ended questions and focus group discussions to answer the same research questions on the in-service teachers' preparedness to incorporate ethnomathematics approaches into the teaching and learning of geometry.

Political legitimation deals with the level to which the results stemming from the mixed methods research are accepted by the stakeholders. Onwuegbuzie & Johnson (2006) point out that in quantitative methods the making of decision and authority over the research procedure is centralised to the researcher in a top-down manner. On the other hand, in the qualitative methods, the researcher is seen as a collaborator and facilitator. In mixed research, the investigator takes multiple roles that would lead the researcher to "incorporate a distributed power and decision-making process (the researcher being a multiple-role bearer, a pragmatist working to reach workable solutions" (Onwuegbuzie & Johnson, 2006, p59). In an effort to achieve this kind of legitimation, the current study used pragmatist perspectives that are pluralistic and strive to generate practical ideas. Also an effort was made to ensure that the data gathered would address the research questions adequately.

4.8.2 Reliability in mixed methods research

Sarantakos (2013) define reliability as the ability of any data gathering method to yield consistent research findings. It is as well concerned with measuring consistency, objectivity, precision and stability. In mixed methods research, reliability might be ensured through the use of the same instrument, what Cohen et al. (2015, p. 147) refer to as "reliability as equivalence". By making use of the same instruments during data gathering, this study produced the similar results during the pilot study and the main study. Even though reliability is a concept with various tones in qualitative research, it is commonly taken to mean "replication in generating, refining, comparing and validating constructs" (Cohen et al., 2015, p148). That was attained through the investigator maintaining the same sampling techniques in selecting participants and the same research setting where data was collected.

Practically the same as in validity, in reliability there are two main aspects of concern in this study, which are external reliability and internal reliability as shown in Table 4.3**.**

Table 4.3: Reliability issues in mixed methods research

Reliability Type	**Description**
Internal Reliability	It is concerned with the constancy of gathering, analysing and interpreting of data.
External Reliability	It is deals with the replication of the study.

According to Sarantakos (2013) internal reliability is the consistency of findings in the site and that the gathered data is plausible in that site, while, external reliability is consistency and replicability of research findings across sites. Reliability in quantitative methods refers to the consistency, stability and repeatability of results, for instance, the result of a research is considered reliable if consistent results have been obtained in identical situations but different circumstances. However, the notion of reliability in the qualitative research has do with to the consistency, reliability, dependability, credibility, applicability or trustworthiness of the research results (Cohen et al., 2015). Furthermore, in qualitative research, reliability entails the degree of accuracy and full coverage of the research issues (Cohen et al., 2015). According to Cohen et al. (2015) the term reliability is appropriate to quantitative methods that presumes that research results are reliable if they can be replicated and that if the same methods are used with the same sample, they should produce similar findings. Likewise, in qualitative methods, a certain level of reliability is guaranteed.

Internal reliability was addressed by using mechanical means of recording focus group discussions using a tape recorder. The focus group discussions were recorded and conserved, therefore, the replication or the reanalysis of the data could be simply executed by any researcher. That process resulted in increased internal reliability of the data and results.

In this study, external reliability was ascertained through piloting the instruments, member checking or participant feedback, and triangulation and through a detailed explanation of data gathering methods and analysis procedures. According to Creswell (2015), member checking is a procedure where the participants would serve as a check during the data analysis process. In this study member checking was achieved through taking the findings back to the participants for confirmation and validation purposes. Member checking was used to ensure the accuracy of transcriptions of focus group discussions (McMillan & Schumacher, 2010). Though all eight respondents in each group reviewed their focus group transcripts, no changes were made. In the current study, the various processes of gathering data were clearly explained. The major data gathering methods in the current mixed method research were questionnaires and focus group discussions. Hence, gathering various forms of data through various methods enhanced data reliability.

4.8.3 Validity and reliability of data gathering methods

Validity and reliability are quality measures for data gathering methods in research. The questionnaires included items that generated both quantitative data, as well as open-ended questions that yielded qualitative data. McMillan & Schumacher (2010) refer to this approach as "multi-method strategies" that allows for triangulation of data which helps to improve the validity of the findings. Quantitative and qualitative data were used for triangulation to support the research findings of how in-service teachers were prepared to integrate ethnomathematics approaches into the teaching and learning of geometry.

Moreover, the validity of the self-administered questionnaire and focus group discussion items were ascertained by the mathematics educators in the department of mathematics education. To ensure face and content validity as well as interpretive validity and descriptive validity, Thomson (2011) and McMillan & Schumacher (2010) reported that data gathering instruments may be given to peers or specialist in the area under study for scrutiny. In the current study the developed questionnaires and focus group discussion items were given to three mathematics educators, who were involved in data gathering instrument validation for research at the university under study. The three mathematics educators were asked to comment on the clarity of the questionnaire items and focus group discussions items and their (items) capacity to address the research questions:

1. How are in-service teachers prepared to integrate ethnomathematics approaches in geometry teaching?

Sub-questions

a) How were the in-service teachers trained to teach geometry?
b) How were in-service teachers trained to integrate ethnomathematics approaches in geometry teaching?

2. How do the in-service teachers view the integrating of ethnomathematics approaches in geometry teaching?

Sub-questions

a) How do in-service teachers view ethnomathematics approaches?
b) What are the views of the in-service teachers regarding the integration of ethnomathematics approaches in geometry teaching?

3. Why are in-service teachers not integrating ethnomathematics approaches in geometry teaching?

Sub-question

a) What do in-service teachers perceive as challenges to the integration of ethnomathematics approaches in geometry teaching?

Furthermore, they were asked to take note of grammatical errors. The three mathematics educators' feedback showed that the instruments contained the required information to answer the research questions. Their feedback on grammatical errors were used to improve the items before the instruments were administered in the pilot study. This was done so as to make sure that the focus group discussion items and questionnaires cover the research aspects both in terms of content and details.

Lastly, on validity, member checking was also used to check the accuracy of the data from the focus group discussions (Creswell, 2015). This was achieved through, printing transcripts of focus group discussions that were given to the in-service teachers so that they could check the "accuracy of information" recorded and whether or not the interpretations were fair; and where necessary, amendments to the report were made accordingly (Creswell, 2015). Thus, the plausibility and truthfulness of the findings were established and supported in this research that explored teachers' preparedness in integrating ethnomathematics approaches in geometry teaching.

Reliability was achieved through using a variety of techniques, for instance, the use of both focus group discussions and questionnaires (Neuman, 2000). Thus, reliability in this study was achieved by triangulation. Flick (2009) argues that triangulation can take the form of combining several qualitative methods, or of combining qualitative and quantitative methods. It is considered that the different methods complement one another and in so doing compensates for the weakness of a particular method (Flick, 2009).

This study resorted to a triangulation approach by combining different methods of data collection, both qualitative (focus group discussions, questionnaire open-ended questions) and quantitative (questionnaire closed-questions), to ensure reliability. Triangulation also enhances credibility through improving equally internal reliability and generalisability. Furthermore, the reliability of the instruments was established through a pilot study. The pilot study was conducted with a different group of in-service teachers at the university under study. The process is discussed in detail in the pilot study section. The testing was done to determine the extent to which the questionnaires and focus group discussions schedule were likely to yield consistent responses from in-service teachers (Cohen et al, 2015). The piloting of instruments can reveal unanticipated problems with question wording, and instructions (Seale, 2012). It helped the researcher to become aware of whether the participants understand the meaning of questions the way the researcher understands them.

4.9 Piloting study

A piloting study was carried out to determine the reliability and validity of the data gathering instruments including the aspects of feasibility of administering the data gathering instruments (Cohen et al, 2015) in the constrictions of the university. Trying the data gathering instruments using a small number of teachers was helpful in coming to grips with the actual phases of the study methodology.

4.9.1 Purpose of pilot study

In particular, the main purposes of conducting a pilot study were;

- To estimate the duration of administering the data gathering instruments.
- To gain feedback on techniques for conducting the main study.

- To find out whether the instructions and the data gathering items were clear to the participants.
- Testing the reliability and validity of the data gathering instruments.

4.9.2 Sample of the pilot study

Twelve willing in-service teachers who were excluded in the main study sample as their involvement in the pilot study would distort the research findings took part in the pilot study.

4.9.3 Administration of the pilot study

Permission to carry out the study was attained from the university under study. In-service teachers signed consent letters, which informed them about the rationale of the study, their right to take part or not to, that participation was of your own free will, as well as the techniques in which confidentiality would be guaranteed. The research instruments namely, questionnaires and focus group discussions were administered to the teachers during the pilot study after they have been validated by three mathematics educators. The in-service mathematics teachers were asked to note the time taken to respond to the questions, and to comment on the simplicity of questions and grammatical mistakes as well as to write down any comments they have regarding the nature, appropriateness and sequencing of the items. Two focus group discussions were piloted with the twelve in-service teachers. Each group comprised of two female teachers and four male teachers. Data collected from both the questionnaires and focus group discussions was analysed.

4.9. 4 Results of pilot study

- There were similarities, consistency and similitude on the pilot study results. In other words, the responses of the in-service mathematics teachers were in agreement in terms of how they responded to the questions on each data gathering instrument. The reliability of data gathering instruments was generally guaranteed basing on the pilot study's outcome.
- The in-service mathematics teachers' views on their preparedness to integrate ethnomathematics approaches in geometry teaching were established.
- The findings of the pilot study were used to improve the data gathering instruments. For instance, question 4 on focus group discussion guide was deleted because it yielded the same result as question 12.
- The pilot study results were also used to ascertain the estimated duration of each instrument. The average time taken by the in-service teachers to complete each instrument

was used to determine the duration of each instrument. The focus group discussions took an average of one hour whilst the questionnaires required an average of 50 minutes. The average duration required for each instrument guided the main study.

4.10 Administration of the main study

4.10.1 The main study

The forty selected in-service teachers at the university under study took part in the main study.

4.10.2 Administration of the main study

The procedures used in the pilot study were also employed in the main study. The research instruments that were piloted and validated were administered to the teachers.

4.11 Anticipated Problems/Limitations

It was possible that some participants could provide answers which may not be true, but which they believed would be appreciated since the researcher was one of the lecturers teaching mathematics education to in-service teachers. It was hoped that through a follow up with focus group discussions, such responses may be validated. The researcher was conscious of the conceivable conflict of interest that might emerge because of the double role of researcher and lecturer (Lankshear & Knobel, 2005).

The investigator did not take advantage of her position as lecturer to force, manipulate or coerce in-service teachers to take part in the study (Burton & Bartlett, 2005). The investigator was conscious of power relations between her as a lecturer and participants since this could have had effects on the both questionnaire and focus group discussions responses. Participants could have responded in ways that they felt would make the investigator happy or act in manners they think the investigator needed them to act. Hence, absence of cautious consideration regarding the impacts of the lecturer as an authority in the study could have rendered results of the study invalid. Gray (2011) recommends that researchers must remain calm and unbiased in such situations. It was important that the researcher carried out her usual responsibilities of teaching as if no research was going on.

It was also possible that participants could withdraw from the study. In such cases, the researcher must recognise the rights of any participant to withdraw from the study at any time, and informed them of this right (Curtis & Curtis, 2011). In such circumstances, the appropriate course of action for the researcher was to accept the participants' decision to withdraw. In the event that participants decide to withdraw from the study, the researcher should not use duress of any form to convince participants to re-engage them in the study (Curtis & Curtis, 2011). Fortunately, none of the participants withdrew from participating in the study.

4.12 Ethical Issues

Given that this study included the gathering of information from and about individuals (Creswell, 2015), every single moral prerequisite that apply to such research were considered and particularly as it was with in-service mathematics teachers. Ethical principles were considered to protect the dignity and safety of the teachers in the study or as a result of publication of the research findings (Silverman, 2011).

An ethical clearance was applied for from the Ethics Committee of the University of Kwazulu-Natal before data collection commenced. Permission to carry out the research was granted, and an ethical clearance certificate was issued as confirmation that the study was conducted in line with the expectations stated in the application for ethical clearance.

In order, to gain access into the university under study, written permission was obtained from the university under study. In this study, a letter of consent (Appendix A1), with ethical principles which include: voluntary participation; informed consent; guaranteeing anonymity of teachers and confidentiality of their responses (Bulmer, 2008), was implemented. The letter also briefly explained the focus of the research to teachers so that they could make an informed choice to take part in the research voluntarily, and were informed that they had the right to withdraw from the study at any time (Flick, 2009). Participants signed consent letters (Appendix A1) to indicate consent and voluntary participation in the study (Curtis & Curtis, 2011). Permission to audio-record the focus group discussion was obtained from the teachers.

All those who took part in the study were referred to using pseudonyms 'to preserve anonymity and to safeguard confidentiality' (Silverman, 2011, p.166). Pseudonyms were also utilised to identify to the university and in labelling the groups' audio-recordings and transcriptions as a way of guaranteeing confidentiality and non-traceability of participants. The researcher also undertakes to keep all notes, audio-tapes and transcripts in a secure place during the research and to destroy them afterwards to avoid misuse of the data by other parties for other purposes not related to this study.

4.13 Summary

The chapter presented the research methodology for the current study outlining the research paradigm, design, the population and the sample. Data gathering, envisioned data analysis processes, administration of the pilot study in addition to instrumentation procedures were discussed. Reliability and validity issues were as well discussed. Ethical issues considered in the study were also addressed in this chapter. Chapter 5 focuses on the findings, analyses and discussion of the data.

CHAPTER 5: FINDINGS, DATA ANALYSIS AND DISCUSSION

5.1 Introduction

The preceding chapter discussed the methodology employed to carry out the research. The purpose of this convergent parallel mixed method study was to explore the in-service teachers' preparedness to integrate ethnomathematics approaches into the teaching of geometry. Forty in-service mathematics teachers who completed the questionnaires also formed five groups comprising eight participants (five male and three female) for the discussions. As alluded to in chapter 4 and consistent with the ethics in research, anonymity was observed. Therefore, the five groups were coded A, B, C, D and E for confidentiality purposes. The research results presented below emerged from the analysis of two data sources; namely, questionnaires with closed-ended and open-ended questions and focus group discussions. The quantitative data were derived from the closed-ended likert type questionnaire questions, whilst the qualitative data were from the open-ended questionnaire questions and focus group discussions. After quantitative data analysis methods and qualitative data analysis methods were used to analyse the data, as elucidated in chapter four, the two data sets were merged in this chapter, and the six themes that emerged are indicated in Table 5.1.

Table 5.1: Themes and sub-themes

Main themes	**Sub-themes**
1. Teachers' views on their training to teach geometry	Teacher training on geometry
	Their lecturers' instructional practices
	Instructional practices for teaching geometry
2.Teachers' views on their training to integrate ethnomathematics approaches	Integration of ethnomathematics approaches
	Not trained to integrate ethnomathematics approaches in teaching geometry
	Definition and understanding of Ethnomathematics

3. Teachers’ conception of ethnomathematics approaches	Awareness of ethnomathematics approaches
	Teachers’ views on geometry content taught in schools
	Teachers’ views on their roles for teaching geometry
4.Teachers’ integration of ethnomathematics approaches into the teaching of geometry	
5.Teachers’ views on integration of ethnomathematics approaches into the teaching of geometry	
6. Challenges in integrating ethnomathematics approaches into the teaching of geometry	Learner related challenges
	Nature of geometry
	Insufficient resources
	Curriculum related challenges
	Teacher related challenges
	Parental involvement

To remain focused in the presentation, results are presented under the main and sub-themes. The themes correspond to the main and sub-research questions that guided this study. In some instances, results covered more than one research question. In addition, some responses were mentioned several times under different themes, but from a different point of view. The first theme of teachers’ views on their training to teach geometry is discussed below with its three sub-themes.

5.2 Teachers’ views on their training to teach geometry

It was crucial to consider teachers’ training on geometry as their possession of the geometry content knowledge is vital in the integration of ethnomathematics approaches. Teachers’ geometry content knowledge is essential as it relates to their practice of teaching including the integration of ethnomathematics approaches into the teaching of geometry. During their training, teachers are expected to acquire geometry content knowledge, which enables to them to teach and to relate geometry to real situations. Therefore, it was vital for this study to examine whether the teachers were trained to teach geometry and how they were trained.

5.2.1 Teacher training on geometry

Data from closed-ended questionnaire questions showed that 25 participants had taken some courses in geometry during their teacher training. This was supported by the data from the open-ended questionnaire questions which revealed that 28 participants were taught geometric concepts during their training. The statistics clearly indicate that geometry concepts were taught at teacher training institutions. Data from the focus group discussions also confirmed that teachers were taught geometry concepts during their teacher training, as the following teachers' extracts show:

"Three courses with all the concepts such as statistics mechanics, pure mathematics. Two courses; mechanics and pure mathematics had geometry concepts". (Group A)

"Eight courses, almost all the courses had an element of geometry; mechanics 1 & 2, pure mathematics 1, 2, 3 & 4 and Applied Mathematics Education 1&2". (Group B)

"Four courses for 2 years, two courses had geometry concepts; mechanics and pure mathematics". (Group C)

"Ten courses, two had geometry concepts, Applied Mathematics Education 1&2". (Group D)

"Ten courses, three had geometry concepts, pure mathematics 1, Applied Mathematics Education 1&2". (Group E)

From the above statements, Groups D and E had the highest number of mathematics courses, ten followed by Group B, with eight, Group C, with four and Group A, with three which was the least. Geometry concepts were taught in as few as two mathematics courses (Group A, B and D) and as many as eight (Group B). This is in line with the view that teachers need to have an in-depth knowledge of the geometry concepts that they teach (Jones, 2002). Teachers' geometry knowledge is necessary for the integration of ethnomathematics approaches into the teaching of geometry.

However, the results show that there were inconsistencies in how the teachers view the ways they were trained to teach geometry. The following two sub-themes are discussed below which are; adequate teacher training in geometry and inadequate teacher training in geometry.

5.2.1.1 Adequate teacher training in geometry

The results of this study from open-ended questionnaire questions showed that 21 participants believed that they were adequately prepared to teach geometry. Their responses are presented in Table 5.2.

Table 5.2: Reactions from the teachers who were adequately prepared to teach geometry (n=40)

Representative quotes
I did not see or face any challenges when the topic was introduced to me
I mastered the concepts and aware of the problem areas
I don't have any problems in teaching geometry concepts
I have been well equipped with several approaches
It's an interesting topic

Some of the teachers (21) reported that they were adequately prepared to teach geometry concepts. They indicated that they did not have any problems when teaching geometry (see Table 5.2). This was supported by the data from the focus group discussions which showed that the teachers from Groups A, B and C were prepared to teach geometry during their training or professional development. A statement representative of Groups A, B and C was presented by Group B:

"Yes, we were trained to teach geometry. We were trained to use teaching aids and charts and to draw shapes using mathematical instruments." (Group B)

Teachers from Groups A, B and C reported that they were trained to teach geometry. This data was further supported by teachers' responses from open-ended questionnaire concerning the coverage of geometry content during training, where 18 participants indicated that their training was adequate. Reasons mentioned by the 18 participants whose lecturers taught geometry-related areas of the curriculum adequately were classified into two categories; adequate coverage of the syllabus without linking to culture (see Table 5.3) and adequate coverage of the syllabus with a linkage to culture and practical examples (see Table 5.4).

Table 5.3: Adequate coverage of the syllabus without linking to culture (n = 40)

Representative quotes
Almost all areas were covered in the course outline.
Used were methods that made me answer examination questions.
Concepts were linked well to the demands of the syllabus.
General geometry was covered.

The lecturer managed to cover all concepts highlighted in the syllabus.
It was according to the curriculum leading to maximum understanding.
Only used chalk-board and textbook through demonstration.
Just used geo tools and did not explain how we used them to arrive at the final answers rather deeper understanding as it demands.

The responses from open-ended questionnaire questions (as shown in Table 5.3), indicated that some of the teachers felt that they adequately covered the syllabus, but their learning of geometry concepts was not related to their cultural activities or experiences. The finding is in line with Katsap & Silverman (2008) who asserted that teacher training institutions prepare teachers for geometry teaching without any connection to culture. This scenario makes the teachers to view geometry as universal and culture-free (D'Ambrosio, 2001).

Table 5.4: Adequate coverage of the syllabus with a linkage to cultural examples and activities (n=40)

Representative quotes
We were given a project of making geometrical instruments, using locally available materials, for use in the class in the event that you would be deployed in a remote school without resources.
Very well and practical examples were given.
Practical examples were done.
Linked syllabus requirements and culture.

On the other hand, some teachers (see Table 5.4) felt that their adequate coverage of the syllabus was complemented with a linkage to cultural examples and activities. The idea of relating geometry concepts to cultural examples and activities is advocated for in ethnomathematics approaches (Massarwe, et al, 2012). The responses of the participants indicated that they did not face difficulties in understanding geometry concepts because their lecturers related the teaching of geometry to cultural examples and activities. The finding is in line with Katsap & Silverman (2008) who noted that teachers' experiences with ethnomathematics approaches and geometry did not only refine and extend their understanding of geometry content but also their understanding of geometry pedagogy.

Teachers' reasons for not facing difficulties in understanding geometry concepts

The data from open-ended questionnaire questions show that 24 participants did not face difficulties in understanding the geometry concepts. Their reasons for not facing difficulties in understanding geometry concepts during their teacher training program were coded as lecturers' practices (see Table 5.5), sufficient resources (see Table 5.6), lecturers' geometry content knowledge (see Table 5.7) and the interdisciplinary nature of geometry as shown in Table 5.8.

Table 5.5: Lecturers' practices (n=40)

Representative quotes
Examples taken from the local environment.
Geometry was linked to culture.
The practical approach was stimulating since it was learning by doing.
Using practical examples enables better understanding of geometry concepts.
Equipped with practical methods of teaching geometry, using geo-boards.
ICT in teaching and models helped a lot.
Steps followed sequentially in learner-centred approaches and aids were used.
I was given skills to employ different media and technological tools.
All approaches were used and are at my disposal for use now.
It is easy to explain and demonstrate if knowledgeable.
The instruments and media for the lessons were well prepared.
Geometry concepts were well understood due to use of media such as practical activities using geo-boards and compasses.

Lecturer's practices can influence how the learners learn and understand the geometry concepts. Data from open-ended questionnaire questions showed that their lecturers' practices helped the teachers understand the geometry concepts (see Table 5.5). Teachers attributed their adequate training in geometry to learner-centred approaches such as practical teaching methods and the use of media and geometry instruments that helped in their understanding of geometry concepts. Lecturers' use of the practical approach to teaching geometry is in line with D'Ambrosio (2001) who stated that ethnomathematics approaches can also be used as a practical approach. In addition, geometry concepts were linked to the cultural and environmental backgrounds of the teachers. The use of learner-centred approaches, media and relating geometry to their cultural background is in line with the both social constructivist, humanist views of teaching geometry and ethnomathematics approaches. These support a more learner-centred approach to learning as well as connecting the learners' culture and social context to the teaching of geometry (Vygotsky, 1978; Boaler, 1993; Ernest, 1991).

Table 5.6: Sufficient resources (n=40)

Representative quotes
Very few to no challenges because resources are natural and easily/readily available.
Visual models were there to support the learning of geometry.

Teachers indicated that geometry resources were sufficient because the resources were natural and locally available (see Table 5.6). This was supported by teachers from Group B who felt that they had enough resources to consolidate their geometry understanding. Teachers from Group B said:

"At college we had enough materials". (Group B)

Their response about content sources available to them on the topic of geometry indicated that they had had enough activities to consolidate concepts taught. In addition, their response might point to the fact that content sources were not so much of a problem in contributing to difficulties in their learning of geometry.

Table 5.7: Lecturers' geometry content knowledge (n=40)

Representative quote
The lecturer had adequate knowledge and was very skilful.

The responses of the participants indicated that that their lecturers' had adequate geometry content knowledge (see Table 5.7). The responses of the participants indicated that they were of the view that adequate knowledge helped their lecturers to understand how they acquire knowledge and to develop geometry activities based on their cultural experiences that supported their understanding of geometry concepts.

Table 5.8: The interdisciplinary nature of geometry (n=40)

Representative quote
It integrates well with other mathematical concepts, such as properties and construction of shapes, vectors and matrices.

The participants' responses in Table 5.8 show that geometry integrates well with other mathematics topics. Geometry is of great importance in a wide range of topics in mathematics (Jones, 2002) and therefore facilitates integration across topics.

Data from the focus group discussion also supported teachers' views from the open-ended questionnaire questions that 24 participants did not have difficulties with geometry concepts. Teachers from Groups A, B and C indicated that they did not have any difficulties with geometry concepts. This was supported by the following statements from the focus group discussions:

"No we don't have any problems with geometry. At our level no we think we are trying our best". (Group A)

"For the level that we are currently teaching, that is, 'O' Level we don't have any problems". (Group B)

"No, we don't have any problems". (Group C)

The comments further support that those teachers did not have any challenges when teaching geometry. The teachers were able to use their knowledge of geometry in decision-making, in choosing teaching approaches and to prepare the teaching and learning activities they use in class.

Furthermore, data from the focus group discussions showed that some teachers (8) were even capable of teaching geometry up to 'A' level, asking what is new about teaching geometry at that level as can be seen from the teachers in group B's statement:

"Very much. Yes we are competent. We can teach even up to 'A' level what's new?" (Group B)

From these comments it seems that those teachers were over-confident in terms of their knowledge base. It indicates that they were positive and ready to teach geometry because teaching content was not a problem to them. They claimed that they were competent in teaching geometry.

Some of the teachers (16) felt that they were competent to teach geometry to the level that they were teaching, the 'O' level, which was the level they were trained to teach. This was supported by the following statements from the focus group discussions:

"Yes, we are competent to teach geometry, but not using ethnomathematics, it also depends with the level for the 'O' level we are comfortable". (Group A)
"Yes we are competent, it is practical, hands-on activity". (Group C)

The comments illustrate an emphasis on the practical aspect of teaching geometry. According to what they said, these teachers seemed to be competent in teaching geometry, but not using ethnomathematics approaches as indicated by teachers from Group A.

5.2.1.2 Inadequate teacher training in geometry

It is possible that teachers' deficiency in geometry content would affect the teaching and learning of geometry concepts. Data from open-ended questionnaire questions showed that 19 participants believed that they were not adequately prepared to teach geometry, hence their geometry content knowledge for teaching was inadequate, as indicated by representative quotes in Table 5.9.

Table 5.9: Lack of geometry content knowledge

Representative quotes
I lacked the key needs required to teach geometry.
Not enough knowledge was acquired during my training.
Less knowledge on teaching geometry.
Lack understanding of geometry concepts.
It is not possible because some of the concepts were not even taught, for instance, transformation.

Lack of geometry content knowledge

Teachers reported that they lacked knowledge on geometry (see Table 5.9), signifying that they were not adequately trained to teach geometry. In order to teach using ethnomathematics approaches, teachers should have a deep understanding of geometry content. Teachers not only did they have to be experts in geometry content knowledge, they should also have a good idea of how much their learners know about the content, which can be accomplished if teachers have a deep understanding of geometry. Teachers' lack of geometry content knowledge was also supported by the data from open-ended questionnaire questions and focus group discussions on partial coverage of geometry concepts and those who were never taught geometry concepts.

Partial coverage of geometry concepts

Data from open-ended questionnaire questions showed that 16 participants felt that their lecturers only partially taught the geometry-related areas of the syllabus; their responses are shown in Table 5.10.

Table 5.10: Partial coverage of geometry concepts (n=40)

Representative quotes
Not all concepts were covered.
The lecturers did not have enough time to cover all the geometry concepts.
The lecturer dealt with issues that were familiar to him.
Time factor. The lecturer just gave only an introduction to geometry.
Some of the concepts were left untaught, for instance, transformation.

Data from the focus group discussions supported the partial coverage of geometry content during teacher training. This is what teachers from Group D said:

Not prepared to teach geometry concepts such as transformation because teachers skipped the topic. Lecturers themselves don't understand it, maybe they were not teaching it because they themselves too were never taught. Transformation was skipped so we will skip it too, because we don't know what to teach" (Group D).

The teachers pointed out that geometry was not adequately covered, for instance, they pointed out that they were going to skip the concepts of transformation that were also skipped during their own training.

Never taught geometry concepts

Data from open-ended questionnaire questions showed that 6 teachers felt that their lecturers never taught geometry-related areas of the syllabus; their responses are shown in Table 5.11.

Table 5.11: Never taught geometry concepts

Representative quotes
Not familiar with the concepts.
We were never taught the areas of the syllabus concerning geometry.
Not formally part of their syllabus.

Data from focus group discussions also confirmed that a few teachers were never taught geometry concepts either during secondary school or their teacher training period, as the following teachers' extract shows:

"No, not trained to teach geometry. At secondary school this was poorly done, and the teacher never taught us, at the college the lecturers said this was covered at secondary school level, so there was no need for repeating the same geometry concepts" (Group E).

Those teachers pointed out that they were never taught geometry concepts during their training. This may indicate that those teachers had little or no experience and knowledge of their own on which to base or develop geometry teaching activities. The finding is in line with Jones (2002) who asserts that geometry was neglected in some schools, colleges and universities in favour of other mathematics topics.

Furthermore, the data from the focus group discussions showed that teachers were not competent to teach geometry because they lacked geometry knowledge, they were not confident because geometry concepts were not fully taught during their teacher training. Considering that those teachers were trained and they were supposed to teach geometry concepts as a topic in the syllabus that is currently in use in Zimbabwe, it was surprising that they were not competent to teach geometry. The groups' responses were:

"No we are not competent and not confident because we lack knowledge on geometry" (Group D).

"No we are not competent, we were not adequately taught geometry concepts, we lack knowledge to teach geometry, and it was partially taught" (Group E).

The lack of geometry knowledge and confidence to teach it was a critical issue, because teachers' lack of geometry teaching competency increases the likelihood that because it will not be taught as planned, the ethnomathematics approaches cannot be realised.

Teachers' difficulties in understanding geometry concepts

The teachers who were not adequately trained to teach geometry also had some challenges in understanding geometry concepts. Data from open-ended questionnaire questions showed that 16 participants had difficulties in understanding geometry concepts during teacher training. Their reasons for not being adequately trained to teach geometry and for facing difficulties in understanding geometry concepts were categorised as lecturers' practices (see Table 5.12), teachers' lack of the interdisciplinary nature of geometry (see Table 5.13) and insufficient (see Table 5.14) resources and terminology/language of geometry as shown in Table 5.15.

Table 5.12: Lectures' practices (n= 40)

Representative quotes
Lecturers did not link geometry concepts to culture or environment.
Teaching methods used were not clear to understand geometry concepts.
I still face challenges to deliver since l was taught using a demonstration method.
My teacher never explained clearly and in detail.
There were no examples made by the teachers during lessons for instance, relating to our real life.
Teachers forced me to regurgitate or memorise without deriving them for me to see where the concept is coming from.
Simply followed what the lecturer asked us to do.
Some of the concepts like transformation were not taught.
Geometry content was from the syllabus only.

Lecturers' practices involves the way they interact with the learners and the teaching approaches they use. The teachers considered how they were taught by their lecturers to be responsible for their difficulty in understanding geometry concepts and for their inadequate training to teach geometry (see Table 5.12). The approaches used involved learning through memorisation and rote learning which are based on traditional views of teaching. Geometry knowledge learned through memorisation is limited and shallow which could eventually lead to difficulty in understanding geometry concepts and ultimately limited geometry content knowledge. Some of the teachers (see Table 5.12) pointed out that their lecturers, did not link geometry teaching and learning to cultural examples and experiences. Their lecturers' practices were not in line with ethnomathematics approaches that connects the learners' cultural and immediate environments to the teaching of geometry (D' Ambrosio, 2001).

Table 5.13: Teachers' lack of knowledge of the interdisciplinary nature of geometry (n=40)

Representative quotes
Lack of background knowledge.
Inability to link geometry content with other areas of mathematics.

Geometry concepts are interrelated with many topics in mathematics (Jones, 2002). The extracts from the open-ended questionnaire questions showed that the teachers lacked the background knowledge and could not relate geometry to other areas of mathematics (see Table 5.13).

Data from focus group discussions also confirmed that the teachers' lack of pre-requisite knowledge in geometry such as vectors and matrices, as the following teachers' extracts show:

"Geometry transformation, shear, stretch and enlargement requires the knowledge of vectors and matrices. It is difficult to link these geometry concepts with other topics such as matrices and vectors because we lack the knowledge on how to link these topics. We have limited prior knowledge on linking geometry concepts with topics such as vectors and matrices" (Group D).

Lack of background knowledge and the inability to connect geometry to other areas of mathematics hinders the integration of ethnomathematics approaches into the teaching of geometry, as this cannot be achieved if the teachers themselves have difficulties with the pre-requisite knowledge required for the teaching of geometry.

Table 5.14: Insufficient resources (n=40)

Representative quotes
Lack of resources
Time and resources were scarce.
Because of the time factor, it was not enough.
Geometry needs more time.

Some of the teachers (see Table 5.14) felt that they had insufficient time and resources. In most instances where time is a scarce, resource lecturers tend to rush to cover the syllabus, and in doing so they employ traditional methods that makes it faster to complete the syllabus. Such practices do not support the integration of ethnomathematics approaches. The data from focus group discussions confirmed that the teachers did not have enough geometry resources during their training. The teachers from Group A, C, D and E felt that they did not have enough resources to consolidate their understanding of geometry as represented in their voices below:

"No, we didn't have enough geometry resources and also the time did not allow us to do much. Lecturers did not have adequate knowledge on geometry" (Group A).

"We lacked modern visual aids and models and also we lacked field trips in geometry" (Group C).

"No, we didn't have enough resources in geometry" (Group D).

Teachers from Group A, reported that their lecturers lacked geometry content knowledge. This might have posed challenges on their understand geometry and how they would approach it in their own teaching in schools. The implication is that it would be difficult for both such lecturers and the teachers to integrate ethnomathematics approaches into the teaching of geometry.

Table 5.15: Terminology/language of geometry

Representative quotes
Words and terms used were too abstract, for example, corresponding/alternate, l do not understand what they mean.
I could not understand the concept of equidistance of shapes in geometry construction.
Geometry is too abstract.
Geometry is demanding especially with this modern era of technology.

Participants pointed out that geometry is abstract and demanding, particularly with the use of technology (see Table 5.15). Furthermore, the participants indicated that terminology/language of geometry acts as a barrier in their understanding of geometry concepts. The finding concurs with Telima (2011) who notes the geometrical language and terminology as factors that contribute to the difficulty in understanding geometry.

In addition, the data from the focus group discussions confirmed that teachers had some problematic areas in geometry. The following extracts are exemplars:

"Yes some geometry concepts are difficult, for example, transformation, shear, stretch. These are difficult and boring concepts, which needs a practical approach. We lack knowledge on these concepts" (Group D).

"Yes concepts such as transformation, circle geometry are difficult and these were skipped during our training. There are too many theorems in geometry" (Group E).

The teachers attributed their difficulties with these geometry concepts to lack of background knowledge, the concepts being skipped during training, too many theorems, and difficult and boring tasks in geometry concepts.

The findings from this section of the study showed that some teachers (16) were not adequately prepared to teach geometry because they did not possess the kind of repertoires of geometry content knowledge which would assist them in teaching geometry.

5.2.2. Their lecturers' instructional practices

The teaching approaches employed in teacher training program were important to this study because they point to how the teachers were trained and also determine the way the teachers would teach geometry in schools. The teachers described the approaches which were implemented in teaching geometry by their lecturers. Two categories of approaches that their lecturers used were identified from their explanations: learner-centred approaches and teacher-centred approaches.

Learner-centred approaches

Data from the closed-ended questionnaire questions showed that 22 participants disagreed that geometry concepts were taught using the traditional approaches during their teacher training. This indicates that other teaching approaches such as the learner-centred approaches could have been employed during their teacher training program. The non-use of traditional approaches during their training was supported by the data from the open-ended questionnaire questions that indicated that 17 participants were taught geometry concept through learner-centred approaches, for instance, guided discovery methods, problem based learning as well as project-based techniques. In addition, the participants reported that their lecturers made use of teaching aids such as wire models, geo boards and visual aids.

Lecturers also used cultural examples whereby they could relate geometry to cultural experiences; for instance, a goat tied to a tree with a rope can walk around the tree with the rope fully extended to make a circle with a radius equal to the length of the rope. This could be used to find the total area grazed by the goat. Participants also indicated that case studies and practical approaches were also employed by their lecturers in the teaching of geometry and they referred to these approaches as learning by doing with the use of real objects.

Data from focus group discussions also confirmed that the lecturers used learner-centred approaches when teaching geometry. For example, teachers from Group B and D said:

"We were exposed to a practical approach. Practical is very important and helpful in understanding geometry" (Group B).

"Discovery learning was used by our lecturer. We were given tasks to work on and encouraged to research" (Group D).

The learner-centred approaches such as the practical approach, discovery methods, and problem based learning and project-based methods were used by their lecturers. These learner-centred approaches fit well within the social constructivist instructional approaches and ethnomathematics approaches (Matang, 2002; Schunk 2014).

Teacher-centred approaches

Data from the open-ended questionnaire questions showed that 23 participants were taught geometry concepts during their teacher training through traditional methods, for instance, the lecture method and the demonstration method. This was supported by the data from the focus group discussions where teachers from Groups A and C said:

"Abstract teaching, it is only now that we understand some of the concepts" (Group A).

"Use of formulas, abstract concepts, formula approaches rather than practical approach was used. It was too theoretical from the lecturer, bookish and examination oriented that is why our learners do not like geometry because of the way we teach. We teach in the same manner we were taught and our learners cannot apply geometry in daily life so they say geometry is not relevant in their life" (Group C).

The above comments indicate that the teaching approaches involved use of formulas and the teaching was also abstract. It also emerged that the teachers were likely to teach in the same way that they were taught.

Data from the focus group discussions indicated that all the teachers have done some pedagogics courses: Group A had taken six, the highest number of courses; Group B and E each had taken five; Group C had taken three and Group D had taken one, the least number of courses. Two categories of teaching approaches that were used during pedagogics courses were identified: learner-centred approaches and teacher-centred approaches.

Learner-centred approaches

Teachers from all the five groups mentioned that they were involved in learning groups, for instance, group presentations and peer learning. A statement representative of all the groups was presented by Group B teachers:

"We had tutorial groups and peer teaching for specific subjects where we would criticise one another" (Group B).

Peer teaching and tutorial groups are features of both social constructivists' views of teaching geometry and ethnomathematics approaches (Ernest, 2009; White-Fredette, 2010; Schunk, 2014). During peer teaching and group presentations, the participants had opportunities to ask questions and be involved in meaningful discussions where they were free to contribute and discuss issues in pedagogy from a mathematical perspective, as a result new knowledge was constructed.

Teacher-centred approaches

Within the category of teachers who said that they were taught pedagogic courses using teacher-centred approaches, an example of such methods was the lecture method mentioned by the participants from all groups where the lecturer transmits knowledge to the learners who try to receive and keep it. A statement representative of all the groups was presented by Group C teachers:

"A lecture method was employed. What we call mass lecture involving all of about 200 pre-service teachers from all the different subjects. The group was just too large" (Group C).

From the above comment, it was noted that in this study, the reason for using the lecture method may have been the large class size, which was about 200. This very high ratio of trainee teachers to lecturer in teachers training programs in Zimbabwe, made lecturers to resort to teacher-centred approaches. Use of the lecture method by their lecturers concurs with Adler (2005) who observed that teacher-centred approaches were widely used in teacher training programs.

5.2.3 Instructional practices for teaching geometry

This section focuses on the teachers' instructional practices in teaching geometry. From the teachers' explanations, two broad categories of teaching approaches have been identified. The approaches were categorised as teacher-centred approaches and learner-centred approaches.

Teacher-centred approaches

The focus group discussions generated data which indicated that about 24 participants used teacher-centred approaches that did not engage learners greatly in the teaching and learning process. Their reasons for using such approaches were content coverage, time, lack of geometry content knowledge and that it is how they were taught. This is what they said:

"Teacher exposition is being used because the approach is fast in covering the syllabus that is too long. In order to finish the syllabus. If methods such as guided discovery were to be used it is challenging because the rate of operation of the learners is slow" (Group B).

"Demonstration method is used because learners are not knowledgeable, lack of time and that's the way we were taught" (Group D).

"We use teacher demonstration, procedural approach, pose questions and let them research because we too lack knowledge. We don't have the adequate content to teach geometry" (Group E).

Teacher-centred approaches, for instance, demonstration and exposition were mentioned by the teachers and were useful in covering the syllabus because their goal of teaching was to finish the syllabus. Furthermore, the demonstration method was used because of lack of time, inadequate geometry content knowledge and that it was how they were taught.

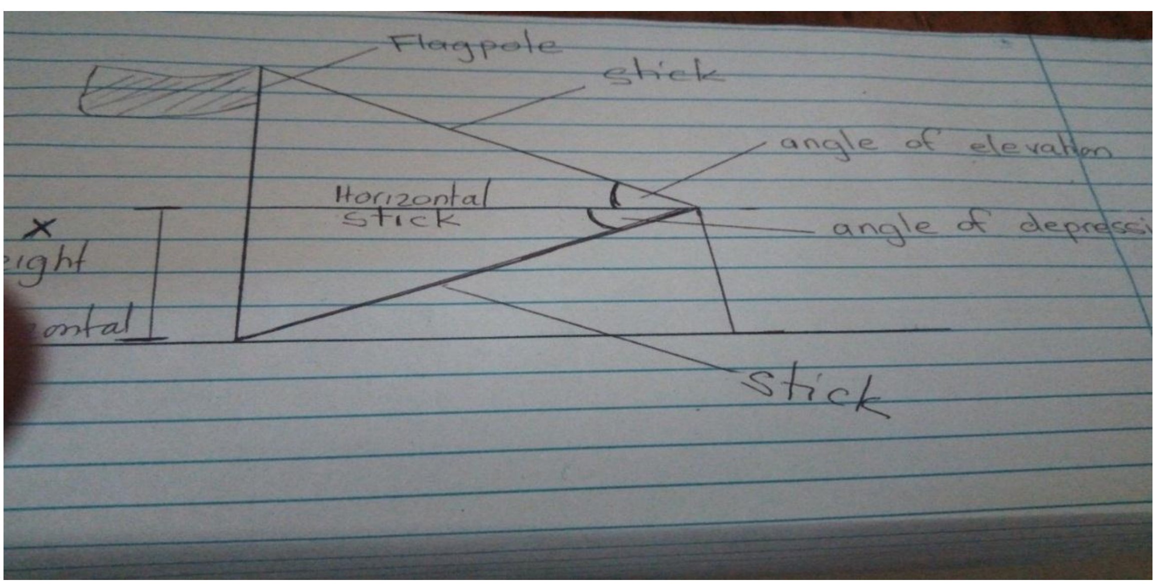
Learner-centred approaches

On the other hand, teachers reported that they used approaches such as discovery, dramatisation, role play and field work. Teachers who claimed that that they use learner-centred approaches had this to say:

"We use guided discovery, dramatisation and role play for shapes, for instance, the learners can be asked to stand in such a way that they form a triangle. We also make use of real objects and

examples in three dimension, for instance, a round hut is useful in teaching mensuration of solid shapes in particular cones and cylinders, with the base of the round hut representing a cylinder and its roof top representing a cone with vertex at the top. For learners to understand the concepts, motivation, usefulness to content, to enjoy geometry, appreciate the geometry in the environment, remove the geometry phobia" (Group A).

We use fieldwork when teaching angles of elevation, for example, learners are put into groups and are asked to bring three long straight sticks. Each group will be asked to go outside to the flagpole. Each group will be provided with a protractor to measure the angles. One learner will hold the stick horizontally to the flagpole and mark where it rests on the flagpole and measure its height from the ground. Another learner will measure the angle of elevation and the angle of depression. From these activities, learners are required to calculate the height of the flagpole through (a) Using the bottom triangle to calculate the length of the horizontal distance X from the flagpole. (b) And then use the top triangle to find the other height of the flagpole. By adding the two heights of the bottom and top triangles you will have the height of the flagpole (see Extract 5.1)" (Group A).



Extract 5.1: Group A's response

"We use guided discovery, we involve the learners, hands-on, and it's a practical topic especially the construction part of it. Learners construct different angles of 120°, 60°, 45°, 30° and 90° using geometrical instruments. We use learners' prior knowledge because they are not empty vessels or

tabula rasa. Prior to teaching geometry we ask learners to identify different shapes in the classroom, and we even measure length and width of various object in the classroom and then find the area of these objects" (Group C).

The responses revealed that learner-centred approaches were used by the teachers. The learner-centred approaches were in line with ethnomathematics approaches that involve strategies that would enable learners to be active during the learning process, practical oriented and project oriented (D'Ambrosio, 2001). Similarly, their reasons for using learner-centred approaches such as capability to motivate learners, help learners to understand geometry concepts, enjoy geometry, appreciate the geometry in the environment, and remove the geometry phobia were in line with the benefits of using ethnomathematics approaches (Matang, 2002; Madusise, 2015; Rosa & Orey, 2010).

In summary, the central objective in this section was to explore teachers' exposure to geometry concepts and the teaching approaches that their lectures employed in teaching geometry. The results showed that some teachers were adequately trained to teach geometry, whilst others were not. Results also showed that both learner-centred and teacher-centred approaches were employed by both the lecturers and teachers in teaching geometry. Teachers seemed to have adopted the teaching approaches they experienced during their teacher training program.

5.3 Teachers' views on their training to integrate ethnomathematics approaches

Teachers' views on how their training equipped them with the different ways of incorporating cultural examples in teaching geometry were also considered in this study. These indicated how they were prepared to integrate ethnomathematics approaches into the teaching of geometry.

5.3.1 Integration of ethnomathematics approaches

The data from the focus group discussions showed that all the teachers from the five groups did not take even a specific course on ethnomathematics approaches. However, for most teachers (32) it was mentioned in passing in other courses, whilst for a few teachers (8), they were integrating ethnomathematics approaches because it was a requirement of the syllabus. This can be seen in the next statements from the focus group discussions:

"No. We never did a course on Ethnomathematics, we were never trained". A topic like the indigenous knowledge systems in philosophy that we studied exposed us to the ideas of using learners' culture when teaching geometry, and also the more geometrical knowledge that we now possess enabled us to integrate culture when teaching geometry" (Group A).

"No, but at college it was mentioned in passing although it was not specific to the teaching of mathematics/geometry but also helping the learners in all areas of life. At the moment it appears we are in the same scenario. We are not being trained to do so, especially in pedagogics courses, however, this was mentioned in passing in a section of indigenous knowledge from philosophy, where we are supposed to link to what the learners' already know, improvisation was also taught, although not directly linked to mathematics/geometry again" (Group C).

"No course was done on Ethnomathematics, but it was mentioned in passing in some courses such as, pedagogics, concepts on geometrical transformation, for example, reflection using a mirror. We were taught to use the environment to enable learners to understand, more of improvisation where real resources are not available" (Group D).

"No. Our training lacks courses on Ethnomathematics, we were taught how to improvise in pedagogics course when teaching geometry concepts. We used a string and peg to teach circle geometry" (Group E).

"No. We have tried to do it by ourselves. It's only that the syllabus requires us to link what we teach with the environment so we just take some of the things from the environment, but we were never trained to do so" (Group B).

The study revealed that teachers from Groups A, C, D and E acknowledged that the courses which they studied at the teacher training institutions, such as philosophy of education and pedagogics courses made them to be aware of the possibility of connecting cultural activities of the learners to teaching of geometry. Data from focus group discussions on aspects of ethnomathematics approaches that were mentioned in passing in other courses was supported by the data from closed-ended questionnaire questions. For instance, teachers' prior knowledge was considered by their lecturers when teaching geometry (see Table 5.16).

Table 5.16: Teacher training on integration of ethnomathematics approaches (n=40)

Item	Statement	SA N (%)	A N (%)	N N (%)	D N (%)	SD N (%)
7	Lecturers/tutors took into account my prior knowledge when they were teaching geometry.	6 (15)	24 (60)	3 (7.5)	1 (2.5)	5 (12.5)
27	My teacher training program provided a variety of ways of including cultural examples when teaching geometry.	8 (20)	16 (40)	2 (5)	9 (22.5)	5 (12.5)

Findings in Table 5.16 (item 7) show that 30 teachers' prior knowledge was taken into account when they were being taught geometry and 24 participants (item 27) were provided with several methods of incorporating cultural examples when teaching geometry.

Furthermore, data from open-ended questionnaire questions showed that only 15 participants were taught to integrate ethnomathematics approaches when teaching geometry. Their responses were categorised as acquiring the necessary skills (see Table 17), used the environment as source of teaching examples, materials and resources (see Table 18), learning from known to unknown (see Table 19), making of teaching aids (see Table 20), and use of different approaches (see Table 21).

Table 5.17: Acquiring of skills (n=40)

Representative quotes
Training was adequate in teacher's colleges Acquired the necessary skills and they are useful in my teaching.
Got the necessary skills during training
I know how to relate geometry to culture
I understand the benefits to the learners of relating to culture

Teachers, (15), who indicated that they were adequately prepared to integrate ethnomathematics approaches admitted that they possess various skills of integrating ethnomathematics approaches into the teaching of geometry (see Table 5.17). Teachers claimed that they had gained the necessary skills to integrate ethnomathematics approaches into the teaching of geometry, and they also understand the benefits of using ethnomathematics approaches when teaching geometry. Teachers need to have the knowledge and skills (Shulman, 2004), which they can base upon when planning to integrate ethnomathematics approaches into their teaching.

Table 5.18: Used the environment as source of teaching examples, materials and resources (n=40)

Representative quotes
Reference to our culture were given in geometry questions, questions linked to the real objects
Emphasis was made on the cultural norms and values were elaborated during geometry lessons by lecturers.
Environment was used as source of material/ examples and objects
Used examples from the environment and local culture
Practical examples from our real life situations were given and clearly explained
Examples of building round huts and knitting patterns were used
Examples of drawing circles using a string that is similar to the one used when constructing round huts.
Some structures in culture have geometrical representation that were used as examples
Lecturers used examples from their own culture different from everyone else, lecturers' culture dominated.

Participants' responses in Table 5.18 indicate that they were of the view that their lecturers related geometry teaching to the environment or culture. Participants were of the view that their lecturers used geometry examples from their environment and culture. For instance, cultural examples such as the drawing of circles as used in round huts were used by their lecturers. The teachers also said that their lecturers used different environmental and cultural objects/ materials and examples as resources for teaching geometry. The learners' environment and culture are crucial in ethnomathematics approaches (D' Ambrosio, 2001; 2007).

Table 5.19: Teaching from known to unknown (n=40)

Representative quotes
Teaching start from our experiences and then build on that to new concepts
Use our experience from home to integrate into geometry concepts
By beginning from the known to the abstract

Learners' background knowledge is vital for acquiring new geometry knowledge (D'Ambrosio, 2001). All the knowledge that the learners bring into the geometry classroom is potentially important for gaining new knowledge in geometry (Schunk, 2014). Participants' responses in Table 5.19 indicate that they were of the view that teaching started from what they knew from their experiences to the abstract. This is in agreement with one of the underlying principle of ethnomathematics approaches, which states that teaching should start from the known to the unknown (Matang, 2002).

Table 5.20: Making of teaching aids (n=40)

Representative quotes
Making models of 3- dimensional shapes
Using locally available resources such as available sticks to make chalk-board compasses
Encouraged to research and give real models in society
Most of the aspects used in Ethnomathematics approaches are innovative

Participants' responses in Table 5.20 indicate that they were of the view that they were trained to use locally available resources from the environment to make teaching and learning materials. The data from the focus group discussions confirmed the teachers' training on making geometry teaching and learning aids from locally available materials. This is what teachers from Group A said:

"We were asked to construct geo-board to teach geometry that we used whilst on a one year teaching practice during training. Geo-boards are useful in teaching geometry concepts such as shapes, perimeter, translation, area, rotation, scaling, reflection, congruence, similarity and right angles. Learners find it interesting to study geometry using geo-boards. However, some of us only

used the geo-boards whilst we were being supervised during teaching practice and never used it again" (Group A).

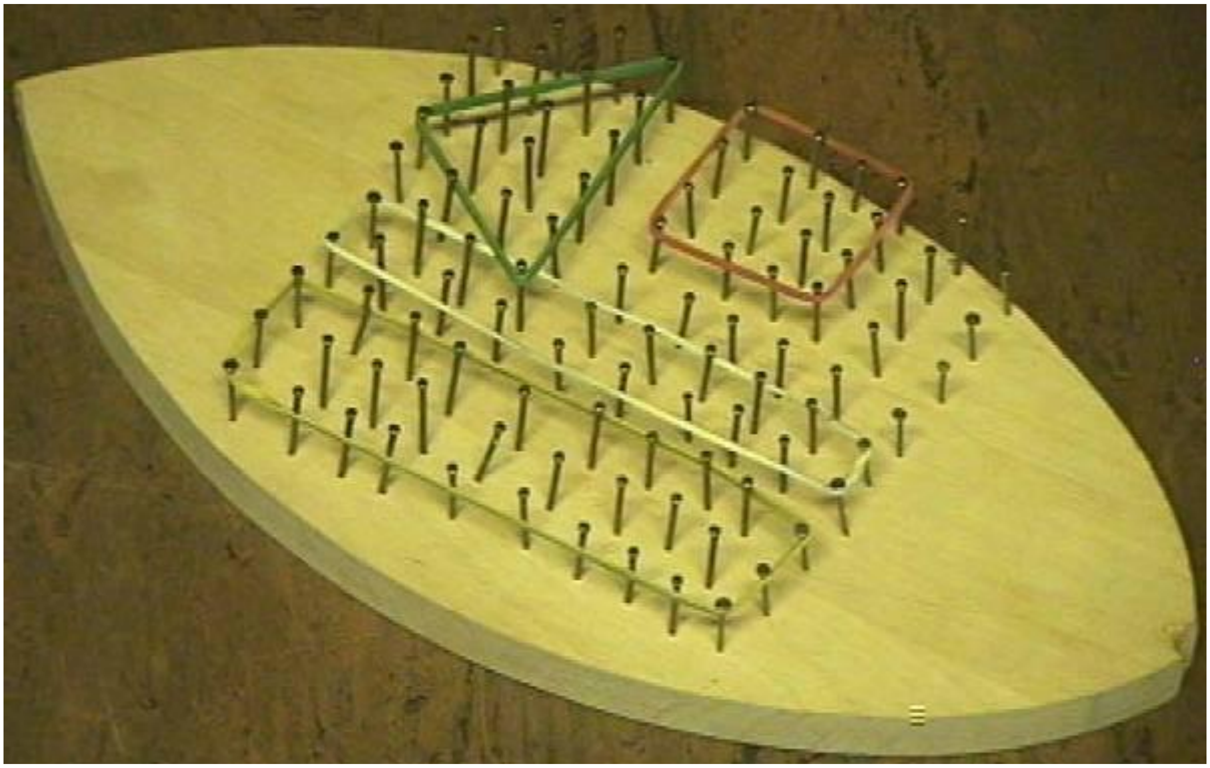


Figure 5.1: Model of a geo-board (Picture supplied by Group A)

Similarly, teachers from Group B testifies that:

"We were trained to improvise teaching and learning aids. We constructed geo-boards and compasses using locally available materials which are very applicable in geometry. We used scrap wood, nails and rubber bands to construct geo-boards and chalk board compasses. Some of us we had a tendency to overlook the geo-boards, some cannot even remember where the geo-boards are whilst some constructed bigger ones and are still using them" (Group B).

Figure 5.2: Model of a chalk board compass (Picture supplied by Group B)

Teachers reported that they prepared geo-boards (see Figure 5.1) and chalk board compasses (see Figure 5.2) using the locally available materials which they mainly used during teaching practice. Teachers also reported the benefits that their learners gained from learning geometry with the aid of geo-boards, such as interested in learning geometry during their teaching practice. However, some teachers constructed and used teaching aids for purposes of teaching practice, that was, for them to pass the teaching practice course, whilst others even constructed bigger models for use in their geometry teaching.

Table 5.21: Use of different approaches (n=40)

Representative quote s
Use of a variety of approaches
Use of case studies

Participants' responses indicate that they were of the view that their lecturers used a variety of teaching approaches when teaching geometry (see Table 5.21). The use of the different approaches when teaching geometry would cater for different learning styles of learners, which would help in understanding geometry concepts (Jones, 2002).

Data from the open-ended questionnaire questions showed that 18 participants indicated that their lecturers linked the teaching of geometry to the environment or culture. Sixteen (16) of them indicated that their lecturers connected the teaching of geometry to the environment or culture very often, while, the majority 24 participants stated that their lecturers sometimes did so. The large number of participants in the "sometimes" category might point to some of the difficulties that teachers could face when integrating ethnomathematics approaches into the teaching of geometry, due their limited exposure to the aspects of connecting geometry concepts to the environment or culture during their training.

5.3.2 Not trained to integrate ethnomathematics approaches in teaching geometry

The qualitative findings from the open-ended questionnaire questions showed that most teachers (25) were not trained to integrate ethnomathematics approaches in the teaching of geometry. Their responses for their lack of training are presented in Table 5.22.

Table 5.22: Teachers' reactions on their lack of training on ethnomathematics approaches (n=40)

Representative quotes
I was not taught to use the approach.
I was not trained to teach using cultural examples.
Pedagogical skills that l acquire during the training did not include ethnomathematics approaches.
Not much was discussed about ethnomathematics approaches during training.
I am of the opinion that environmental examples should have been given.
Ethnomathematics has a lot to be involved not just the approaches that we know.

The data in Table 5.22 show that most teachers were not trained to integrate ethnomathematics approaches into the teaching of geometry. This concurs with what Rosa & Orey (2013) asserted that teachers did not use ethnomathematics approaches because they lacked the training that allowed for its application into the teaching of geometry. Teachers' reasons for being inadequately prepared to integrate ethnomathematics approaches into the teaching of geometry from open-ended questionnaire questions were classified into six categories as lack of knowledge on ethnomathematics approaches (see Table 5.23), lack geometrical knowledge (see Table 5.24), insufficient resources (see Table 5.25), curriculum related challenges (see Table 5.26), lecturers' practices (see Table 5.27) and location of college, as shown in Table 5.28.

Table 5.23: Lack of knowledge on ethnomathematics approaches (n=40)

Representative quotes
Lack of background knowledge on such approaches.
Lack of cultural examples to use during the learning of geometry concepts.

Data from open-ended questionnaire questions showed that some teachers were not aware of ethnomathematics approaches and the cultural examples to use when teaching geometry (see Table 5. 23). Their lack of knowledge on ethnomathematics approaches could be due to the fact that they were not trained on ethnomathematics approaches as indicated in Table 5.22.

Table 5.24: Lack of geometry content knowledge (n=40)

Representative quote
Lack of geometry content

The participants' responses showed that their lack of geometry content knowledge also hinders the integration of ethnomathematics approaches into the teaching of geometry (as shown in Table 5.24). The lack of geometry content knowledge as a barrier to the integration of ethnomathematics approaches into the teaching of geometry was supported by teachers from group E said:

"We lack knowledge on geometry concepts. We were never taught geometry because our lecturers would say that you will not fail the examination because you did not answer the questions on geometry" (Group E).

The comments illustrate that geometry concepts were not taught because teachers as learners could pass the examination without answering any question on geometry, hence their lack of geometry content knowledge. However, those teachers were now in a dilemma because they were supposed to teach the geometry content that they were never taught during their training, hence, they could not teach what they did not know. Teachers were expected to teach geometry effectively, yet they have done little to none of the geometry content (Jones, 2002).

Table 5.25: Insufficient resources (n=40)

Representative quotes
Time and resources were scarce.
I am not sure because we practice short time.
No textbooks with such examples were available.
Lack of resources in colleges.
Time was scarce for such approaches, the program was packed with different activities.

The responses of the participants showed that they were of the view that time and other resources such as textbooks with cultural examples were scarce (see Table 5.25). The data from focus group discussions also confirmed the scarcity of resources for the integration of ethnomathematics approaches into the teaching of geometry. This is what the teachers from group E said:

"No, resources were not adequate and the questions in the textbooks were not contextualised. There were no real life examples in textbooks" (Group E).

The comment on lack of contextualised and real life examples in textbooks corroborates earlier findings by Orey & Rosa (2006) and Sibanda, Mtetwa & Zobolo (2007) in terms of textbooks' lack of cultural examples that relate to the learners' real life situations.

Table 5.26: Curriculum related challenges (n=40)

Representative quotes
Lecturers were not formally charged to do so in their syllabus.
Syllabus restricts since it is time bound and examination-focused.
This was never emphasised officially in the curriculum.

Focusing on the inadequate preparation of teachers to integrate ethnomathematics approaches, the findings of the study revealed that this could have resulted from curriculum related challenges, such as, the requirements of the syllabus (as shown in Table 5.26. The participants indicated that connecting the teaching of geometry to culture or the environment was not emphasised in the syllabus and that the syllabus was examination driven.

Table 5.27: Lecturers' practices (n=40)

Representative quotes
It was only a matter of chalk and talk.
I think it's because of the methods used and textbooks.
It's only relying on textbooks that do not have environmental examples.
Explained what was in textbooks.
Most examples were derived from the textbooks.

Responses of the participants indicated that they were of the view that their lecturers used the traditional chalk and talk method and they relied heavily on textbooks, which lacked cultural/contextualised examples (see Table 5.27) that did not support the integration of ethnomathematics approaches.

Table 5.28: Location of college (n=40)

Representative quote
Because l attended an urban college, the environment was not so rich to make a meaningful link.

From the data in Table 5.28, the location of the college that the teachers attended was identified as a factor that might have contributed to their lack of training on ethnomathematics approaches and its integration into the teaching of geometry. The study showed that teachers were not sufficiently equipped to integrate ethnomathematics approaches into the teaching of geometry because they trained at a college that was located in an urban area. However, many researchers (for instance, D'Ambrosio, 1990; Bishop, 1992; Matang, 2002; Rosa & Orey, 2010) argue that each society contributes differently in mathematics development, hence the location of the college was not an issue from those scholars' point of view.

To sum up, this section of the study, investigated the teachers' exposure to ethnomathematics approaches during their training. The results of the study showed that there were no specific courses done for ethnomathematics approaches and that the aspects of ethnomathematics approaches were mentioned in other courses such as philosophy of education and pedagogics courses. Similarly to the teachers' training to teach geometry, two categorises also emerged those who were trained to integrate ethnomathematics approaches and those who were not trained. The teachers who seemed to have been trained to integrate ethnomathematics approaches into the teaching of geometry, had acquired the knowledge and skills of integrating ethnomathematics approaches into the teaching of geometry. In addition, some teachers were not trained to integrate ethnomathematics approaches into the teaching of geometry.

5.4 Teachers' views on ethnomathematics approaches

A fundamental aspect of ethnomathematical approaches is that teachers use the informal geometry knowledge and the relevant cultural experiences that learners bring into the classroom (Gerdes, 1996). For teachers to integrate ethnomathematics approaches into the teaching of geometry, they need to be aware of the learners' cultural knowledge and experiences and an understanding of both culture and its relation to geometry (Rosa & Orey, 2016). This section presents four categories of the results related to the teachers' views and understanding of ethnomathematics approaches.

5.4.1 Definition and understanding of Ethnomathematics

In order for the teachers to define ethnomathematics approaches, it was important for them to first define Ethnomathematics. The data generated from the focus group discussions revealed a number of variations in the ways the teachers viewed Ethnomathematics. The quotations here highlight the groups' definitions:

"Integration of mathematics and culture" (Group A).

"Ethno from ethnic, this is the inclusion of cultural activities/ideas in the teaching of mathematics" (Group B).

"Linking mathematics to everyday life experiences including our culture" (Group C).

"Relationship between mathematics and culture" (Group D and E).

According to Rosa (2010) Ethnomathematics consist of the essential components of culture, for instance, language, art, and the everyday mathematical practices of various groups. Teachers from Group A defined Ethnomathematics as the integration of mathematics and culture. It proposes that the study and use of mathematics, including geometry, have cultural implications and must be regarded as such. The definition from teachers in Group B focused on cultural activities or ideas used in the teaching of mathematics. The third view of Ethnomathematics from Group C focused on recognising associations between everyday life experiences including local culture and mathematics. The most recurring views were those of the relationship between mathematics and culture referred to by teachers from Groups D and E. Even though their definitions differ in viewpoint, all their definitions widen the possibility of connecting mathematics to culture or everyday life experiences.

5.4.2 Awareness of ethnomathematics approaches

The integration of ethnomathematics approaches into the teaching of geometry starts by addressing the question of awareness of the approach because it was important for its effective integration. Table 5.29 shows the teachers' responses on some aspects of ethnomathematics approaches.

Table 5.29: Teachers' awareness of ethnomathematics approaches (n=40)

Item	Statement	SA N (%)	A N (%)	N N (%)	D N (%)	SD N (%)
1	I have a clear understanding of ethnomathematics teaching approaches.	8 (20)	27 (67.5)	3 (7.5)	1 (2.5)	1 (2.5)
2	Ethnomathematics teaching approaches allow learners to create their own geometrical knowledge.	19 (47.5)	18 (45)	3 (7.5)	0 (0)	0 (0)
3	Ethnomathematics teaching approaches recognise the teacher as the source of geometrical knowledge.	9 (22.5)	15 (37.5)	8 (20)	6 (15)	2 (5)
4	Ethnomathematics teaching approaches recognise the learner's environment as the source of geometrical knowledge.	14 (35)	22 (55)	4 (10)	0 (0)	0 (0)
5	The learner's language and culture do not influence his/her acquisition of geometrical knowledge.	7 (17.5)	4 (10)	6 (15)	16 (40)	6 (15)
6	Learners effectively acquire geometrical knowledge when they listen to the teacher's explanation carefully.	11 (27.5)	17 (42.5)	6 (15)	3 (7.5)	3 (7.5)
20	Geometrical concepts are taught using universal language and procedures in all cultures.	6 (15)	12 (30)	7 (17.5)	6 (15)	9 (22.5)

As noted in Table 5.29, in-service teachers in this study indicated that they were aware of ethnomathematics approaches. At least 35 participants were in agreement that their understanding of ethnomathematics approaches was clear (see Table 5.29, item1). Thirty seven (37) participants indicated that they understood ethnomathematics teaching approaches as opportunities that enables the learners to create their own geometrical knowledge (see Table 5.29, item 2.

Regarding the source of geometrical knowledge, the participants did not show much consistency with the views of ethnomathematics approaches. The results showed that 24 participants held the opinion that teachers are the sources of geometrical knowledge (see Table 5.29, item 3). The teachers' opinion concurs with Khader (2012) and Ernest's (2009) traditional view of mathematics where the teachers are the sources of all the geometry knowledge. This opinion is not consistent with social constructivist and ethnomathematics approaches where the teacher is viewed as a facilitator and not as an informer (Matang, 2002).

Thirty six (36) participants agreed or strongly agreed that the learner's environment was the source of geometrical knowledge (see Table 5.29, item 4). The finding concurs with D'Ambrosio (2001) who asserted that ethnomathematics approaches build on the learners' prior knowledge and their past and present experiences of their immediate environment.

Twenty two (22) participants indicated that culture and language were essential in geometrical knowledge acquisition (see Table 5.29, item 5). The finding concurs with ethnomathematics approaches that put more emphasis on the role of learners' cultural background and language in their learning of school mathematics/geometry (Matang, 2002; D'Ambrosio, 2001).

The majority of the participants (28) agreed or strongly agreed that learners learn effectively when they listen carefully to the teacher's explanation (as shown in Table 5.29, item 6). In an Ethnomathematics classroom, the teacher is a facilitator who also gives instructions to the learners, and it would benefit the learners if they concentrate on the instructions.

Concerning the statement that geometrical concepts are taught using universal language and procedures in all cultures, the participants did not show much consistency with the views of ethnomathematics approaches. The findings showed that 18 participants held the view that geometrical concepts are taught using universal language and procedures in all cultures (see Table 5.29, item 7). The finding is in line with traditionalist view of mathematics who believe that mathematics/geometry is the same over time, in all places and for everybody, therefore, universal (Ernest, 1990; Rosa, 2016).

The following statements suggest each of the groups' definition of ethnomathematics approaches.

"Use of culture in the teaching of mathematics. Teaching mathematics using cultural methods, media, examples and instruments" (Group A).

"The incorporation of immediate environment from ethnic groups, who share common culture in the teaching of mathematics" (Group B)

"Inclusion of indigenous knowledge in teaching and learning of mathematics" (Group C).

"Incorporation of culture in mathematics education" (Group D).

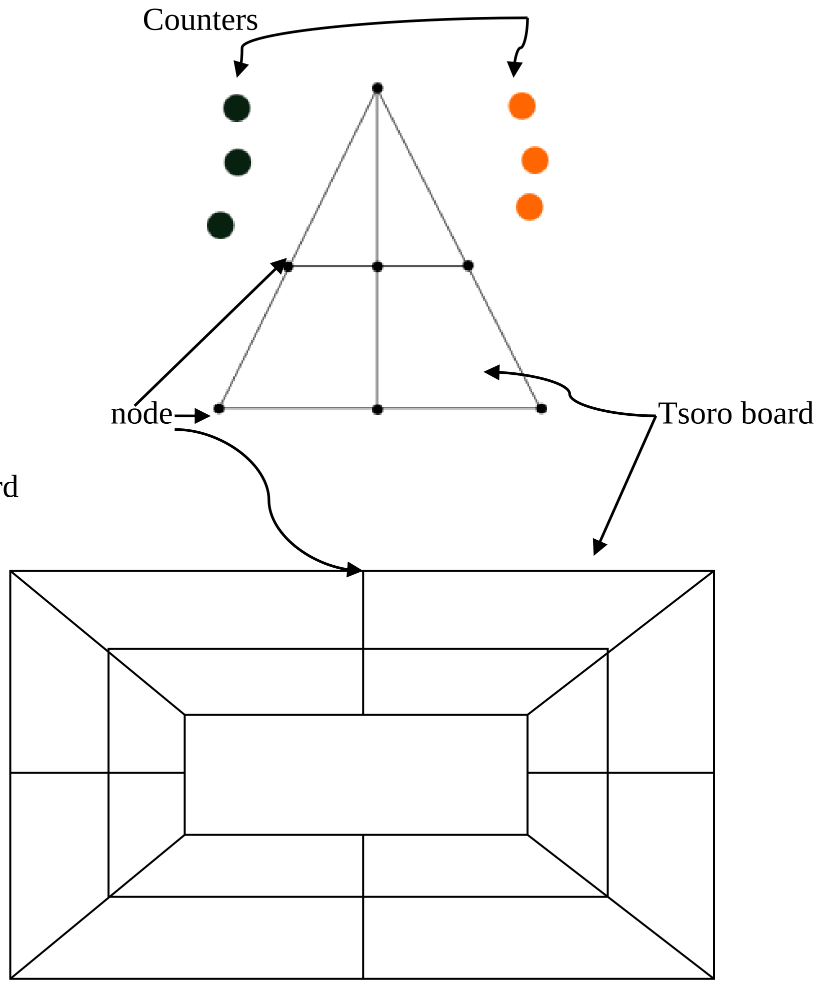
"The linking of cultural things from home and the environment and mathematic. Inclusion of real life situations in mathematics" (Group E).

The teachers' definitions of ethnomathematics approaches underscored the aspects of incorporating learners' cultural and everyday life experiences, immediate environment and the teaching of geometry using real life situations.

Data from the focus group discussions showed that all the teachers from the five groups were aware of the geometry that exist in different cultural activities or experiences. They were quick to point to the presence of geometrical concepts from different cultures and environments. The following excerpts illustrate their responses:

"Yes, the learners are encouraged to play cultural games such as <u>tsoro</u> and <u>nhodo</u> in the new curriculum. These games could be used to teach geometry concepts such as shapes and symmetry". (Group A) [<u>Tsoro</u> and <u>nhodo</u> are traditional games].

The boards for *Tsoro* are shown in Figure 5.3.



Level 3 Tsoro board

Level 12 Tsoro board

Figure 5.3: Level 3 and 12 *Tsoro* board (provided by teachers from Group A)

"Before the players play the game they draw the tsoro board with the application of construction skills, even without using construction instruments. Geometry concepts such as parallel lines, lines of symmetry, trapeziums, and rectangles using the board alone" (Group A).

"Pottery is also encouraged in the curriculum and our learners were involved in the pottery competition and their products, for example, pots have several geometry properties that can be

used to teach geometry better. For instance, the different sizes of similar pots are a good media for teaching enlargement transformations" (Group A).

Figure 5.4: Pottery pots (Picture supplied by Group A teachers)

"The pottery products are utensils made and adorned artistically and attractively with beautiful decorations of congruent designs, from which geometrical concepts such as enlargement transformations, translation, reflection, rotation, and line and rotational symmetry can be inferred. The clay pots with similar shapes may be used to explain the 3-Dimensional enlargements. The masses of the pots can be used as an indicator of volume, heights, widths and diameters can be considered as scale factors"(Group A).

"Yes, geometry is found in dancing and games. For instance, dancing encompasses the counting of the number of steps made, and rotating at angles of 90^0, 180^0 or 360^0 which are some of the geometry concepts. There is hidden geometry in dancing because the dancers have to stand in circles or parallel lines. For example, a game can be used when introducing circle geometry, where all the learners will be asked to stand in a way such that they form a circle in the classroom, except for one leaner who will serve as the center point of the circle. The parts of the circle such as the radius, diameter, chord, central angle, arc, and circumference would be created from the circle and discussed in detail" (Group B).

"Yes, different shapes, for example, circles, triangles, rectangles and squares, heights, breadths, lengths, symmetry and triangular roofs are found in round huts and the artefacts used in carpentry, welding" (Group C).

"Yes in building of round huts, carpentry, and sewing. For instance, when sewing the measurements of the width and length are taken. Geometry can be found in sewing when making different designs that include different shapes such as circles, triangles squares and rectangles that are found in African attires" (Group D).

"Yes in building of round huts, centre for cooking in the huts that can be illustrated as the centre of the circle" (Group E).

Figure 5.5 shows a round hut with a fire place at the centre.

Figure 5.5: Round huts (Pictures received from Group E)

From the focus group discussions, teachers echoed that geometry exists in culture because of the different cultural activities (as shown in Figures 5.3) that involve geometry concepts in one way or the other that they could refer to when teaching geometry. The teachers identified the presence of geometry processes and concepts in their culture or daily lives or the utilization of geometrical knowledge in different cultural contexts. The findings concurs with earlier findings from Adam (2004) in terms of teachers who were able to identify activities and experiences in Maldivian culture, which they were able to link to conventional mathematics. The teachers felt that they were aware of geometrical objects (see Figures 5.4, 5.5) and ideas that were in existence in their cultures and environments, including those of the learners.

5.4.3 Teachers' views on geometry content taught in schools

Statements relating geometry to culture sought to establish whether teachers believed that geometry could be learnt outside the school premises, especially in a traditional cultural situation, using ethnomathematics approaches. Table 5.30 shows teachers' responses from closed-ended questionnaire questions on their views on geometry content taught in schools.

Table 5.30: Teachers' views on geometry content taught in schools (n=40)

Item	Statement	SA N (%)	A N (%)	N N (%)	D N (%)	SD N (%)
8	Geometry is free from culture	5 (12.5)	5 (12.5)	6 (15)	15 (37.5)	9 (32.5)
11	Geometric concepts learners learn are those taught by teachers in schools only	7 (17.5)	4 (10)	6 (15)	15 (37.5)	7 (17.5)
13	Geometry knowledge is gained by taking part in traditional cultural activities such as building traditional houses, fishing etc.	15 (37.5)	17 (42.5)	5 (12.5)	1 (2.5)	2 (5)
14	Teachers should teach only the geometry that is prescribed in the syllabus and textbooks.	4 (10)	7 (17.5)	3 (7.5)	13 (32.5)	12 (30)
16	Geometry concepts identified in traditional cultural activities should also be taught in schools.	18 (45)	18 (45)	3 (7.5)	1 (2.5)	0 (0)
21	There is a relationship between geometry and culture.	16 (40)	21 (52.5)	2 (5)	0 (0)	1 (2.5)

As indicated in Table 5.30, the majority (28, item 8) of the teachers disagreed or strongly disagreed that geometry is free from culture, with the majority (32, item 13) agreeing that geometry is gained by taking part in traditional cultural activities such as building traditional houses, fishing etc. The findings are consistent with findings from earlier studies (Rosa & Orey, 2009; 2010; Pinxten & François, 2007; Gerdes, 2011) in terms of using cultural activities and that mathematical knowledge including geometry is attained outside of the schooling structured systems. In other words, ethnomathematics approaches are concerned with the geometrical concepts that also exist outside schools (Rosa & Orey, 2010).

Twenty five (25) participants disagreed that they should not teach only the geometry that is prescribed in the syllabus and textbooks, with the majority (36) participants agreeing, inclusive of those who either agreed or strongly agreed that geometry concepts identified in traditional cultural activities should also be taught in schools (as shown in Table 5.30, item 16). The study further found out that 37 participants were in agreement with the view that there is a relationship between geometry and culture (see Table 5.30, item 20). This finding concurs with (Massarwe et al., 2010; 2012; Gerdes, 2005; Jones, 2002) who reported that geometry is at the centre of every culture and is innate in all human mind.

Teachers' responses from focus-group discussions (groups C and D) supported the data from open-ended questionnaire questions on their views of geometry taught in schools. This is what the teachers said:

"Integrative, because some learners would become builders, carpenters who are very good at construction but without the use of geometrical instruments as we do in the class. There are some learners who are good at hands-on activities but not in the actual learning of geometry hence the geometry activities would help them for self-employment in future" (Group C).

"Geometry is widely related to culture but it depends on how learners are taught. Need practical activities which are not done in schools" (Group D).

Teachers from Group C were of the view that geometry taught in schools is integrative to cultural interests as they relate it to its utilitarian aspects in real life situations. They pointed out that geometry could be used in construction, for instance, in building and carpentry for self-employment after leaving school. Although, the teachers from Group D were of the view that geometry is widely related to culture, they pointed out that it would depend on how geometry is taught, hence the emphasis on the need for hands-on activities.

On contrary, teachers from groups A, B and E were of the view that the content of geometry taught in schools is not sensitive to culture. The following excerpts were fairly common among the participants who said school geometry is not sensitive to cultural interest:

"Insensitive and discriminative to cultural examples, examples from foreign countries are normally used in textbooks. Even the language used in text books is discriminative, though the new curriculum encourage the use of the learners' first language the textbooks still do not have such examples and from the requirements of the new curriculum it seems it is still examination bound" (Group A).

"Not sensitive to culture. Geometry concepts are prescribed from regular, geometry from culture are not regular, for example, the circles from the round huts and kraals are irregular" (Group B).

"Not being properly taught but is in the syllabus, teachers have a habit of introducing the topic without teaching it. It is discriminative of cultural interests" (Group E)

The teachers from Groups A, B and E were of the view that geometry taught in schools is not sensitive to culture and is discriminative of cultural interests. The view that geometry is insensitive to culture concurs with (Bishop, 2004; D'Ambrosio & D'Ambrosio, 2013) who reported that for a long time mathematics including geometry in schools was observed as neutral and culture free. The teachers pointed out that the curriculum encouraged the use of learners' own language, despite, the fact that the textbooks and the examinations use the English language that was foreign to both teachers and learners. In addition, they pointed out that the textbooks did not have the cultural examples, but have examples that were from foreign countries and the curriculum was examination bound.

5.4.4 Teachers' views on their roles for teaching geometry

In this study, teachers expressed different roles and functions concerning their teaching of geometry, which were categorised into three as; to provide guidance, to facilitate learning and to impart knowledge and skills.

To provide guidance

Participants from Group A view their role as that of guiding the learners in learning geometry concepts in their everyday contexts, as well as choosing the teaching methods and the media that motivate the learners, reducing geometrical concepts into real life situations. Teachers from Group A said:

"As teachers we are responsible for choosing the teaching methods and media that motivate the leaners. Guide the learners in learning geometry and reducing geometrical concepts into real life situations" (Group A).

The teachers' role of guiding the learners in their learning of geometry is in line with Vygotsky's (1978) ZPD, a level in which learners could solve problems with the help of peers or teachers who are more knowledgeable. The teachers' role is to provide learners with situations from their everyday life that would enable them to choose different techniques to solve the problems with minimum supervision from the teacher (Woolfolk, 2010). In addition, teachers reported that their role is to choose the teaching methods, media and linking the geometrical concepts into real life.

To facilitate learning

Amongst the five groups, teachers from the three groups, C, D and E, viewed their role as that of facilitating the learning process through exposing the learners to new geometry concepts and help them to link geometry to real life situations. For example, the teachers said:

"Facilitate the learning process. Expose new concepts to learners help them to discover after being guided" (Group C)

"Facilitate the learning by giving learners more information for example drawing a cone using the example of a heart, help learners to link geometry to real-life situations" (Groups D, E).

The teachers' roles as facilitators is in line with ethnomathematics approaches and social constructivist views of teaching geometry (Matang, 2002; Woolfolk, 2010). In addition, teachers indicated that they help the learners to discover knowledge after being guided. This finding is in line with Vygotsky (1978) who believed that the learner should be guided in the discovering of new concepts. Therefore learners should be helped and supported by teachers to build a firm understanding of the geometry concepts.

To impart knowledge and skills.

On the other hand teachers from Group B stressed that their role was to impart knowledge and skills as prescribed in the curriculum. This is what they said:

"We bring all the learners to the practical part of geometry in shapes. To bring the right terminology as prescribed in the curriculum" (Group B).

It seems that teachers from Group B were of the view that their role was to disseminate geometry knowledge and skills as prescribed in the mathematics syllabus. The finding is in line with the traditionalists who view learning of mathematics/geometry as mastery of a set body of geometry knowledge and skills (White-Fredette, 2010).

In summary, the findings presented an understanding of teachers' conceptions of ethnomathematics approaches. The teachers' roles were to select suitable and meaningful learning activities that were related to the learners' cultural backgrounds and activities. Irrespective of their different definitions, teachers were having common understanding of the features of ethnomathematics approaches. They seemed to have developed the idea that ethnomathematics approaches involved linking the teaching of geometry to their learners' culture or environment.

5.5 Teachers' integration of ethnomathematics approaches into the teaching of geometry

This section presented findings related to the teachers' integration of ethnomathematics approaches into the teaching of geometry. The data from closed-ended questionnaire questions in Table 5.31 shows the teachers' views of their integration of ethnomathematics approaches.

Table 5.31: Teachers' integration ethnomathematics approaches into the teaching of geometry (n=40)

Item	Statement	SA N (%)	A N (%)	N N (%)	D N (%)	SD N (%)
18	I design geometry learning activities that are adapted to learners' cultural background.	5 (12.5)	18 (45)	9 (22.5)	6 (15)	2 (5)
19	It is not possible to link geometrical concepts to learners' social environments.	3 (7.5)	3 (7.5)	5 (12.5)	13 (32.5)	16 (40)

The findings in Table 5.31 (item 18) show that 23 participants agreed (inclusive of those who agreed or strongly agreed) that they design geometry learning activities that are adapted to learners' cultural background. The majority of the teachers (29) were of the view that it was possible to link geometrical concepts to learners' social environments (see Table 5.31, item 19). This finding is consistent with Jorgensen, et al.'s (2010) opinion that many teachers use cultural activities including learners' prior knowledge in their lesson planning and delivery.

The closed-ended questionnaire data in Table 5.31 was supported by the open-ended questionnaire data which showed that 24 participants made provisions for use of cultural/ contextual examples in geometry lesson planning. The manner in which they did it was categorised into two as learning materials and resources (see Table 5.32) and learning context as indicated in Table 5.33.

Table 5.32: Teachers' inclusion of cultural examples in geometry lesson planning as learning materials and resources (n=40)

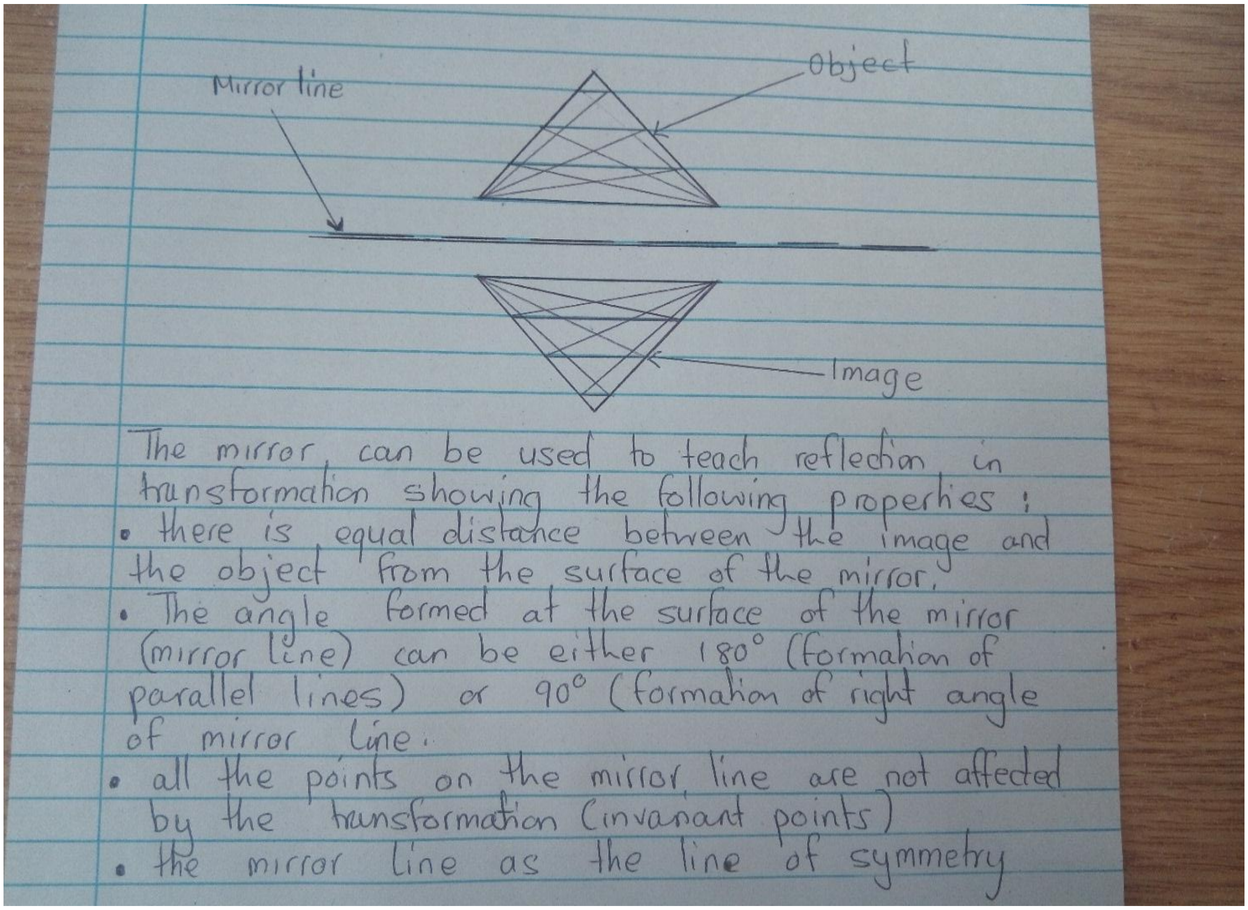
Representative quotes
Through the use of media such as indigenous fruits
Learners are asked to bring in learning aids such as circular tops to draw circles
By using available environment resources
I engage the environment and the readily available objects
To demonstrate shear l use using a boy pulling a catapult.

The teachers' responses indicated that they used cultural/contextual examples as learning materials and resources in the teaching of geometry (see Table 5.32). The teaching and learning materials and resources referred to the different cultural examples that the teachers incorporated in their geometry lesson planning to help the learners develop the envisioned geometry knowledge and skills. The findings are consistent with findings from earlier studies (Hunter, 2013; Meaney & Lange**,** 2013) in terms of including cultural/contextual examples when planning for geometry lessons and using them as learning materials and resources.

Data from the focus group discussions also confirmed the teachers' use of cultural examples as resources and materials in teaching geometry. This is presented in the teachers' voices below.

"We also relate to the environment when we teach transformation, for instance when teaching reflection and symmetry we use a mirror. Each learner is asked to bring a mirror that is used to teach reflection. Learners are asked to stand before their mirrors and they will see their images" (Group A).

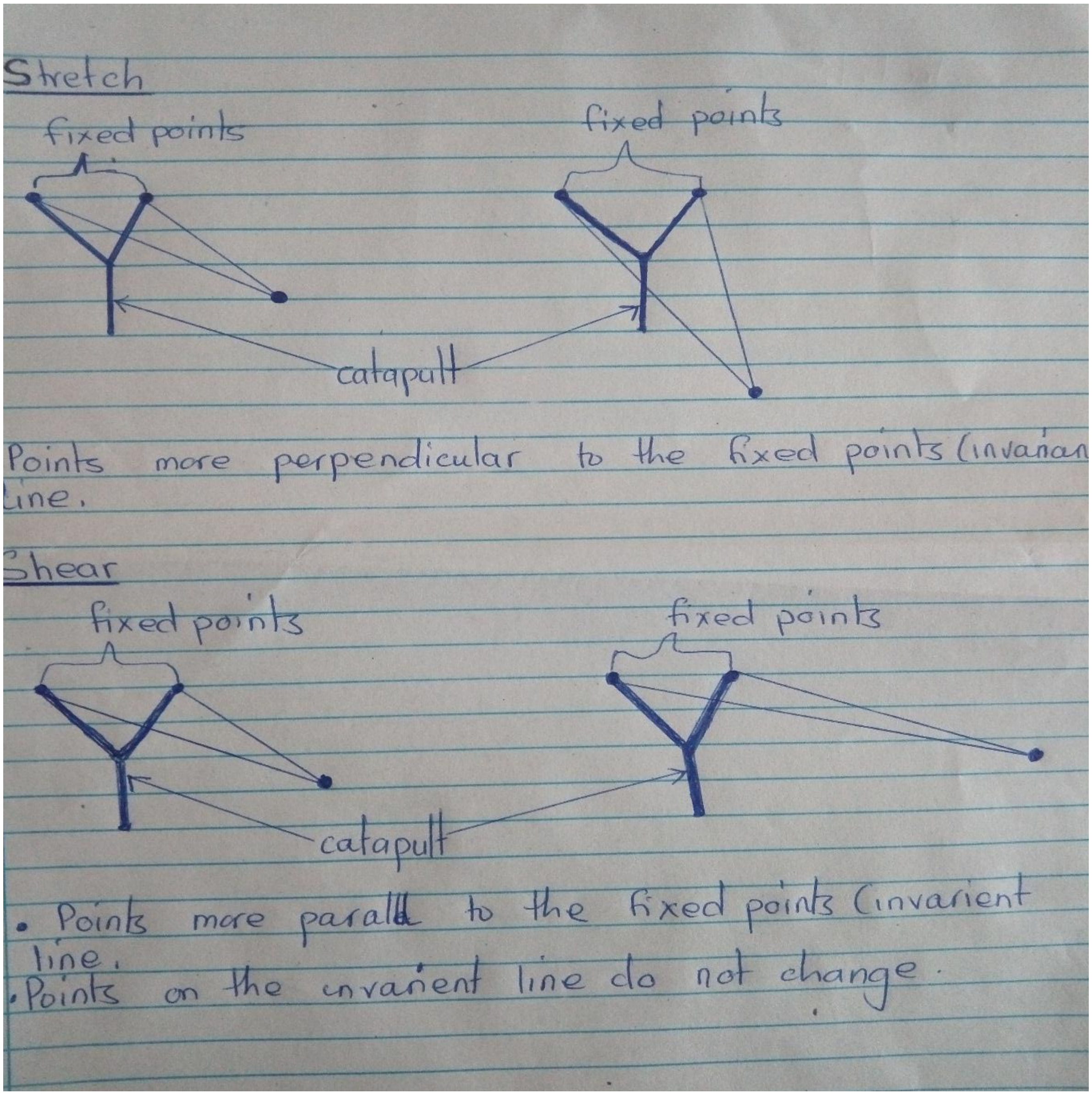
When using the mirror this will look like this: (Group A teacher then wrote, see Extract 5.2):



Extract 5.2: Group A's response

"We teach geometry concepts such as shear and stretch using a catapult" Group B.

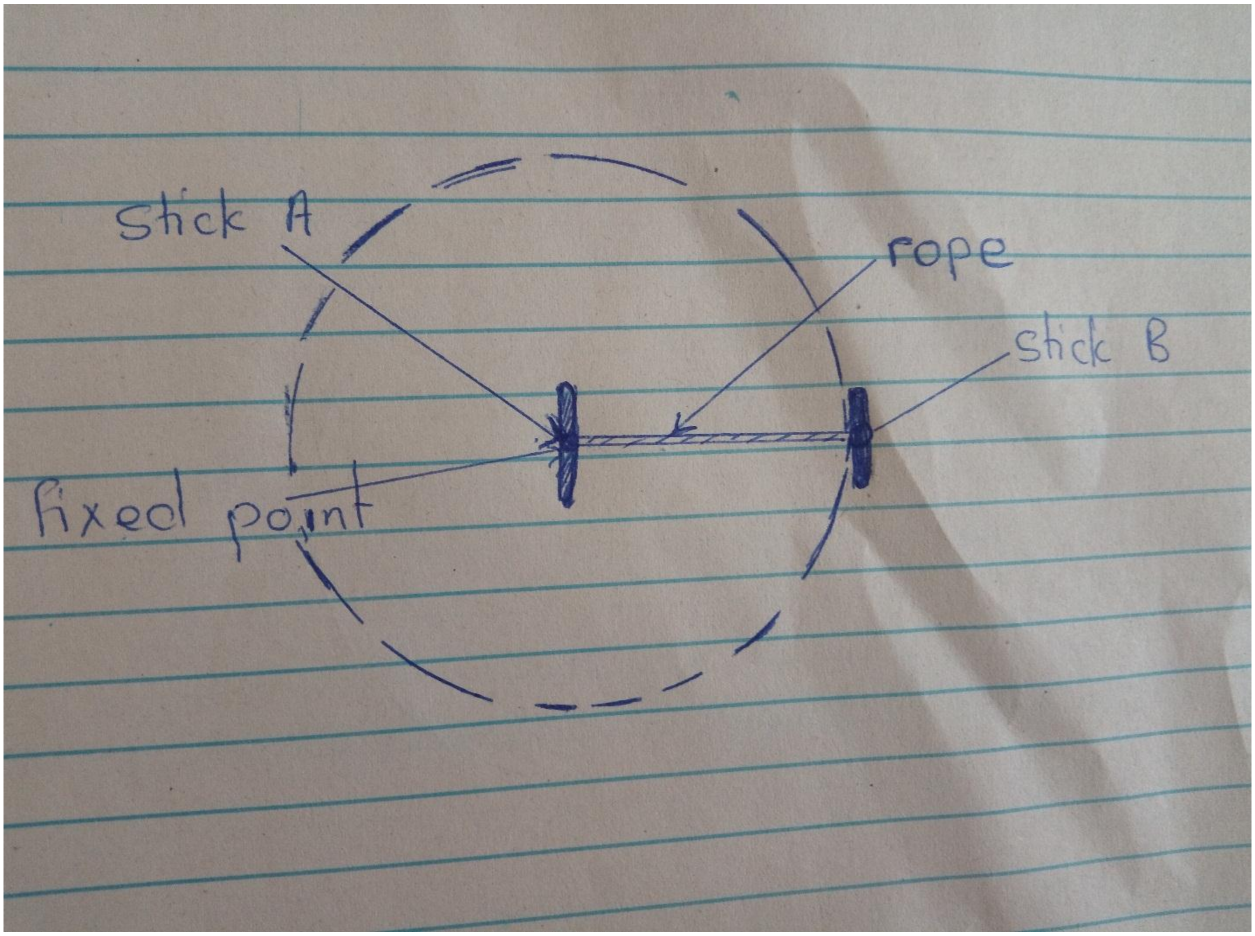
You know if you have a catapult, this will look like: (Group B teacher then wrote, see Extract 5.3):



Extract 5.3: Group B's response

"Yes, for example, two sticks and a string can be used to explain how to draw a circle from a fixed point with a certain radius, r. A string of a certain radius, suppose r, is attached to the two sticks. In rural areas, this is the idea that is used in the foundations of the huts. This can be used to teach circle geometry concepts such as the radius, circumference of circle and the locus of points equidistant from a fixed point" (Group C).

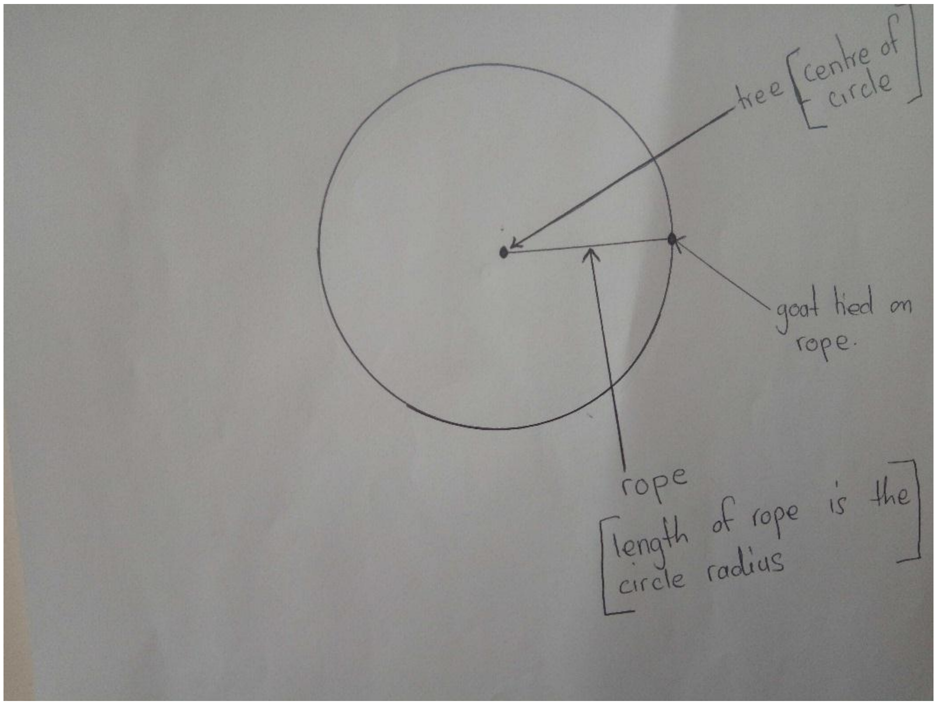
When doing this in the class, in practice, it will be like this: (Group C teachers then wrote, see Extract 5.4):



Extract 5.4: Group C's response

"Sometimes, examples on drawing the circles when building round huts. An example of a goat tied on a tree where the total grazing area is the area of a circle, which is determined by the length of the string equal to the radius, r. The locus of point's r from a fixed point can be taught by considering the boundary a goat can graze whilst tied with a rope of length r from a tree. The example can be used to explain how to draw a circle from a fixed point with a certain radius as well as the locus points equidistant from a fixed point" (Group D).

The diagram will be like this: (Group D teachers then wrote, see Extract 5.5):



Extract 5.5: Group D's response

The teachers' responses (Extracts 5.2, 5.3, 5.4, 5.5) illustrated how they used cultural examples in teaching geometry. However, integrating ethnomathematics approaches in the teaching of geometry, to them, is limited to models, objects and problems that reflect the real world activities.

Table 5.33: Teachers' inclusion of cultural examples in geometry lesson planning as learning context (n=40)

Representative quotes
To demonstrate translation l use examples from the construction of buildings
Use examples from different cultures
Examples such as circumference of the base of the hut
All the learners are given the opportunity to give examples from their environment
I make use of the round tank to explain circle geometry
Use materials from learners' daily experiences
For example in transformation many cultural examples are available
Say in circle geometry many cultural examples are available
By linking each concept to the immediate environment
Use of real life examples, for instance, relating to how the rural hut is built

Apart from using the cultural /contextualised examples as learning materials and resources from the environment in teaching geometry, some of the teachers reported that they teach geometry through a number of activities carried out in the society (see Table 5.33). They used the cultural /contextualised examples as context for learning. They referred to outdoor activities done outside the classroom. The teachers believed that they can relate the geometry that they teach to culture and environmental situations. For instance, relating the teaching of circle geometry to round tanks and huts. Teachers' use the cultural /contextualised examples as context for teaching geometry were supported by the following data from the focus group discussions:

"We do when we relate geometry to the learners' home activities and culture. To demonstrate the relationship between circumference and diameter, learners can use clay pots of different sizes and then measure the circumference by aligning strings around the pots then compare the diameter with the measured circumferences, thereby deducing that the diameter is proportional to the circumference with π as the constant of proportionality" (Group A).

"We do especially when dealing with circles we use circular objects in the environment, you may refer to such examples. Houses both in rural and urban areas are built at a certain distance from

the road for precaution measures. This example can be used to teach locus of points equidistant from a line" (Group B).

"We use objects that learners are familiar with to teach geometry concepts. For instance, if we show the learners a photograph and its large enlargement, this could be used to introduce the concepts of enlargement. Photographs can be used to explain the negative scale factor since the image is smaller than the object. Some real-life examples are house plans and maps that can fit on A4 pages" (Group C).

The teachers' examples above showed how they used the cultural /contextualised examples as context for teaching geometry. Rosa & Orey (2016) assert that it was crucial for teachers to use culturally specific examples in teaching geometry through exposing learners to a range of cultural contexts.

Usage of indigenous (Shona) language

The findings from the focus group discussions showed that some of the participants (8) reported that they used Shona language when teaching geometry. This is what the teachers from Group A said:

"We use Shona language when introducing geometry concepts to make learners understand better. We start by explaining in Shona then move to English. Shona is part of the learners' culture and is their first language hence we do integrate. Shona language is rich with multiple meanings contained in a single word, for example denga in English can mean the roof, the sky or on top" (Group A).

The participants from Group A's intention was to present geometrical content in a local language, Shona, so that learners can understand the concepts of geometry. The findings are in line with the view held by Pinxten & François (2007) who used the indigenous (Navajo) language in teaching geometry. However, the participants were also quick to point out that some Shona words have several meanings, for example, *denga* in Shona can mean the roof, the sky or on top. This implies that the different meanings of the word *denga* poses challenges for an effective integration of ethnomathematics approaches into the teaching of geometry. Geometry language include words specific to geometry and the everyday language has different meanings when used in geometrical contexts (Cangelosi, 1996). Therefore, teachers should be made aware that some geometrical terms might not translate well into indigenous languages, thus leaving the learners with the challenge of trying to understand the geometry content taught.

In summary, this section of research analysed the findings to provide an answer as to whether or not the teachers employed ethnomathematics approaches and how they did it and to explore the techniques they used to integrate it as influenced by their teacher training experiences.

5.6 Teachers' views on integration of ethnomathematics approaches into the teaching of geometry

Teachers' opinions of incorporation ethnomathematics approaches into the teaching of geometry were also considered because they influence their decision on whether to use these approaches or not. Data from focus group discussions showed that most of the teachers were of the view that ethnomathematics approaches should be integrated into the teaching of geometry. A statement representative of Groups A, B and C was presented by Group A:

"Yes, should be incorporated into the teaching of geometry" (Group A).

The above finding is consistent with findings from earlier studies (Kang 2004; Kanu, 2005; Hara-#Gaes, 2005) in terms of incorporating ethnomathematics approaches in teaching.

The benefits of integrating ethnomathematics approaches into the teaching of geometry were categorised as the relevance of geometry, motivation and interest, facilitation of understanding of geometry concepts and application of geometry concepts.

Relevance of geometry

Data from closed-ended questionnaire questions in Table 5.34 shows teachers' views of integrating ethnomathematics approaches into the teaching of geometry.

Table 5.34: Teachers' responses on integration of ethnomathematics approaches (n=40)

Statement	N (%)
This will encourage learners to take pride in their own cultural heritage and value their culture	9 (22.5)
This will encourage the learners to respect their cultural activities and practices	7 (17.5)

The data from the closed-ended questionnaire in Table 5.34 was supported by the data from the focus group discussions. In this perspective, teachers stated that:

"Learners will appreciate the usefulness of geometry" (Group A).

"Should be incorporated for learners to see the relevance of geometry, to enable learners to link previous learning with the new knowledge" (Group C).

"It is good in the sense that the learners will own the subject. They would say this is our own geometry and this could improve the pass rate" Group D.

"It's good for the learners to understand geometry because of the link between mathematics from home and the school" (Group E).

From the above comments, ethnomathematics approaches would enable the learners to appreciate the significance and relevance of their indigenous knowledge in their present and future life. The findings concurs with Rosa & Orey (2016) who assert that the intention of integrating ethnomathematical approaches into the teaching of geometry was that of making it more meaningful and relevant to the learners.

Motivation and interest

Teachers appreciated the motivational aspect of ethnomathematics approaches. Data from closed-ended questionnaire questions showed that 21 participants held the opinion that the integration of ethnomathematics approaches could motivate the learners to learn geometry. This was supported by the data from the focus group discussions. Typical of teachers from Group B and D comments were:

"Important in motivating the learners" (Group B).

"It is very important as it motivate learners as they learn concepts related to their culture and they will be interested in learning geometry" (Group D).

The responses from the teachers showed that they felt that the integration of ethnomathematics approaches into the teaching of geometry might make the learners motivated and interested in learning geometry. If learners are highly motivated they will be in a better position to benefit from the integration of ethnomathematics approaches because these approaches allow the learners to discover patterns and relationships during geometry knowledge construction which requires interested learners (Zaslavsky, 1973).

Facilitation of understanding of geometrical concepts

Not only could ethnomathematical approaches motivate learners to learn geometry, but also assist in their understanding of the school geometry. The closed-ended questionnaire data showed that 30 participants were of the view that the use of ethnomathematics approaches in teaching would improve the quality of geometry education and only 8 participants indicated that cultural content would not be a hindrance to the teaching of geometry.

The data from the open-ended questionnaire questions supported the view that ethnomathematics approaches facilitate the understanding of geometry as shown in Table 5.35.

Table 5.35: Ethnomathematics approaches facilitate understanding (n=40)

Representative quotes
It helps simplify abstract concepts into real life practice
It is easier to use real life examples when teaching geometry
Learners understand better when the learning encompasses indigenous knowledge
This help the learners to understand geometry better

Data was further supported by the data from the focus group discussions as noted from the following comments:

"Yes, it should be integrated as it helps in conceptualization of concepts, retention/ remembrance, and remove geometry phobia. It also makes abstract concepts easy to understand, learners will be in a position to use the words that are familiar to them" (Group A).

"It is of paramount important that we incorporate our cultural settings to our teaching we start from what they know to the complex, it's inevitable that we incorporate it. Yes, we support it as it is a problem solving approach that is incorporated in the teaching, a lot will be discovered by incorporating it. It helps to clear misconceptions and abstractness of the topic. Useful for learners as they grasp more on what they see and do. Good idea that makes learners to pass if properly integrated" (Group B).

"Yes, it affects our everyday life feel at home. It is very important, because it, remove abstractness of geometry. Improve learners' performance since they learn using the object they know and understand concepts easily" (Group D).

"Yes, help in understanding of concepts especially when they visualise, for example, choto (cooking fire place) the centre of the hut and the radius from the centre, retention is high and learners easily recall what they have learnt" (Group E).

Teachers' responses showed that they were of the view that the integration of ethnomathematics approaches helps to simplify the abstract concepts through connection with familiar cultural examples which would make the learners to understand the geometry concepts. This view is in line with (Rosa & Orey, 2010; 2016; Adam, 2004; Madusise, 2015; Gerdes, 1999) who pointed out that when ethnomathematics approaches were integrated into the teaching of geometry, the school geometry would become more relevant and meaningful for learners as well as promoting the general quality of mathematics education. Teachers felt that retention would be very high and learners' performance in geometry would improve if ethnomathematics approaches were used in the teaching of geometry. The finding concurs with Achor et al., (2009) who reported that if geometry content is taught using ethnomathematics approaches, learners would be able to retain the information as well as improving their performance.

Application of geometry

The application of knowledge is viewed as successful learning by the humanistic (Ferner, 2013). The application of geometry in real life even after leaving the schools was mentioned by some participants (16) from focus group discussions as one of the benefits of integrating ethnomathematics approaches into the teaching of geometry. Teachers from Group C and D made the following remarks:

"To some extent, yes for application purposes, useful in self-employment, identification of talents develop and nature talents for carpentry and construction industry and perfect skills for them to work in the industries, it's a good idea" (Group C).

"Yes, good for application of skills in everyday life, useful approach" (Group D).

From teachers' responses, the integration of ethnomathematics approaches into the teaching of geometry had the potential of facilitating self-employment or good skills in the learners' lives. Their responses also showed that ethnomathematics approaches could provide opportunities for learners to apply the knowledge and skills acquired in the classrooms to their cultural context.

Even though, findings show that most of the teachers were of the view that ethnomathematics approaches be integrated into the teaching of geometry, data from closed-ended questionnaire questions showed that a minority of the participants (1) thought that the quality of geometry education would deteriorate. The finding was supported by data from focus group discussions. This is what the teachers from Group D said:

"If cultural examples are used, learners will not concentrate and this will reduce pass rate" (Group D).

Ethnomathematics approaches could be considered equally negative if they appear to "water down" content of geometry taught in schools (Orey & Rosa, 2006). The view held by the teachers that their learners will not concentrate concurs with Orey & Rosa's (2006) findings that pointed out that a lot of teachers felt that their learners would not learn mathematics/geometry if ethnomathematical approaches are incorporated into the teaching of geometry.

This section dealt with teachers' views on the integration of ethnomathematics approaches into the teaching of geometry. What was evident from the results is the positive views held by the teachers on the integration of ethnomathematics approaches into the teaching of geometry.

5.7 Challenges of integrating ethnomathematics approaches into the teaching of geometry

Although teachers admitted that they integrate ethnomathematics approaches when teaching geometry (refer to section 5.5) and they held positive views about the integration of ethnomathematics approaches (refer to section 5.6), they felt that they did not integrate it very well because they were constrained by numerous challenges. The challenges which they mentioned were categorised as learner related challenges, nature of geometry, insufficient resources, curriculum related challenges, teacher-related challenges and parental involvement. These challenges are discussed in the following sections.

5.7.1 Learners related challenges

Leaners' challenges to the integration of ethnomathematics approaches from the open-ended questionnaire questions were categorised into four as learners' attitudes towards ethnomathematics approaches (see Table 5.36), learners' lack of knowledge on cultural examples (see Table 5.37), cultural diversity(see Table 5.38) and resistance to change by learners as shown in Table 5.39.

Table 5.36: Learners' attitudes towards ethnomathematics approaches (n=40)

Representative quotes
May not take the teacher seriously at the introduction of ethnomathematics approaches.
Learners may not want to use primitive ways of teaching and learning and will not take it seriously.
Learners are not cooperative and not interested in such methods.

The teachers' responses showed that they were of the view that learners might feel that the teaching approach is primeval and might not take the teaching and learning process seriously (see Table 5.36). Teachers' concerns were supported by the following excerpt:

"Some learners may find the things used as irrelevant especially with the use of technology. Learners might not want to be associated with cultural things" (Group D).

The responses showed that the teachers were of the view that learners have negative views about the integration of ethnomathematics approaches into the teaching of geometry.

Table 5.37: Learners' lack of knowledge on cultural examples (n=40)

Representative quotes
May not take the teacher seriously at the introduction of ethnomathematics approaches.
Learners may not want to use primitive ways of teaching and learning and will not take it seriously.
Learners are not cooperative and not interested in such methods.

Participants were of the view that learners might not understand the cultural examples or might not be familiar with the context used by the teacher, hence, no learning would take place (see Table 5.37). They felt that learners might not be able to relate the known to the abstract. The finding is in line with Maldivian learners in Adam's (2004) study who became aware of the mathematics that exists outside school and in their culture, after they were introduced to an ethnomathematics based measurement unit, pointing to the fact that before they were not aware of the mathematics that exists outside the schooling system. In addition, Boaler (1993) argued from the social constructivist view that a single cultural/contextualised example cannot offer the same application that is familiar and even meaningful for all the learners.

Table 5.38: Cultural diversity (n=40)

Representative quotes
Different cultures of learners.
Learners come from different cultural backgrounds.
Different cultures of learners some of the learners won't be able to link what the teachers will be giving as examples because of their cultural backgrounds.
Some learners may not know the examples given for instance indigenous fruits, they have different cultures so it is difficult to come up with a common goal.
Globalisation leading to mixing of cultures.
Learner's different backgrounds can affect can affect the integration of ethnomathematics approaches.

As indicated in Table 5.38, the learners' different cultures had been reported by the participants as a challenge that they could face when integrating ethnomathematics approaches. In support of the cultural diversity from open-ended questionnaire questions teachers from Group E said:

"Cultural differences, for example, finding the area grazed by a goat tied on a rope at a tree, learners from rural areas would be aware of the contextualisation but this might be meaningless to some learners from the urban areas. Some of the examples used do not cater for learners from different cultural background, For instance, the question in Figure 5.6. The question best fits learners in urban schools where there are lampposts and mowers" (Group E).

Figure 5.6 illustrates this aspect.

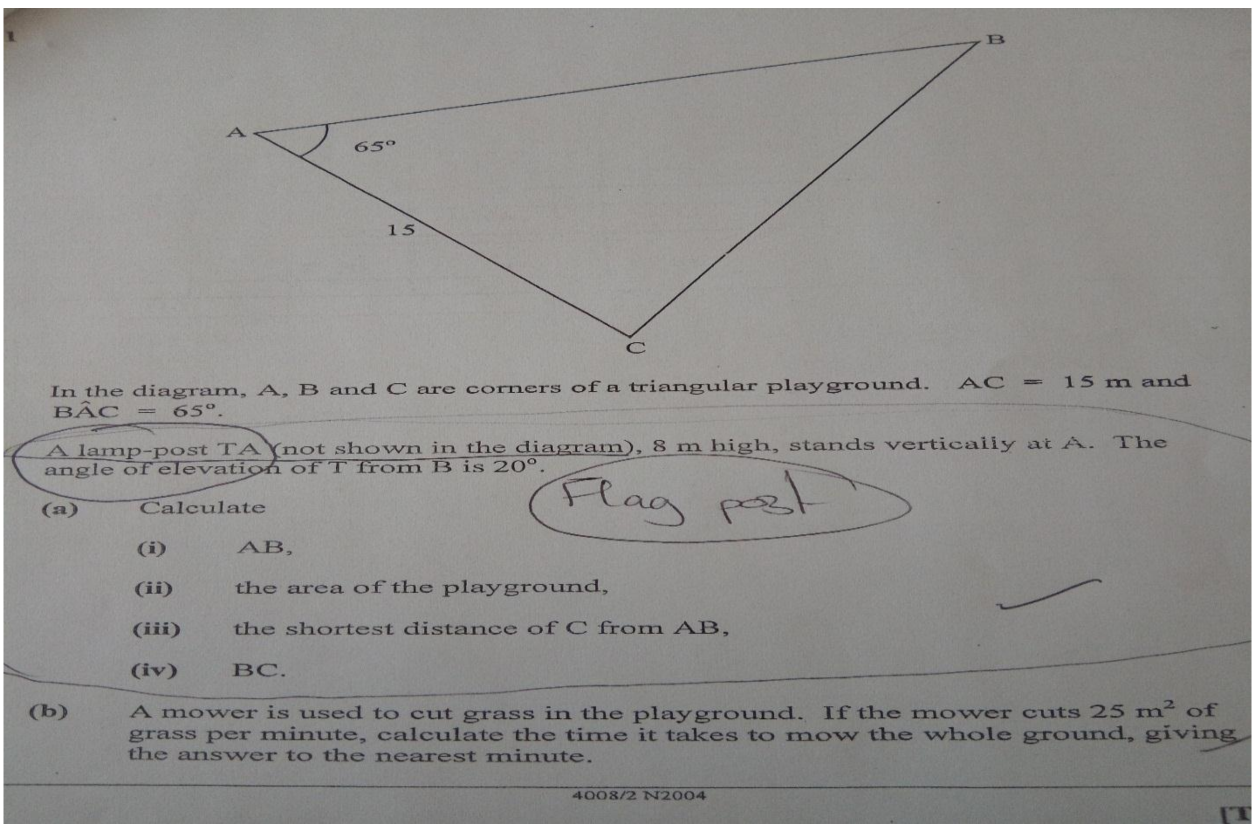
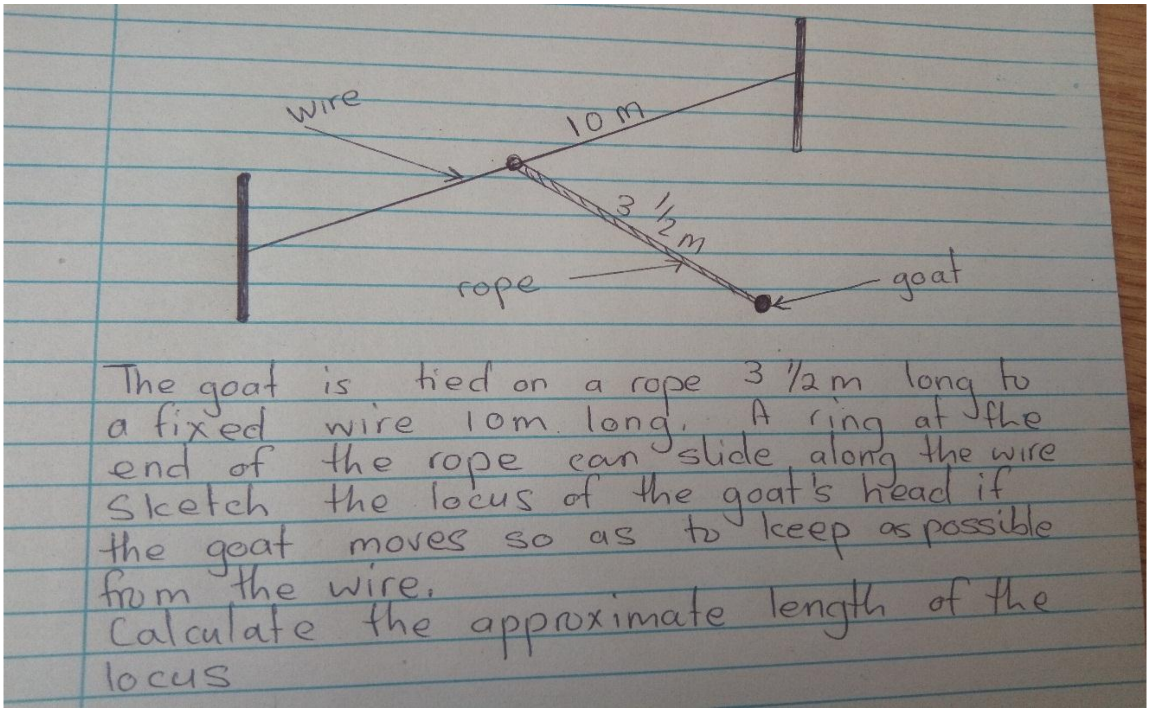


***Figure 5.6**: Examination question provided by Group E*

"The geometrical problem is best designed for the learners from urban schools where the lamp-posts and mowers are found" (Group E).

Similarly, teachers from Group D testifies that:

"We are teaching in urban schools where some of the learners don't know some of these cultural things integrated into the teaching of geometry. (See example provided in Extract 5.6)" (Group D)



Extract 5.6: Group D's response

"If the teacher's social background and culture differs from the culture of the learners what examples should be used? For example, if the teacher is Wasu (Manyika) and the learners are zezuru (Zezuru)". (Group E) [Manyika and Zezuru are Shona dialects]

In different cultures, there are different geometry examples and artefacts that might pose challenges to the teachers as they need to select the ones that suit all the learners, without disadvantaging the other learners (Rosa & Orey, 2010). Furthermore, coming up with relevant examples to contextualise geometry content is difficult in heterogeneous classes where learners are from different social and cultural backgrounds (Barnes & Venter, 2008). In such cases, teachers could get their learners to find examples from their culture and environment that links to the relevant geometry concepts.

In addition, to support the challenge of cultural diversity, the teachers pointed out that globalisation had also led to cultural diversity. The teachers concerns can be supported by the following excerpts:

"Globalisation, for instance, watching of television and culture is not necessary, hence no time to look outside the world" (Group C).

"Teaching learners to be globally accepted, so there is no need for Ethnomathematics" (Group E).

Teachers' response that globalisation affects the integration of ethnomathematics approaches contradicts D'Ambrosio's (2001) views in which he asserts that mathematics is an essential cultural tool that have a better effect on 'today's leaners, since they now live in a society led by mathematically grounded technology and is an exceptional means of communication. Therefore, the notion of incorporating geometry as used by learners in their backgrounds and cultural environments should be taken into consideration in geometry teaching. In addition, ethnomathematics approaches provide an opportunity to expose learners in the geometry class to cultures other than their own, which is even more important in the contemporary world, where nations are becoming multicultural and globally connected. However, ethnomathematics approaches are regarded as negative when it leaves learners unprepared to take part in greater global academic and social activities (Orey & Rosa, 2006).

Table 5.39: Resistance to change by learners (n=40)

Representative quotes
Learners are resistant to change, and might not like the teaching of geometry with a link to the environment or culture.
Learners are trained to be passive since this needs their active participation learners develop topic phobia.

Teachers' responses showed that they were of the view that the learners were resistant to change (as shown in Table 5.39), and might not like the teaching of geometry based on ethnomathematics approaches. The finding is in line with Duit & Treagust, (1998) who reported that learners will be mystified and will even resist such approaches because they would have become relatively contented and gratified with approaches that enable them to learn geometry knowledge by heart.

Table 5.40: Lack of listening and relating skills by learners (n=40)

Representative quote
Learners lack listening skills and relating skills.

As indicated in Table 5.40, teachers' responses showed that the learners lacked some important skills that are required in the construction of geometry knowledge. Specifically, the teachers' efforts to employ ethnomathematics approaches were unfulfilled because of the learners' lack of listening skills and relating skills.

Table 5.41: Learners' attitudes towards geometry (n=40)

Representative quotes
Learners don't like geometry.
Learners have a negative attitude towards geometry.

Teachers' responses showed that the learners had negative attitudes towards geometry (see Table 5.41). Learners' negative attitudes towards their learning of geometry was also reported by Cherinda (2012) and Jones (2002). Learners' negative attitude towards geometry impede implementation of ethnomathematics approaches because no matter what method the teacher might use the learners would not be interested in learning geometry.

5.7.2 Nature of geometry

The nature of geometry poses challenges to the integration of ethnomathematics approaches into the teaching of geometry. The quantitative data from closed-ended questionnaire question showed that 16 participants strongly agreed or agreed that geometry is too abstract. This was confirmed by the data from open-ended questionnaire questions in Table 5.42 and Table 5.43. The data from the open-ended questionnaire question were categorised into two as abstractness of geometry (see Table 5.42) and geometry concepts cannot be linked to culture (see Table 5.43).

Table 5.42: Abstractness of geometry (n=40)

Representative quotes
Geometry is abstract to most learners, too difficult for learners, geometry requires precision, too abstract.
It is generally difficult to comprehend.
Some of the ideas and concepts seem to be too abstract.
Geometry topic requires are lot so it is too demanding.

Teachers' views about the nature of geometry and about its teaching and learning intensely influence their willingness to integrate ethnomathematics approaches into the teaching of geometry (Ernest, 1991). The teachers' responses showed that they were of the view that geometry is an abstract, difficult topic, which is demanding and too practical (as shown in Table 5.42). The abstractness of geometry was supported by the data from the focus group discussions. Teachers from Group A said:

"*Abstractness of concepts, some concepts are difficult to relate to culture. If concept is too abstract you cannot link it to culture" (Group A).*

From the comments above, the abstractness of geometry makes it difficult to relate it to culture. The finding corroborated those by Akpo (1999); Makari (2007) and Naweseb (2012) who reported that geometry is one of the topics that is abstract and hence difficult for teachers to relate to learners' cultural or environmental experiences. The view that geometry is abstract has its origins in the traditionalist views of mathematics that views mathematics as abstract and leads to geometrical instruction that does not have anything to do with culture (Ernest, 2009; Ukpokodu, 2011).

Table 5.43: Geometry concepts cannot be linked to culture or environment (n=40)

Representative quotes
Some of the ideas and concepts are not reducible to cultural beliefs.
Do not suit the inclusion of culture.
Some concepts are too abstract that you cannot link them to culture.
Interesting but not linked with environment, some concepts are difficult to link with culture
Some concepts are too abstract to link with culture.
The concepts are too complex to link with culture.

Teachers reported that some of the geometry concepts cannot be linked to culture (see Table 5.43). The view that geometry could not be linked to the learners' daily and cultural experiences was supported by the data from focus group discussions. Teachers from Group B said:

"Shapes in geometry are perfect arts, lines and natural shapes are not perfect, at times fail to match with the curriculum shapes" (Group B).

From the above comments, it can be noted that the teachers believe that some concepts in geometry cannot be related to the environment or to the cultural experiences of the learners due to its nature. Teachers' view of geometry as perfect arts concurs with Lipka (cited in Barton 1996) who pointed out that mathematics including geometry is a logical set of propositions that represent an ideal world, for example, a line in geometry. The traditionalist's view of mathematics pay no attention to the irregularities found in cultural geometry objects forcing a vision of mathematics as smooth, neat, and orderly (White-Fredette, 2010).

5.7.3 Insufficient resources

The quantitative data from the closed-ended questionnaire questions in Table 5.44 indicate that textbooks did not have cultural examples.

Table 5.44: Teaching-learning resources challenges (n=40)

Item	Statement	SA N (%)	A N (%)	N N (%)	D N (%)	SD N (%)
24	Textbooks that are used for teaching geometry have cultural examples	5 (12.5)	11 (27.5)	3 (7.5)	11 (27.5)	10 (25)
25	Textbooks available to learners lack enough cultural examples on geometric concepts.	11 (27.5)	19 (47.5)	2 (5)	4 (10)	4 (10)

The data in Table 5.44 (item 24) showed that 21 participants disagreed that the textbooks used for teaching geometry had cultural examples. The result is supported by the 30 participants who agreed with the converse statement, that the textbooks available to the learners lack enough cultural examples on geometry concepts. The data is further supported by teachers' responses from the open-ended questionnaire questions as shown in Table 5.45.

Table 5.45: Resource related challenges (n=40)

Representative quotes
Scarce resources, very limited and sometimes poorly sourced by authorities, resources are not easily available, inadequate, and there is serious lack of resources in schools. *We do not have text books in schools* *We lack resources, for example, models like geo-boards in schools.* *There is a lack of environmental resources that match geometry concepts to be covered.* *Learners lack money to buy mathematical sets for geometry.* *Resources may not be affordable since some fruits are seasonal.* *The approach is expensive and requires a lot of money*, resources are scarce and expensive. *Due to lack of time teachers and learners may fail to use local environment and to design geometrical instruments*.

There was a general outcry on the lack of resources to integrate ethnomathematics approaches into the teaching of geometry, as indicated by teachers' expressions in the Table 5.45. The scanty resources that they mentioned included time, textbooks, models like geo-boards and money to buy geometrical instruments. At times geometry concepts requires specialised instruments from the mathematical sets (Naweseb, 2012). For instance, geometrical construction needs pairs of compasses and dividers, set squares and rulers from the mathematical sets (Naweseb, 2012). The teachers were also of the view that the cultural or environmental resources did not match the geometrical concepts. Furthermore, teachers reported that some of the materials used in teaching geometry were seasonal and could be expensive for both the teachers and the learners.

5.7.4 Curriculum related challenges

Curriculum related challenges such as unclear syllabus (see Table 5.46), lack of cultural examples in syllabus and examinations (see Table 5.48), effect of syllabus on examination (see Table 5.49), development of the syllabus (see Table 5.50) and the volume of content to be covered in the syllabus (see Table 5.51) were mentioned by the participants in open-ended questionnaire questions. .

Table 5.46: Unclear Syllabus (n=40)

Representative quotes
Syllabus is not clear on how to integrate these approaches.
The syllabus does not clearly indicate exactly were the aspects of culture can be integrated.
The syllabus has to have more emphasise on the integration.
The syllabus need to clearly emphasis the concepts of Ethnomathematics.

Teachers' responses showed that the syllabus was not clear on what to include, where and how to include it when using ethnomathematics approaches (see Table 5.46). Although, the syllabus was not clear on the aspects of Ethnomathematics to be included when teaching geometry, Orey & Rosa (2006) pointed out that teachers were not permitted to teach what was not specified in the syllabus.

Lack of cultural examples in the syllabus and examinations

Teachers' responses to the closed-ended questionnaire questions are shown in Table 5.47.

Table 5.47: Syllabus and examination related challenges (n=40)

Item	Statement	SA N (%)	A N (%)	N N (%)	D N (%)	SD N (%)
1	Examinations do not have geometrical questions drawn from the environment	11 (27.5)	10 (25)	5 (12.5)	10 (25)	4 (10)
26	The design of the syllabus allows teachers to integrate cultural examples when teaching geometry.	10 (25)	18 (45)	6 (15)	4 (10)	2 (5)

The quantitative data showed that 21 participants agreed that examinations do not have geometrical questions drawn from the environment (as shown in Table 5.47). The lack of cultural examples in examinations was supported by the data from open-ended questionnaire questions as shown in Table 5.48.

Table 5.48: Lack of cultural examples in syllabus and examinations (n=40)

Representative quotes
Examinations do not have cultural examples.
Syllabus do not have cultural examples.
Not well thought out, examinations on aspect not yet known, no enough examples.
Idea not formally emphasised in the examinations.
Syllabus does not offer the use of Ethnomathematics
It is not incorporated in the syllabus.
Syllabus is not culture sensitive, no cultural examples, lack of questions involving cultural activities in the learning of geometry.
The syllabus should include this method, should include culture based topic.
A balanced syllabus must include indigenous knowledge systems to enhance culture of learners.
The syllabus must have indigenous knowledge questions.
Proper examples should be used in examinations and syllabus and should include cultural based questions in examinations.

Teachers' responses showed that they were of the view that examinations left out cultural examples or activities (see Table 5.48). This was further supported by teachers' responses from focus group discussions. This is what the teachers said:

"ZIMSEC sets examinations with irrelevant and out-of-context geometry problems, for instance, 'a boat is 20m from a straight river bank and 29m from a tree on the edge of the bank. By scale drawing draw two possible positions of the boat. Measure the distance between them'" (Group E).

Some geometry questions such as, 'a ship sails in an ocean' related to other countries and not to our own situation are also found in examinations. For instance, 'a ship sails 5km due north from port A to port B on a bearing 045^0 from port C. Given that AB is 5km. how far is port C from the line joining A and B.' The question is out of context as the learner will concentrate on finding the actual meaning of port, imagine how a ship looks like, thereby failing to demonstrate the bearing because the situation modelled was farfetched. This was not relevant to the Zimbabwean context to worsen the situation the questions are always new to the learners" (Group E).

From the above comments, teachers were of the view that examination questions were not relevant to learners because examples were drawn outside the Zimbabwean cultural context, and were in most cases new to learners posing even more challenges to learners who did not understand the examples.

Although, the majority of the participants (28) agreed that the design of the syllabus allowed them to integrate cultural examples when teaching geometry (as shown in Table 5.47), this was not supported by data from open-ended questionnaire questions. Teachers' responses show that they were of the view that the syllabus did not include cultural examples or activities (see Table 5.48). Lack of cultural examples in syllabus (as indicated in Table 5.48) was also supported by data from focus group discussions. This was presented by teachers from Group A and C when they stated that:

"Syllabus does not encourage the use of cultural examples" (Group A).

"Syllabus does not encourage integration of such approaches. We teach following the syllabus. We are not allowed to teach content that is outside the syllabus" (Group C).

Lack of cultural examples in the syllabus as indicated by the participants was a critical one, for the reason that the syllabus that was in use was "prescriptive", as a result what was not emphasised in the syllabus would not be taught. The finding concurs with Matang (2008) who observed that the curriculum content lacked the basic local content that mirrored learners' own home and cultural background.

Table 5.49: Effect of syllabus on examination (n=40)

Representative quote
The syllabus is well standardised, the syllabus is exam bound, too examination oriented syllabus, and syllabus is examination and result oriented.

Teachers' responses showed that they were of the view that the syllabus was well standardised, examination oriented and result oriented (see Table 5.49). Based on teachers' comments on the effect of syllabus on examination, it could be assumed that the main purpose for teaching geometry was for the learners to pass examinations, regardless of whether they understood the concepts or were meaningful to them. Orey & Rosa (2006) argue that it is challenging to mix objectives and philosophy of Ethnomathematics, academic benchmarks, standards, and aims associated with passing of standardised examinations that were based on traditional school mathematics. An examination-bound curriculum is based on what Ernest (2009) referred to as the traditionalist view of mathematics where teacher-centred approaches are used to speed up the coverage of the all the curriculum topics in preparation of examinations.

Table 5.50: Development of the syllabus (n=40)

Representative quotes
Teachers are not involved in designing the syllabus. *We are not involved in the formulation of syllabus.*

Participants' responses showed that they were not involved in designing the syllabus (see Table 5.50). Teachers were not afforded the opportunity to participate in the development of the syllabus that they were implementing, hence, this was a barrier to the integration of ethnomathematics approaches. Involving the teachers in all the stages of the syllabus development would give them a sense of ownership and accountability, and hence they would be in a position to implement the syllabus effectively (Carl, 2005).

Table 5.51: The volume of content to be covered in the syllabus (n=40)

Representative quotes
The syllabus is long and you cannot finish it when trying to give real life examples.
It will be difficult to cover the syllabus, it can take a lot of time.

Teachers were of the view that there was limited time for geometry concepts to be well covered using ethnomathematics approaches because the syllabus is too long (as shown in Table 5.51). The finding concurs with Cherian (2012) who asserted that teachers did not use ethnomathematics approaches when teaching because there is too much to be covered in the syllabus for the allocated time.

Lack of support from curriculum development unit and political leadership

Data from open-ended questionnaires showed that the teachers perceived the CDU and political leadership in Zimbabwe as barriers to the integration of ethnomathematics approaches due to their lack of support. The political situation affects allocation of resources and funding for both the schools and teacher training institutions, which hinders the integration of ethnomathematics approaches into the teaching of geometry (Matang, 2009; Matang & Owens, 2004).

5.7.5 Teacher related challenges

Data from open-ended questionnaire questions in the show teacher related challenges that were categorised as teachers' lack of training on Ethnomathematics (see Table 5.52), teachers' lack of knowledge on ethnomathematics approaches (see Table 5.54), lack of knowledge on cultural/ contextual examples (see Table 5.55), lack of geometry content knowledge (see Table 5.56) and resistance to change by teachers as shown in (see Table 5.57).

Teachers' lack of training on Ethnomathematics

Table 5.52: Teachers' lack of training on Ethnomathematics (n=40)

Representative quotes
Teachers were not taught to integrate culture into the teaching of geometry.
Teachers were not adequately trained to show link between geometry and culture.
Teachers were not trained to use the approach.
I was not taught to link culture in the teaching of geometry, the idea was not emphasised in colleges.
The concept of ethnomathematics approach was not covered in the teacher training curricula.
Lacked the training required, not much was done since demonstration method was used.

The teachers were of the view that they were not trained on ethnomathematics approaches (as shown in Table 5.52). The lack of training on ethnomathematics approaches was confirmed by the data from focus-group discussions. This is what the teachers said:

"Never trained using these methods so can't use them" (Group D).

"Lack background knowledge on how to do it we were never given training" (Group E).

The above comments showed that the teachers lacked training on ethnomathematics approaches. The findings of this study are consistent with findings of earlier studies on lack of training on ethnomathematics approaches when teaching (Ukpokodu, 2011; Velasquez, 2014; Naresh, 2015).

Lack of knowledge on ethnomathematics approaches

Table 5.53 shows teachers' responses on teacher related challenges from closed-ended questionnaires questions.

Table 5.53: Teachers' responses (n=40)

Item	Statement	SA N (%)	A N (%)	N N (%)	D N (%)	SD N (%)
22	I cannot develop culturally contextualised examples for geometry teaching.	6 (15)	2 (5)	4 (10)	18 (45)	10 (25)
23	I lack knowledge on ethnomathematical approaches.	5 (12.5)	9 (22.5)	9 (22.5	12 (30)	9 (22.5)

The data from the closed-ended questionnaire revealed that 21 participants disagreed that they lack knowledge on ethnomathematics approaches (see Table 5.53). The data from the closed-ended questionnaire revealed that 28 participants disagreed or strongly disagreed that they cannot develop culturally contextualised examples for geometry teaching (as shown in Table 5.53, item 22).

Table 5.54: Teachers' lack of knowledge on ethnomathematics approaches (n=40)

Representative quotes
I lack the knowledge of linking geometry to culture.
No adequate training has been done in this area.
Lack of skills and knowledge by the teachers on these approaches.
I do not have enough knowledge on Ethnomathematics.
I*nadequate knowledge to integrate culture when teaching.*
Lack of knowledge on teaching methods suitable for teaching geometry incorporating culture and environment.
I am not aware of the methods.
Not equipped to teach in that methods.
I lack background knowledge on such example.
I do not know the valid examples.
Not really, l do not fully understanding it.

Data from open-ended questionnaire questions did not support the data from closed-ended questionnaire questions. Data from open-ended questionnaire questions showed that the teachers lacked ethnomathematical knowledge and skills required for the integration of ethnomathematics approaches into the teaching of geometry (see Table 5.54). Teachers' lack of ethnomathematical knowledge was supported by the data from focus group discussions. The following response from the focus group discussion exemplified the lack of ethnomathematical knowledge and how to integrate ethnomathematics approaches:

"Lack of knowledge on how to integrate ethnomathematics approaches, we don't know how to do it" (Group A).

The teachers' responses showed that their lack of knowledge on ethnomathematics approaches that affected their integration of ethnomathematics approaches into the teaching of geometry. This finding is in line with Mosimege (2012) who pointed out that teachers lack the ability to make connections in their teaching. In addition, in Mogari (2014)'s study the teachers were able to repeat workshop activities during their teaching but they were not able to develop and use their own ethnomathematical activities, which concurs with the findings of this study.

Lack of geometry content knowledge

Table 5.55 shows teachers' responses on teacher related challenges from closed-ended questionnaires questions.

Table 5.55: Teachers' responses (n=40)

Item	Statement	SA N (%)	A N (%)	N N (%)	D N (%)	SD N (%)
15	I lack knowledge on geometrical concepts	7 (17.5)	3 (7.5)	4 (10)	11 (27.5)	15 (37.5)

Data from the closed-ended questionnaire showed that the majority of the participants (30) were in disagreement with the statement that they lack knowledge on geometrical concepts (as shown in Table 5.55).

Table 5.56: Lack geometry knowledge (n=40)

Representative quotes
I was not well equipped with geometry concepts.
I was never trained to teach geometry.

However, from the focus group discussions some teachers (8) confessed that they had limited knowledge of geometry. Teachers from Group E commented:

"Our geometry content mastery is low. We do not have the content required to teach geometry" (Group E)

For the teachers to integrate ethnomathematics approaches they need to have a deeper understanding of the mathematics/geometry concepts (Madusise, 2015). The above comments indicate that the teachers' mastery of geometry content was low, hence integrating ethnomathematics into its teaching is a problem. In an Ethnomathematics classroom, teachers must possess geometry content knowledge because they are tasked with the responsibility of choosing the cases that are related to learner cultural background and their environment (Orey & Rosa, 2006).

Table 5.57: Resistance to change by teachers (n=40)

Representative quotes
Reluctance to conform to new changes. Resistance from the teachers.
The teachers might take it for granted.

The data from the open-ended questionnaire questions in Table 5.57 corroborate the data from the focus group discussions where the teachers mentioned they were resistant to change. The following examples from focus group discussions show the teachers' expressions:

"We are to change from being teacher-centred to learner-centred that requires us to become facilitators. It is better to do what we are used to" (Group D).

"Teachers are resistant to change because they are colonised by the current use of technology" (Group E).

Teachers' responses show that they were of the view that they were to change their approaches from teacher-centred to learner-centred and that they were colonised by the use of technology. In actual fact, in an Ethnomathematics classroom teachers are required to recognise learners as equal companions in the teaching and learning process, motivating them to contribute meaningfully to geometrical activities (Matang, 2002). In other words, learners are made to be active members of teaching and learning process rather than passive receivers of information, which could result in teachers resorting to their own traditional ways of teaching geometry.

5.7.6 Parental involvement

Data from the focus group discussions showed that the teachers were of the view that the integration of ethnomathematics teaching approaches into the teaching of geometry is influenced by the support of parents. Teachers from Group C said:

"Learners' lack of exposure due to lack of funds and support from parents to go to sites and fieldtrips. Parents do not support the learners' interaction with the environment, they don't want their children to be outside the school as learning is believed to take place at the school, so we face resistance" (Group C).

Teachers' responses showed that they felt that they lacked support from the parents. They were of the view that parents should support school activities such as fieldtrips that would enable out-of-school learning.

The challenges highlighted by the teachers revealed that the integration of ethnomathematics approaches into the teaching of geometry in schools and in teacher training programs were not done effectively.

5.8 Summary

This chapter has reported results from data analysis of questionnaires and focus group discussions. The findings indicate that ethnomathematics approaches are valued by the teachers and the approaches have several benefits for both the teachers and the learners. While the teachers articulated the value of ethnomathematics approaches, its integration into the teaching of geometry still face challenges. These challenges included teachers' related challenges, learner related challenges, and curriculum related challenges, nature of geometry and insufficient resources. The next chapter focuses on providing the answers to research questions, gives conclusions as well as recommendations.

CHAPTER 6: CONCLUSIONS AND RECOMMENDATIONS

6.1 Introduction

This chapter presents answers to research question, provides conclusions of this study, recommendations, limitations of this study, and suggestions for further research.

6.2 Answers to the research question

For the participating in-service teachers, this section focuses on answers to their: training to teach geometry; training to integrate ethnomathematics approaches in geometry teaching; views on ethnomathematics approaches; views on integration of ethnomathematics approaches in geometry teaching; and challenges to integrate ethnomathematics approaches into the teaching of geometry.

6.2.1 Question 1 a: How were the in-service teachers trained to teach geometry?

Although, the majority of the teachers (28) were taught geometry concepts during their training, this did not guarantee an understanding of geometry concepts or being prepared to teach geometry. Answers to this research sub-question focus on: adequately trained to teach geometry; inadequately prepared to teach geometry; and teachers' instructional practices in teaching geometry.

6.2.1.1 Teachers who were adequately trained to teach geometry

Findings showed that 21 teachers were adequately trained to teach geometry. Teachers' adequate training was due to the fact that geometry was related to other areas of mathematics, their lecturers' practices and sufficient resources. Geometry was not taught as an independent topic, it was related to other topics in mathematics. This supports findings by Jones (2002) who reported that geometry could be used to help learners make sense of other topics of mathematics such as fractions and multiplication in arithmetic, the relationships between the graphs of functions and graphical representations of data in statistics.

As shown by findings in chapter 5, the in-service teachers who were adequately trained to teach geometry were exposed to the teaching approaches that were based on the humanist, social constructivist and ethnomathematics approaches. Approaches included use of practical and cultural activities with examples, media and visual models that made geometry not to be difficulty for them and approaches that enhanced the teachers' understanding of geometry concepts. This supports findings by Paraide (2015) who reported that connecting cultural activities and experiences with geometry concepts in the classroom can strengthen the learners' understanding of geometry concepts, which could be possibly a reason for teachers' lack of difficulty in understanding geometry concepts. Bishop (1988) pointed out that mathematical/geometrical ideas from the learners' cultural background could be used to deliver geometrical concepts in the classroom, which was evidenced in this study.

In this study, findings showed that the resources for teaching geometry were easily available because they were natural and locally available. This finding is in line with Daniel (2014) who pointed out that cultural resources are easily accessed or just found or available outside the schools or homes were both the teachers and learners have access to the resources for free. The study also showed that the practical approach was used when teaching geometry. The finding concurs with Jones (2002) who reported that a practical topic that requires a practical approach and a variety of resources makes the teaching and learning experiences more interactive and meaningful.

Evidence from the research findings suggest that those teachers possessed the kind of the subject-matter knowledge of geometry which would allow them to teach geometry concepts. This indicates the possibility of integrating ethnomathematics approaches into the teaching of geometry

6.2.1.2 Teachers who were inadequately trained to teach geometry

Findings showed that 19 teachers were inadequately trained to teach geometry, hence, they lack geometry content knowledge required for teaching. Such teachers cannot be effective in integrating ethnomathematics approaches into the teaching of geometry; if they had some inadequacies, they cannot be expected to teach well what they did not know very well (Mogari, 2014).

Teachers had challenges with their understanding of geometry concepts because of the following reasons: lecturers' practices, teachers' lack of the interdisciplinary nature of geometry, insufficient resources and nature of geometry. The teachers indicated that they were not aware of the interdisciplinary nature of geometry. This finding concurs with Orey & Rosa (2006) who reported that teachers were not aware of the interface between geometry and other topics in mathematics, that is, the interdisciplinary nature of geometry that was necessary in ethnomathematics approaches.

As highlighted by the findings in chapter 5 their lecturers' practices could be classified under the Ernest's (2009) traditionalist view of mathematics because of their over-reliance on the syllabus, textbooks and their use of teacher-centred approaches, where geometry was taught as a culture free topic. Their lecturers' practices did not foster conceptual understanding of geometry concepts which could probably explain why those teachers faced difficulties in understanding the concepts. Teaching without relating to the learners' environment may also contribute to the difficulty in understanding the geometry concepts by those teachers (Bishop, 2004; D'Ambrosio, 2001).

In this study, findings show that geometry is a demanding topic and its language/terminology posed challenges to those teachers. The finding corroborates earlier findings by Jones (2002) who pointed out that geometry is a demanding topic as it can be taught using different approaches, for instance, the use of technology, or ethnomathematics approaches and this requires teachers who are versatile with geometry concepts. In addition, Naweseb (2012) noted that it is not possible for teachers to connect to the environment or culture the topics that they view to be demanding to teach. The difficulty faced by those teachers that stemmed from geometry language/terminology concurs with Bishop (1986) who said that many geometry learners have weakness in the vocabulary of geometry. The language of geometry involves a particular terminology, which is unique and needs to be considered and understood before it can be meaningfully used, because if it is not properly used it can result in misunderstanding of geometry knowledge (Bishop, 1986). The current study also supported that finding for this group of participating teachers.

In summary those teachers' reasons for facing difficulties were: instructional approaches, non-availability of instructional materials and the nature of geometry including its language/terminology. This supports findings indicated by other researchers (Noraini, 2006; Telima, 2011; Mashingaidze, 2012). All these contributed to those teachers' difficulties in understanding geometry concepts and the non-integration of ethnomathematics approaches into the teaching of geometry. The argument is that it is not possible for teachers to relate the geometry concepts that they themselves view to be difficult to the learners' cultural background and experiences. Further, difficulties that such teachers face with geometry concepts are likely to impact negatively on their use of ethnomathematics approaches into their teaching of geometry.

6.2.1.3 Teachers' instructional practices in teaching geometry

As highlighted by findings in chapter 5, those teachers who used the teacher-centred approaches applied different procedures and algorithms that put emphasis on facts, procedures and rules that were used to solve geometrical problems. Ernest (2009) classified the teacher-centred approaches under the traditionalist view of mathematics that did not encourage the integration of ethnomathematics approaches into the teaching of geometry. The reasons for participating teachers' use of teacher-centred approaches were content coverage (so that learners would be able to sit for the examinations) and it was also due to their limited geometry content knowledge. Such teachers used teaching approaches that served their purpose as well as the approaches that they were familiar with. Their purpose for teaching geometry was to help learners pass examinations in accordance with Fasheh (1983) views.

Findings also showed that some teachers used learner-centred approaches such as the discovery approach, with the hope of with the aim of motivating and helping learners to understand geometry concepts, make them enjoy geometry, appreciate the geometry in their environment and its application in real life situations, and to remove geometry phobia. Those teachers' reasons for using learner-centred approaches were aligned to benefits of integrating ethnomathematics approaches into the teaching of geometry (refer section 5.6). The learner-centred approach to geometry teaching lends itself more to ethnomathematics approaches (Mogari, 2014). In the current study, those teachers who used learner-centred approaches were more aligned to the social constructivism views of teaching mathematics, the humanistic view of mathematics and to ethnomathematics approaches as opposed to the traditional views of mathematics (Ernest, 2009). Therefore, those teachers were likely to integrate ethnomathematics approaches into the teaching of geometry.

The study showed that the participating teachers used different teaching approaches that spanned from the teacher-centred approaches to the learner-centred approaches when teaching geometry.

This could be the same approaches that were accentuated and demonstrated for them during their teacher training, which further supports Ferner's (2013) observation that teachers teach in the same manner that they were taught. It can, therefore, be argued that the teaching approaches that teachers encountered when trained were passed on to their classroom practices.

6.2.2 Question 1 b: How were the in-service teachers trained to integrate ethnomathematics approaches in geometry teaching?

The answer to this sub-question focuses on: integration of ethnomathematics approaches; not trained to integrate ethnomathematics approaches.

6.2.2.1 Integration of ethnomathematics approaches

As highlighted by findings in chapter 5, all the teachers did not take any specific course on ethnomathematics approaches or Ethnomathematics in general during their training. The non-existence of courses on Ethnomathematics in teacher training program concurs with Orey & Rosa (2006) and Naresh (2015) who indicated that in most cases there is no context, nor content for Ethnomathematics courses in traditional teacher training programs.

Although, teachers did not take any Ethnomathematics courses, findings from this study showed that some aspects of Ethnomathematics were mentioned in passing in courses (such as philosophy of education and pedagogy) during their teacher training years. However, Averill et al. (2009) noted that merely mentioning aspects of ethnomathematics approaches in passing was not enough to make the teachers aware of such approaches and for its effective integration into the teaching of geometry in particular.

Ethnomathematics approaches focuses on cultural experiences, elements and activities that may possibly serve as starting points for doing and explaining geometry in the classroom (Gerdes, 1996). Findings showed that some teachers (15) were trained to use the environment and culture as teaching and learning resources that resulted in deep learning and understanding of geometry concepts. The use of culture and environment as sources of geometry knowledge is in line with the syllabus (ZIMSEC, 2015), the humanist and the social constructivist views of mathematics as well as ethnomathematics approaches (Ernest, 2009).

Some of the participating teachers also acquired various skills that enabled them to connect geometry to cultural and environmental situations. This is in line with Massarwe, et al. (2011) who reported that teachers acquired skills needed for teaching geometry in a cultural context, after being trained on how to teach geometry in a cultural context. As a result, in this study such teachers felt that they possessed the required knowledge and skills as far as integrating ethnomathematics approaches into the teaching of geometry is concerned.

Findings also showed that their lecturers used ethnomathematics approaches when teaching geometry because they used their cultural background knowledge as sources of geometry teaching and learning activities. Geometrical ideas from the trainee teachers' own cultures were integrated into the teaching of geometry through introducing the lessons with concepts that were familiar to the teachers, with the intention of connecting existing knowledge with their own cultural geometry knowledge (Adam, 2004). This supports the view that promotes learning geometry in context that are familiar which entails the incorporation of ethnomathematics approaches into the teaching and learning process that could result in more effective and meaningful learning (D'Ambrosio, 2001; Adam, 2004; Matang & Owens, 2004).

6.2.2.2 Not trained to integrate ethnomathematics approaches

The majority (25) of the participating teachers who were inadequately prepared to integrate ethnomathematics approaches into the teaching of geometry indicated that this was due to lack of geometry content knowledge, insufficient resources, lecturers' practice and curriculum related challenges. Findings showed that those teachers lacked adequate skills to integrate ethnomathematics approaches in the teaching of geometry because they were not trained to do so. This study's findings are consistent with those in earlier studies on lack of training on how to use ethnomathematics approaches when teaching (Ukpokodu, 2011; Mogari, 2014; Velasquez, 2014; Naresh, 2015). It becomes problematic for such teachers to effectively use ethnomathematics approaches in teaching geometry if their training did not adequately equip them to do so (Alder, 2005; Gainsburg, 2008; Venkat, et al., 2009).

Findings showed that these teachers lacked geometry content knowledge, which hindered the integration of ethnomathematics approaches into their teaching which concurs with Madusise (2015). In this study, teachers were responsible for selecting geometry examples on situations that were interesting to learners, however, in order to do it properly they must be knowledgeable in the geometry content because they are the ones who choose cases that are related to learners' cultural background and their environment (Orey & Rosa, 2006).

The study also revealed that their lecturers were used to a comprehensive syllabus which they strictly followed, as a result, if what they were expected to teach was not clearly stated in the syllabus then it would not be taught. In most cases, lecturers are not permitted to work divorced from the prescribed syllabus (Orey & Rosa, 2006; Ukpokodu, 2011), as a result, it is not possible for ethnomathematics approaches to be integrated into the teaching of geometry.

In addition, their lecturers used teacher-centred approaches and they relied heavily on textbooks for information. The textbook based instruction was viewed by Ukpokodu (2011) as one of the barriers to the integration of ethnomathematics approaches in the classroom because the teachers might develop procedural fluency, but they frequently lack the deep conceptual understanding required to make connections between geometrical ideas as in the case of ethnomathematics approaches. In an ethnomathematics classroom teachers were supposed to appreciate that there is geometry in everything, not just the geometry found in the syllabus and the prescribed textbooks (Rosa & Orey, 2016).

Findings revealed that some of those teachers were not trained to integrate ethnomathematics approaches because their teacher training college was located in an urban area. However, Bishop (1988), Gerdes (1988) and Zhang & Zhang (2010) pointed out that geometrical shapes, construction and designs were practiced everywhere and in any cultural activity including house construction, drawing, and weaving. There is a wide range of geometry applications in almost all cultures and human activities that could be used in the classroom (Bishop, 1998). This could imply that the non-linkage of geometry to cultural activities could be something else, not the location of the college.

6.2.3 Answer to research question 1

In general, these findings responding to the question that investigated how the in-service teachers were prepared to integrate ethnomathematics approaches into the teaching of geometry. The conceptual knowledge of geometry would help the teachers to explain geometry concepts in different ways that would make the learners understand the concepts, as well as using a variety of teaching approaches, including ethnomathematics approaches (Jones, 2002).

Therefore, it is important for teachers to have deep and strong geometry content knowledge because this kind of knowledge helps them to interpret their learners understanding of the concepts. Teachers' deep geometry content knowledge could also help them with their integration of ethnomathematics approaches in their teaching of geometry, because ethnomathematics approaches require a deep understanding of geometry content (Madusise, 2015). If this it accepted, then those teachers who lacked geometry content knowledge may not be in a position to integrate ethnomathematics approaches into their teaching of geometry. It is, therefore, important that such teachers are provided the required geometry content knowledge for teaching, since Shulman (2004) also argued that the effective integration of ethnomathematics approaches is centred on deeper conceptual understanding of geometry.

Evidence suggested that although most teachers (28) had taken some courses in geometry, there were some teachers who were not adequately trained to teach geometry. Such teachers had difficulties in teaching geometry, hence, they were not in a position to integrate ethnomathematics approaches into the teaching of geometry. Jones (2002) pointed out that most of the teachers lacked the kind of repertoires of subject matter knowledge and pedagogical content knowledge of geometry that would allow them to teach geometry effectively. This view was supported by the current study.

Furthermore, findings showed that some teachers (15) were trained to integrate ethnomathematics approaches into the teaching of geometry whilst the majority (25) were not. Findings revealed that no Ethnomathematics courses were taken by all teachers during training, but the concepts of Ethnomathematics were mentioned in passing in some courses such as pedagogics and philosophy of education. This might imply that the teachers were not adequately prepared to integrate ethnomathematics approaches into the teaching of geometry.

6.2.4 Question 2 a: How do in-service teachers view ethnomathematics approaches?

The answer to the sub-question focuses on: teachers' understanding and awareness of ethnomathematics approaches; teachers' integration of ethnomathematics approaches; teachers' views on nature of geometry taught in schools; and teachers' views on their roles in teaching geometry.

6.2.4.1 Teachers' understanding and awareness of ethnomathematics approaches

Findings showed that the most recurring definition of Ethnomathematics was based on the relationship between mathematics and culture. This definition is in line with the view held by D'Ambrosio (2001) and Izmrili (2011) who define Ethnomathematics as the study of the association between culture and mathematics. Ascher (cited in Barton, 1996) viewed Ethnomathematics as the connection of mathematics and culture, which ties with the most recurring definition presented in this study. The most recurring definition suggested that culture is an important tenet of Ethnomathematics and that mathematics is not culture free but rather it is culture-bound (Ernest, 1991; D'Ambrosio, 2001; Bishop, 2004; Rosa & Orey, 2010). It is possible that this definition has a bearing on the integration of ethnomathematics approaches into the teaching of geometry.

Findings also showed that most of the teachers (35) indicated that they had a clear understanding of ethnomathematics approaches. Furthermore, findings showed that the teachers' definitions of ethnomathematics approaches pointed to the incorporation of learners' cultural and environmental experiences and practices into the teaching of geometry. Their definitions on ethnomathematics approaches were within the broad parameters of the social constructivist view and the humanist view of geometry teaching and learning that were in line with the view held by Matang (2006), who suggested that learners' environment, every day and cultural experiences should be used in the classroom. An ethnomathematics approach to teaching school geometry is based on the notion that learning of school geometry is more effective and meaningful if it is linked to familiar geometrical experiences and activities found in the learner's own cultural environment (Matang, 2002).

Furthermore, findings revealed that teachers were aware of the geometrical cultural examples and activities that exist in their learners' cultural backgrounds and from their experiences such as traditional dancing games, round huts, pottery, and carpentry, welding and sewing. Such forms of geometry that are embedded in cultural activities and everyday experiences fall under the category of Ethnomathematics and have the potential to improve the teaching and learning of school geometry (D'Ambrosio, 1993). Teachers' awareness of such cultural examples and activities that could be integrated into the teaching of geometry had the potential to influence their understanding of how their learners acquire geometry concepts and thus encouraged them to use the learners' local geometrical knowledge as indicated by Paraide (2009).

6.2.4.2 Teachers' integration of ethnomathematics approaches

Findings showed the participating teachers (24) used cultural examples and activities in geometry teaching as learning materials and resources, as context for teaching geometry. The findings concurs with findings from earlier studies (Matang, 2002; Gerdes, 2005; Kang, 2004; Kanu, 2005; Hara-#Gaes, 2005; Massarwe et al, 2012) in terms of linking geometry concepts to the learners' cultural activities and experiences. Teachers also indicated that they used learners' indigenous language to enhance their comprehension of the geometry concepts. Teaching of geometry in a language that the learners were used to, is in line with Paraide (2009, 2014) who concluded that the use of indigenous languages when teaching makes learning more meaningful and improves understanding of concepts learnt. As indicated by Woolfolk (2010) and Vygotsky (1978) learning cannot take place in a vacuum. Learning occurs when learners interact with more knowledgeable peers or teachers in the classroom, for that reason, language is important for communication and any form of interaction in the classroom.

6.2.4.3 Teachers' views on nature of geometry taught in schools

Findings of this study showed that teachers (28) believed that geometry is culture-bound and some teachers (16) indicated that geometry content taught in schools is sensitive to culture. The view held by the teachers that geometry is culture-bound is in line with the view held by other researchers (D'Ambrosio, 2001; Gerdes, 2011; Massarwe et al, 2010; 2012; Jones, 2002) that geometry lies in the heart of culture and Ethnomathematics, and is an integral part of cultural experiences. Those teachers held Ernest's (2009) humanistic view of teaching mathematics, which embraces ethnomathematics approaches that connects the teaching of geometry to the learners' cultural background and environment. Those teachers who hold a humanistic view of mathematics as culture- and context-bound are likely to approach the teaching and learning of geometry from an Ethnomathematics perspective.

On the other hand, the majority of participating teachers (24) indicated that geometry taught in schools was not sensitive to culture. This view supports Ernest's (2009) traditional view of mathematics, where geometry knowledge is free from culture. This view has dominated in geometry classrooms, which disrespect the rich everyday out-of-school geometry that learners bring into the classroom (Bishop, 2004; D'Ambrosio & D'Ambrosio, 2013).

6.2.4.4 Teachers' views on their roles in teaching geometry

Findings showed that the majority of the participating teachers (32) indicated that their role was to provide guidance and to facilitate the teaching and learning process of geometry. The finding concurs with ethnomathematics approaches, social constructivist perspectives and the humanistic view of mathematics (Ernest, 2009; Matang, 2002; Woolfolk, 2010), in terms of the teacher who acts as a facilitator, guiding learners in constructing their own geometry meaning and facts.

On contrary, the minority of the teachers (8) indicated that their role was that of imparting geometry knowledge and skills which is based on Ernest's (2009) traditional view of mathematics, where the teachers are considered to possess all geometry knowledge and the learners are empty vessels waiting for geometry knowledge to be poured into them. Those teachers are likely not to integrate ethnomathematics approaches because of their focus on imparting knowledge.

6.2.5 Question 2 b: What are the views of the in-service teachers on the integration of ethnomathematics approaches in geometry teaching?

The findings showed that most of the participating teachers were of the view that cultural examples and activities should be incorporated into the teaching of geometry. Furthermore, as highlighted by the findings in chapter 5, the benefits of integrating ethnomathematics approaches into the teaching of geometry were relevance of geometry, motivation and interest, facilitation of understanding of geometry concepts and application of geometry concepts. Findings on such benefits are in line with those of other researchers (Adam, 2004; Kang, 2004; Anchor, et al., 2009; Rosa & Orey, 2010) in terms of enabling learners to comprehend, understand, and appreciate as well as apply geometry concepts, ideas, processes; and practices in solving practical problems in their societies. Furthermore, findings showed that this approach to geometry teaching would motivate learners to learn geometry and to recognise geometry as part of their daily lives, enhance their ability to make meaningful geometrical links and deepen their understanding of all forms of geometry, which concurs with Boaler (1993), Ernest, (1998) and Adam et al. (2003).

Further, only one teacher from the closed-ended questionnaire data was of the view that the quality of geometry education would deteriorate if Ethnomathematics were integrated into the teaching of geometry.

6.2.6 Answer to research question 2

The purpose of this section of research is to discuss findings that provide an answer to how the in-service teachers view the integration of ethnomathematics approaches into the teaching of geometry. The answer to this research question is framed around views that were produced from the answers framed for the two sub-questions. Findings showed that teachers shared common views about Ethnomathematics and ethnomathematics approaches, that it involves connecting the teaching of geometry to the learners' own cultural background and their environment. Furthermore, the teachers appeared to be aware of the geometry examples and activities that exist in their learners' environment and culture.

Findings also point to the success and discrepancy in teachers' integration of ethnomathematics approaches into the teaching of geometry. In many instances, most of those teachers (24) seemed to have demonstrated a high ability to integrate ethnomathematics approaches into the teaching of geometry On the other hand, the other teachers (16) demonstrated inadequate pedagogical knowledge and skills in the integration of ethnomathematics approaches into the teaching of geometry.

Teachers' views of the nature of geometry taught in schools and their roles influenced the integration of ethnomathematics approaches into teaching of geometry. The majority of the teachers (32) were of the opinion that their role was that of guiding and facilitating the learning of geometry, which is in line with ethnomathematics approaches. On contrary, some teachers (8) viewed their role as that of imparting knowledge, which is based on Ernest's (1991) traditional view of mathematics.

Most of teachers were of the view that ethnomathematics approaches be integrated into the teaching of geometry. Benefits of integrating ethnomathematics approaches into the teaching of geometry, such as, helping learners to experience self-reliance by applying geometry in real life situations including in work places such as builders or carpenters were mentioned. These benefits concurs with the purpose of ethnomathematics approaches to promote a deeper understanding and appreciation of geometry concepts in connection to its day-to-day application (Bishop, 1991; 2004; D'Ambrosio, 2001; Matang, 2002). However, only one teacher was of the view that the integration of ethnomathematics approaches would have a negative effect on the learners' performance.

6.2.7 Question 3: What do in-service teachers perceive as challenges to the integration of ethnomathematics approaches into the teaching of geometry?

Answer to this research question focuses on: learner related challenges; nature of geometry; insufficient resources; curriculum related challenges; teacher related challenges; parental involvement. Teachers felt that they did not integrate ethnomathematics approaches because they were constrained by these numerous challenges.

6.2.7.1 Learners related challenges

The participating teachers indicated that learners may have negative attitudes towards the integration of ethnomathematics approaches in the teaching of geometry, since they may feel that the teaching approach is primeval and may not take the teaching and learning process seriously. In such situations, the teachers could make use of the learners' cultural experiences in the classroom, but the learners may not want to study their own realities because they view them as primitive.

The study also showed that learners lack knowledge on geometry cultural examples and activities. D'Ambrosio (2010) and Bishop (2002) attributed the learners' lack of such knowledge to the absence of culture in content and instruction in the traditional classrooms. The traditional, passive aspect of schooling, makes it difficult for the leaners to see the geometry outside of the traditional classroom context (Orey & Rosa, 2006; Bishop, 1994). This implies that, for many learners, the geometry that they experience in school is not culturally consonant with their home experiences (Bishop, 2002). This mismatch could be one of the contributing factors for their learners' lack of knowledge on geometry cultural examples and activities.

The study further revealed that learners' cultural diversity pose challenges to the integration of ethnomathematics approaches into the teaching of geometry. This finding is in line with Orey & Rosa (2006) who pointed out that teachers would be faced with the challenge of selecting cultural examples or activities that must suit all their learners.

As with the learners, again, the study showed that they had negative attitude towards geometry which concurs with Cherinda (2012). It might imply that for the learners, any innovative technique introduced may not have a positive effect on them because they did not like geometry. No matter, what method would be employed to teach geometry, learners would have already developed negative attitudes towards geometry.

6.2.7.2 Nature of geometry

Findings showed that some teachers held the traditional view of geometry as perfect arts, abstract and a difficult topic that makes it difficult for them to link it to the learners' cultural background and environment. This traditional view of geometry could have a negative effect on the integration of ethnomathematics approaches into the teaching of geometry, which concurs with Ernest (1991) who was of the opinion that teachers' views about the nature of geometry influence their choices of teaching approaches.

6.2.7.3 Insufficient resources

Resources related factors such as time, lack of cultural examples and activities in the prescribed textbook were highlighted by the participating teachers as factors posing challenges to the integration of ethnomathematics approaches into the teaching of geometry. The challenge of time in integrating ethnomathematics approaches was also highlighted by Naresh (2015). He highlighted that the time required to understand the concepts embedded in the cultural activities would conflict with the time required to prepare expertise that is necessary for doing well in examinations. Furthermore, available textbooks did not relate geometry to cultural examples. This supports findings by Orey & Rosa (2006) who observed that prepared resources for ethnomathematics approaches were scant.

6.2.7.4 Curriculum related challenges

The curriculum materials such as the syllabus and standardised examinations were mentioned in this study as challenges that influences teachers' integration of ethnomathematics approaches into the teaching of geometry. Based on the teachers' comments on the effect of syllabus on examination, in this study it was revealed that the purpose for teaching geometry was for the learners to pass examinations, regardless of whether the content was understood or had any meaning to their everyday activities. Therefore, teachers spend most of their time preparing learners for the examinations; hence, teaching for understanding is minimal. As a result, ethnomathematics approaches that were time consuming as indicated by participants of this study were not integrated into the teaching of geometry.

In addition, findings showed that the cultural examples in examinations were drawn from other countries posing even more challenges to the learners who did not even understand the problems. This implies that the learners would have to understand the nature of the example before tackling the geometrical problem. This is in contrast to the views of Jones (2002) who asserted that learners need to be exposed to situations that are relevant to their lives and not to examples and activities that did not make sense or were meaningless to their lives.

Although, teachers play a crucial role in the implementation of the syllabus, the findings showed that they were not allowed to participate in the designing of the syllabus. Therefore, if they were not involved in the designing of the syllabus, they were unlikely to integrate ethnomathematics approaches into the teaching of geometry as expected.

6.2.7.5 Teacher related challenges

Findings showed that teachers were not trained to integrate ethnomathematics approaches into the teaching of geometry. Teachers' lack of training on the integration of ethnomathematics approaches into the teaching of geometry helps in explaining why they were typically reluctant to try this instructional approach (Rosa & Orey, 2013; Velasquez, 2014; Naresh, 2015).

Findings also showed that teachers were unaware of the cultural examples to use in geometry teaching. However, Rosa (2013) pointed out that a deep understanding of both culture and its association to geometry is an essential source of knowledge for teachers, for them to integrate ethnomathematics approaches when teaching. Further, teachers need to be knowledgeable about their learners' cultural backgrounds, prior experiences and how these may influence their understanding of geometry and their performance.

In addition, the study showed that the lack of geometrical content knowledge was a barrier to the integration of ethnomathematics approaches into the teaching of geometry. Furthermore, the study showed that teachers are resistant to integrate ethnomathematics approaches into the teaching of geometry. Teachers gave the impression that it could be challenging to suspend the teaching approaches that they were used to in favour of the ethnomathematics teaching. The resistance of the teachers might indicate their satisfaction with the traditional teaching approaches.

Findings also showed that the teachers lacked support from both the CDU and the political leadership in terms of resources and funding. These indeed limit the likelihood for ethnomathematics approaches to be used in the teaching of geometry. The successful integration of ethnomathematics approaches dependents on political will of the leadership to aid in the provision of essential resources in the teaching of mathematics as a whole and geometry specifically (Matang, 2009; Matang & Owens, 2004), which seemed not to be the case in this particular study.

6.2.7.6 Parental involvement

The study findings also showed that the teachers expected parents to help them in the teaching of geometry by supporting their kids with resources and funding for field trips. However, the teaching and learning of geometry is believed to take place in school settings, that is, geometry concepts were acquired only if a learner goes to school (Orey & Rosa, 2006), as a result, the parents may not support or fund such trips.

In summary, the study findings showed that there were a number of challenges that hinders the integration of ethnomathematics approaches into the teaching of geometry.

6.3 Conclusion

The aim of the study was to explore in-service mathematics teachers' preparedness to integrate ethnomathematics approaches into the teaching and learning of geometry at a selected university in Zimbabwe. The findings reveal that:

1. Teachers' geometry content knowledge influenced the integration of ethnomathematics approaches into the teaching of geometry. There were two categories of teachers in this study, those who were adequately trained to teach geometry and those who were not trained to teach geometry. The teachers who were adequately trained to teach geometry might be in a better position to use ethnomathematics approaches when teaching geometry as compared to those who were not trained to teach geometry.
2. Teachers' professional development on ethnomathematics approaches was essential for its effective integration when teaching geometry. There were teachers who were trained to integrate ethnomathematics approaches and those who were not. In teacher training institutions there were no specific courses for ethnomathematics approaches. However, teachers (24) indicated their ability to integrate ethnomathematics approaches by using various cultural examples and activities as teaching and learning resources as well as learning context.
3. Teachers' views of ethnomathematics approaches were philosophically rooted in social constructivist perspective and humanistic view of mathematics. Teachers held positive views regarding the integration of ethnomathematics approaches into the teaching of geometry. They indicated the benefits of incorporating ethnomathematics approaches into the teaching of geometry such as improving the learners' understanding of geometry concepts.
4. The integration of ethnomathematics approaches is hindered by several challenges, including teacher related challenges.

However, for the effective incorporation of ethnomathematics approaches into the teaching of geometry that would benefit the learners, there should be adequate training in both geometry and ethnomathematics approaches. This is important for the teachers so that they would be in a position to empower the learner with adequate geometry knowledge and skills, by connecting these to their learners' cultural experiences and activities.

6.4 Recommendations

The following recommendations are essential for the teachers to integrate ethnomathematics approaches into the teaching of geometry.

Geometry should be included in teacher training institutions curriculum

Teachers must be trained to teach geometry effectively. It is important for the teachers to cover all the geometry concepts that they were required to teach in schools during their training.

The mathematics curriculum followed in teacher training institutions should be revised

The mathematics curriculum that are currently in use in teacher training institutions should be revised to incorporate courses on ethnomathematics approaches, so that the teachers would appreciate the importance of these approaches as well as implementing them in their teaching effectively. Teachers should be trained to use a variety of cultural aspects exemplifying geometry in the teaching and learning process to improve performance in geometry in particular and mathematics in general and to demystify the learners' views about geometry as an abstract topic, which could be changed upon seeing the relevance of geometry in their daily lives. Geometry should be used to explore innovatively a diversity of challenges in the learners' environment that might improve the development of positive attitudes to geometry and its performance. This indicates that attention could be usefully paid both on the initial education of teachers and to their continuing professional development.

Teachers should be involved in the designing of the syllabus and setting of examinations

The teachers should be involved in all the stages of syllabus design to enable them to implement it effectively. This should include the setting of examinations that are based on learners' cultural backgrounds and environment. The teachers should be involved in the syllabus design so that they could change certain existing curriculum structures such as timetabling in schools to enable them to integrate ethnomathematics approaches without rushing to complete the syllabus for examination purposes.

Support from the community

Parents need to help both the teachers and their children by supporting them with financial resources for geometrical resources and for visiting sites with cultural geometrical aspects. Resource persons from the community must be identified and used in teaching geometry concepts.

Professional development of teachers

Continuous professional development through workshops should be put in place by the Ministry of Education, to help teachers on the integration of ethnomathematics approaches into the teaching of geometry in particular and mathematics in general. Such professional development interventions should be aimed at supporting teachers to integrate ethnomathematics approaches in their lessons effectively. The CDU and political leadership should support by funding the schools with resources and providing relevant in-service programs and workshops on ethnomathematics approaches.

6.5 Limitation of the study

Since this study is limited to one teacher training institute in Zimbabwe, findings may not be transferable to other institutions in the country. In-service teachers in this teacher training institution may or may not have characteristics similar to in-service teachers in other teacher training institutions in the country. It was not possible for the researcher to cover all the teacher training institutions in Zimbabwe due to lack of finance and time. However, the diversity of teachers from this teacher training institution is similar to the level of diversity at many teacher training institutions in Zimbabwe.

An additional limitation was that the study focussed on geometry as a topic and not all the mathematics topics in the syllabus. The study explored teachers' preparedness to integrate ethnomathematics approaches into the teaching of geometry and the research findings may not be possible to generalise to other topics in the mathematics syllabus.

Further, only characteristics directly allied to the sample of second year Bachelor of Science Education Honours in-service mathematics teachers taking part in this study and their responses to the questionnaires and focus group discussions were investigated. All the Bachelor of Science

Education Honours in-service mathematics teachers, if included as research participants in the study could have brought forth more elaborate assortments of data that might fall away from the scope of a PhD study.

In Zimbabwe, there is limited research that has been studied in this area. This restricted the researcher in terms of important general data with respect to the literature review. Nevertheless, appropriate studies on ethnomathematics approaches and its integration into the teaching of geometry carried out in other countries in Africa and elsewhere helped the researcher with the relevant information.

The mathematics in-service teachers who participated in this study were volunteers. With such a scenario at hand, the researcher was left with no option but to work with the responses from those that volunteered.

This study lacked classroom observations that coould have enriched the work, since this together with the teachers' own accounts of their practices would have functioned as a triangulation tool. The exploration does not explicitly take a stand on reformulating teachers' professional development programmes, which could have added another quality dimension to this work.

6.6 Suggestions for further research

Integrating ethnomathematics approaches into the teaching of geometry could make learning more meaningful to learners because it removes the abstractness of geometry. The study focused on in-service teachers' preparedness to integrate ethnomathematics approaches into the teaching of geometry. All the other topics included in the syllabus have potential for interesting areas for research. Even though, numerous issues have been mentioned and deliberated upon in this study, they can be investigated further.

This study focused on in-service teachers' preparedness to integrate ethnomathematics approaches into the teaching of geometry only. Other important findings can be gained if stakeholders such as teacher educators' voices can also be explored. For instance, studies amongst teacher educators regarding the integration of ethnomathematics approaches in the teaching of geometry or mathematics in teacher training institutions could shed light on how teachers are trained to enable them to integrate ethnomathematics approaches. In addition, there is need for research that focus on how the training of teachers on ethnomathematics approaches can contribute to the effective teaching of geometry. Furthermore, research could be carried out that analyse and reflect on the content used in teacher training programmes.

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APPENDIX A

APPENDIX A1: INFORMED CONSENT FOR IN-SERVICE MATHEMETICS TEACHERS

University of Kwa Zulu Natal

Edgewood Campus

Private Bag X03

Ashwood 3605

South Africa

Dear Mr./Mrs./Ms..………………

INFORMED CONSENT LETTER

My name is Sunzuma Gladys. I am an Education, PhD candidate studying at the University of KwaZulu-Natal, Edgewood Campus.

This is a formal invitation to you to participate in the research project titled: Exploring in–service mathematics teachers in Zimbabwe's preparedness to incorporate ethnomathematics approaches to geometry teaching.

Such research is essential in Zimbabwe given the poor performance in mathematics in general and geometry in particular at 'O' level for decades now.

I am studying a university from Mashonaland Central Province, Zimbabwe. Your university is the only one selected for this study. To gather the information, I am interested in administering a questionnaire and to interview you in groups.

Your participation includes that:

- Your confidentiality is guaranteed as your inputs will not be attributed to you in person, but reported only as a participant's opinion.

- The focus group discussions may last for about one hour. I intend to conduct a series of focus group interviews with you for detailed discussion of pertinent issues in the study.
- I intend to administer a questionnaire during the block.
- Any information given by you cannot be used against you, and the collected data will be used for purposes of this research only.
- Data will be stored in secure storage and destroyed after 5 years.
- You have a choice to participate, not participate or stop participating in the research. You will not be penalised for taking such an action.
- Your participation is voluntary, and it will not affect your relationship with the Teacher Education Program, or with the university. You may also withdraw from this study at any time without affecting your relationship with the Teacher Education Program, or with the university. The participation in this study or a decision to withdraw at a later time will not impact your grades.
- Your involvement is purely for academic purposes only, and there are no financial benefits involved.
- If you are willing to be part of the focus group discussion, please indicate (by ticking as applicable) whether or not you are willing to allow the interview to be recorded by the following equipment:

	willing	Not willing
Audio equipment		
Video equipment		

I can be contacted at:

Email: gsunzuma@gmail.com

Cell: +263 (0) 773 401 557

My supervisor is Prof Aneshkumar Maharaj, who is located at the School of Mathematics, Statistics and Computer Science, Westville Campus, University of KwaZulu-Natal.

Contact details:

Prof Aneshkumar Maharaj

Academic Leader: Teaching and Learning

School of Mathematics, Statistics and Computer Science

University of KwaZulu-Natal

Westville Campus

Private Bag X54001 Durban 4000

H1 Building

Room 438

Tel: 031 2601021

Fax: 031 2607806

email: maharaja32@ukzn.ac.za

You may also contact the Research Office through:

Mariette Snyman

University of KwaZulu-Natal

Research Office: Ethics (HSS)

Govan Mbeki Building

Private Bag X54001

Durban

4000

Tel: +27 31 260 8350

Fax: + 27 31 260 4609

Email: snymanm@ukzn.ac.za

Thank you for your contribution to this research.

DECLARATION

I……………………………………………………………………… (full names of teacher) hereby confirm that I understand the contents of this document and the nature of the research project, and I consent to participating in the research project. I understand that I am at liberty to withdraw from the project at any time, should I so desire.

SIGNATURE OF PARTICIPANT DATE

……………………………………… …………………………………

A2: ETHICAL CLEARENCE CERTIFICATE

UNIVERSITY OF KWAZULU-NATAL

INYUVESI YAKWAZULU-NATALI

19 January 2017

Ms Gladys Sunzuma 216076211
School of Education
Edgewood Campus

Dear Ms Sunzuma

Protocol reference number: HSS/0029/017D
Project Title: Exploring in-service mathematics teachers in Zimbabwe's preparedness to incorporate ethnomathematics approaches to geometry teaching

Full Approval – Expedited Application

In response to your application received 4 January 2017, the Humanities & Social Sciences Research Ethics Committee has considered the abovementioned application and the protocol has been granted **FULL APPROVAL.**

Any alteration/s to the approved research protocol i.e. Questionnaire/Interview Schedule, Informed Consent Form, Title of the Project, Location of the Study, Research Approach and Methods must be reviewed and approved through the amendment /modification prior to its implementation. In case you have further queries, please quote the above reference number.

PLEASE NOTE: Research data should be securely stored in the discipline/department for a period of 5 years.

The ethical clearance certificate is only valid for a period of 3 years from the date of issue. Thereafter Recertification must be applied for on an annual basis.

I take this opportunity of wishing you everything of the best with your study.

Yours faithfully

....

Dr Shenuka Singh (Chair)
Humanities & Social Scinces Research Ethics Committee

/pm

cc Supervisor: Dr Aneshkumar Maharaj
cc. Academic Leader Research: Dr SB Khoza
cc. School Administrator: Ms Tyzer Khumalo

Humanities & Social Sciences Research Ethics Committee
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APPENDIX A3: EDITOR'S CERTIFICATE

BINDURA UNIVERSITY OF SCIENCE EDUCATION

FACULTY OF SOCIAL SCIENCES AND HUMANITIES
EXECUTIVE DEAN
Prof. C Pfukwa
DLitt et Phil (UNISA)
Associate Professor

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Bindura, Zimbabwe
Tel: +263-271-6270
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Email: c4pfukwa@gmail.com

11 October 2018

TO WHOM IT MAY CONCERN

RE: THESIS EDITING: SUNZUMA GLADYS (216076211)

This is to certify that I have edited Gladys Sunzuma's thesis titled *Exploring In-Service Zimbabwean Mathematics Teachers' Preparedness to Incorporate Ethnomathematics Approaches to Geometry Teaching and Learning.*

Should you need further information on the above, do not hesitate to contact the undersigned.

Yours Sincerely

Prof. C. Pfukwa
DLitt et Phil (UNISA)
Associate Professor

APPENDIX A4: TURNITIN CERTIFICATE

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APPENDIX B

APPENDIX B1: IN-SERVICE TEACHERS' QUESTIONNAIRES

Instruction: You are kindly requested to tick (√) as well as supplying short response(s) in spaces provided in a number of questions in the questionnaire.

Section A: Teachers' views on how they are prepared to integrate of ethnomathematics approaches in the teaching of geometry**.**

For each of the following statements, please show the degree of your agreement or disagreement by placing a tick in the appropriate column to show your view about the issues on the integration of ethnomathematics approaches into the teaching and learning of geometry.

Strongly Agree (SA); Agree (A); Neutral (N); Disagree (D); Strongly Disagree (SD)

STATEMENT	S	A	N	D	SD
1. I have a clear understanding of ethnomathematics teaching approaches.					
2. Ethnomathematics teaching approaches permit learners to create their own geometrical knowledge.					
3. Ethnomathematics teaching approaches recognise the teacher as the source of geometrical knowledge.					
4. Ethnomathematics teaching approaches recognise the learner's environment as the source of geometrical knowledge.					
5. The learner's language and culture do not influence his/her acquisition of geometrical knowledge.					
6. Learners effectively acquire geometrical knowledge when they listen to the teacher's' explanation carefully.					
7. Lecturers/tutors took into account my prior knowledge when they were teaching geometry.					

8. Geometry is free from culture					
9. Geometry is too abstract					
10. Examinations do not have geometrical questions drawn from the environment					
11. Geometric concepts learners learn are those taught by teachers in schools only					
12. My teacher training offered courses on geometry					
13. Geometry knowledge is gained by taking part in traditional cultural activities such as building traditional houses, fishing etc.					
14. Teachers should teach only the geometry that is prescribed in the syllabus and textbooks.					
15. l lack knowledge on geometrical concepts					
16. Geometry concepts identified in traditional cultural activities should also be taught in schools.					
17. Geometrical concepts were taught using traditional approaches in teacher training program					
18. I design geometry learning activities that are adapted to learners' cultural background					
19. It is not possible to link geometrical concepts to learners' social environments.					
20. Geometrical concepts are taught using universal language and procedures in all cultures					
21. There is a relationship between geometry and culture					
22. l cannot develop culturally contextualised examples for geometry teaching					

23. l lack knowledge on ethnomathematical approaches					
24. Textbooks that are used for teaching geometry have cultural examples					
25. Textbooks available to learners lack enough cultural examples on geometric concepts.					
26. The design of the syllabus allows teachers to integrate cultural examples when teaching geometry.					
27. My teacher training programme provided a variety of ways of including cultural examples when teaching geometry.					

Section B

28. Were you taught geometrical concepts during your teacher training programme?

Yes	
No	

29. If your answer is a yes to question 28, which approach (es)/method(s) of teaching geometry were employed by your lecturer?

....

....

30. If your answer is no, to question 28, at what level were you taught? ....

....

31. What approach (es)/method(s) of teaching geometry were employed at that level? ....

....

32. Did you face any difficulties in understanding geometrical concepts?

Yes	
No	

Explain..

....

33. Do you think you were adequately prepared to teach geometry?

Yes	
No	

Explain..

....

34. Did your lecturer/tutor link the teaching of geometry to the environment or culture?

Yes	
No	

Explain..

....

35. If your answer is yes to question 34 above, how often did s/he do so?

Very often	
Sometimes	
Rare	

36. Were you taught to integrate ethnomathematics approaches when teaching geometry?

Yes	
No	

If your answer is yes explain how you were taught

....

37. Do you think you were adequately prepared to integrate ethnomathematics approaches when teaching geometry?

Yes	
No	

Explain...

....

38. How well did your tutor/lecturer teach areas of the syllabus concerning geometry?

Partially Taught	
Adequately Taught	
Never Taught	

Explain...

....

....

39. Do you make provision for the use of cultural/ contextual examples in your lesson planning?

Yes	
No	

Explain...

....

40. How often were cultural/ contextual examples employed by your tutor/lecturer in geometry lessons?

Very often	
Sometimes	
Rare	

41. What is your opinion about the incorporation of ethnomathematics approaches in the teaching of geometry?

a. This will discourage the learners in learning mathematics

b. This will motivate the learners to learn geometry and enhance performance

c. This will encourage the learners to respect their cultural activities and practices

d. This will encourage learners to take pride in their own cultural heritage and value their culture

42. What is your opinion about integration of cultural aspects in the teaching of geometry?
    a. Quality of geometry education will be improved ☐
    b. Quality of geometry education will deteriorate ☐
    c. Cultural content will not be a hindrance to teaching geometry ☐
43. What challenges do you face in trying to integrate ethnomathematics approaches in geometry lesson?
    a. Learners

       ....

       ....
    b. Nature of geometry

       ....

       ....
    c. Resources

       ....

       ....
    d. Teacher training

       ....

       ....
    e. Mathematics syllabus/ standardised examinations

       ....

       ....
    f. Any other

       ....

APPENDIX B2: Focus Group Discussion Schedule for teachers

Dear Teacher

The purpose of the focus group discussions is to collect information on how prepared you are in integrating ethnomathematics approaches in geometry the teaching. Your participation in answering the questions is extremely useful and voluntary and you are under no pressure to participate or to answer questions. Please try to understand the questions before giving your responses. Note that you are not required to give your name. Your responses will be kept confidential and anonymous.

Thank you for your cooperation.

Please take your time and listen to the following questions, if you don't understand you can ask me to repeat the question.

1. What do you understand by terms ethnomathematics and ethnomathematics approaches?
2. How do you describe your role in the teaching of geometry?
3. Do you integrate ethnomathematics approaches in geometry teaching? Explain
4. Did you receive any training or professional development on ethnomathematics approaches in geometry teaching? Did the training or professional development prepare you to teach geometry? If yes, describe ways that the training was helpful.
5. Were you exposed to the use of ethnomathematics approaches during your pre-service training?
6. How does the course(s) studied at college/university help you to integrate ethnomathematics approaches in the teaching of geometry?
7. In your view how would you describe the teaching approach adopted by your tutor/lecturer mainly in the teaching of geometric concepts?
8. How do you view the content of geometry taught in schools? Is it insensitive to cultural interests, Integrative to cultural interests or discriminative of cultural interests
9. What is your opinion about integration of cultural aspects in the teaching of geometry?
10. What is your opinion about the incorporation of ethnomathematics approaches in the teaching of geometry?

11. Explain why it is difficult to integrate ethnomathematics approaches in geometry teaching?
12. Did the content sources available to you during teacher training contain enough activities that consolidated your understanding of geometric concepts?
13. How many mathematics courses did you do during your pre-service teacher training? Of the courses you studied how many had geometry concepts?
14. How many pedagogical courses did you do during you pre-service teacher training? What approaches did your tutor/lecturer use when teaching pedagogic courses? Did you do any course to assist you to teach geometry using ethnomathematics approaches?
15. Do you think that you are competent in teaching geometry? Do you have adequate knowledge and skills of teaching geometry?
16. What methods do you use in teaching geometry? Why do you use them?
17. Are there any geometrical concepts that are difficult for you—and if so, for what reasons?
18. Are you aware of the geometry that exists in cultural activities?
19. Do you think it is necessary to integrate ethnomathematics approaches in geometry teaching?