

ETHNOMATHEMATICS: AN EXPLORATION OF THE MATHEMATICS
EMBEDDED IN BASKET MAKING BY AAWAMBO WOMEN IN THE
OSHANA REGION, NAMIBIA

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Abstract

The practice of ethnomathematics has been deeply embedded in the tradition of ethnic groups but its concepts remain untapped in the teaching of Mathematics in schools. In the Namibian context, it seems that curricula are still rooted in colonial policy with little or no integration of indigenous knowledge (IK) in schools. Although the Namibian National Curriculum for Basic Education (Namibia Ministry of Education Art and Culture, 2016) claims that it “embraces traditional knowledge” it does not specify how. It is against this background that the current study focuses on the Mathematics embedded in basket making by Aawambo women in the Oshana Region, Namibia, particularly identifying the mathematical content at the junior secondary level that is applicable. The study examines how Mathematics teachers can integrate geometrical constructs of basket-making into the teaching and learning process of Mathematics. Employing Vygotsky’s Socio-Cultural Theory as an analytical lens, I used an ethnographic research design that enables the development of a deeper understanding of how people make sense of the contexts in which they live and to generate data from interviews, observations and artefacts. I selected participants purposively to meet the objectives of the study and took a thematic approach to generate common sub-themes which I combined to form themes. The findings from a Focus Group Discussion with teachers revealed that basket weavers used various methods to form geometrical terms and relationships, geometrical shapes, geometrical transformation and symmetry. Workshop was an apt approach for training teachers in integration of IK. Recommendations based on the findings include training

Mathematics teachers on the co-development of lesson plans to integrate ethnomathematics in the school curriculum.

Keywords: Ethnomathematics, indigenous knowledge, basket making, mathematics teachers, integration.

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ABBREVIATIONS AND ACRONYMS

BETD	Basic Education Teacher Diploma
CHAT	Cultural Historical Activity Theory
CPD	Continuous Professional Development
IIED	International Institute for Environment and Development
IK	Indigenous Knowledge
IKS	Indigenous Knowledge Systems
ITTP	Integrated Teacher Training Programme
MASTEP	Mathematics and Science Teachers Extension Programme
MBESC	Ministry of Basic Education, Sport, and Culture
MEC	Ministry of Education and Culture
MKO	More Knowledgeable Other
MoEAC	Ministry of Education, Art and Culture
NCRST	National Commission on Research, Science and Technology
NPRSTI	National Programme on Research, Science, Technology and Innovation
NUST	Namibia University of Science and Technology
PCK	Pedagogical Content Knowledge
SDG	Sustainable Development Goal
TPD	Teacher Professional Development

UNAM	University of Namibia
UNAMCPD	University of Namibia Continuous Professional Development Unit
UNESCO	United Nations Educational, Scientific, and Cultural Organization
UNICEF	United Nations Children's Fund
ZPD	Zone of Proximal Development

Dedication

This Thesis is dedicated to my parents, my grandmother; *Benengina Matheus* and my baby girl; *Linda Akawa*, for their endless love and support.

My sister, *Albertina Shimwandi* and aunty *Flavia Negumbo*, this is also for you!

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Declaration

I, **Ruusa Ndeutenge Shimwandi**, hereby declare that this study is my own work and is a true reflection of my research and that this work or any part thereof has not been submitted for a degree at any other institution. No part of this thesis/dissertation may be reproduced, stored in any retrieval system, or transmitted in any form, or by means (e.g., electronic, mechanical, photocopying, recording or otherwise) without the prior permission of the author, or The University of Namibia on my behalf. I, **Ruusa Ndeutenge Shimwandi**, grant The University of Namibia and Carl Schlettwein Foundation the right to reproduce this thesis in whole or in part, in any manner or format, which they may deem fit.

Ruusa Ndeutenge Shimwandi



October 2024

Name of Student

Signature

Date

CHAPTER ONE

INTRODUCTION

1.1 Background of the study

Historically, Africa has a wealth of untapped indigenous knowledge (IK) produced by communities that could be used in schools as an alternative approach to the Western ways of teaching. For example, it could enhance teaching and improve learners' problem-solving skills and understanding of their daily life experiences in preparation for the wider world (Tobin, 1993; Nnadozie, 2009; Kaya & Seleti, 2013). Africans have begun to recognise the value of IK in schools, and efforts have been made through policies and legislative frameworks, stipulating the roles of different stakeholders involved in attaining success. However, identifying its integration methods remains a challenge (Handayani, Wilujeng & Prasetyo, 2018; Bohensky & Maru, 2011), largely because teachers' training programmes do not empower trainees and no strategies are suggested in the existing policies (Seehawer, 2018, Risiro, 2019). Genuine engagement in this process is therefore required, tapping knowledge from communities to capacitate teachers in the classroom (Cindi, 2021; Jacobs, 2015).

A common understanding of IK has not yet resulted from the increased focus on the concept by academic institutions and development agencies. Recent research has defined it in a variety of ways, including as local understanding specific to a given culture or society (Higgs & Van Niekerk, 2003; Kibirige & Van Rooyen, 2007; Onwu & Mosimege, 2004) and as all-inclusive covering technologies and practices that have been and are still used by indigenous and local people for their existence, survival, and part of sustainable development (Mandikonza, 2019; Ronoh, 2017).

Such definitions have emphasised its importance in science subjects as well as mathematical disciplines, these being the focus of this research. The teaching processes used during the modernisation and development of Eurocentric education damaged the cultural and social existence of indigenous peoples (Gerdes, 1995; Langill, 1999; Magni, 2017; Ogunniyi, 2007), overriding indigenous knowledge systems (IKS) embedded in their cultures, histories and civilizations. They form the backbone of social, economic, scientific and technological identity of communities, subsequently making a significant contribution to global knowledge (Odora-Hoppers, 2005).

The integration of IK through linking mathematics to everyday situations and social activities of learners and teachers in ethnic and cultural groups is referred to as *ethnomathematics* (Gerdes, 1995). According to D'Ambrosio (1985), the suffix "ethno" refers to components of a group's national heritage, such as language, vocabulary, race, beliefs, ideologies, norms, physical characteristics, and emblems. In this context, "Mathematics" refers to aspects of thought and culture that result in mathematical structures, opinions, understandings, and explanations within concepts. The inherent principles are that teaching and learning Mathematics in schools should be culturally relevant to teachers and learners (Aronson & Laughter, 2016; D'Ambrosio, 1985), so that it helps in achieving the general goal of the Ministry of Education and Culture (MEC) (1986, p. 58) to create a citizenry free from superstition and colonial mentality, one that holds a scientific world view, is capable of assimilating and uses science technology for the benefit of the society.

A basic framework for the provision of a high quality education for indigenous peoples and the recognition of their rights to education is comprised of several international instruments and declarations, as well as regional agreements (King & Schielmann, 2004). Among them are the United Nations' international agencies, which acknowledge and uphold the vital roles that IKS plays in the academic program. Diversity, indigenous and traditional knowledge, and the rights of indigenous people worldwide are all valued, according to the United Nations Educational, Scientific, and Cultural Organization (UNESCO, 2020). Other organizations, like the International Institute for Environment and Development (IIED) (Andes & Call of the Earth, 2006), support the advancement of paradigms for sustainable human development that construct on knowledge assets in cultures. To follow such agendas, especially in Sub-Saharan African, countries have put in place IKS as integral to the strategic directions of an innovation policy in advancing the significance of open mindfulness of communities (Jauhiainen & Hooli, 2017; Langenhoven & Stone, 2013; Shizha, 2012). Financial provision has been realised towards documentation and promulgation of content and significance to the various socio-cultural contexts (Masoga; 2005; Mosimege (2005). Furthermore, the initiative has been extended to teachers in acknowledging the relevance of IKS to teaching Mathematics, countering ambiguous and negative philosophical perspectives of the nature of indigenous mathematical knowledge and who produces it. Chahine (2013) pointed out the limited views of what counts as Mathematics and lack of understanding of living indigenous practices as the most contributory factors in having silenced deeper discussions about what Mathematics is being taught and how the knowledge is imparted in increasingly diverse classrooms. However, despite the positive responses to policies, much remains to be achieved to increase recognition of indigenous peoples' education and knowledge recognition in the quest for education for all

(Mazrui, 1998), and in meeting the Sustainable Development Goal (SDG) of quality education for empowering people and transforming societies (UNESCO, 2015).

A growing number of ethnographic studies around the world are calling for a decolonised curriculum through a post-colonial education system that reclaims indigenous voices through curriculum reforms and the transformation of educational discourse (Higgs & Makoni, 2016; Ngugi wa Thiong'o, 1986). This would end the Western disposition to impose curriculum during such historical phases as slavery, colonisation and apartheid (Kelly, 1984). Curriculum reform is a process of restructuring education curriculum to make it relevant to challenges through consideration of IKS (Msila, 2016), with teachers being crucial to it as they are aware of the needs of all stakeholders in education. Teachers discuss the essence of the renewal and appropriate classroom implementation strategies while designing, helping them better understand the reform and encourage them to take ownership of it (Handelzalts, Nieveen, & Van den Akker, 2019; Patankar & Megha, 2013).

As with other formerly colonised countries, the current educational programmes in Namibia were acquired from a past era which is far from the lives and experiences of the younger population (Dahlstrom, 2002). The educational plan structure for black schools was unbending and teaching professionals did not have a say in its making (Ministry of Education, Art and Culture (MoEAC, 1993). Teachers were passive recipients of the procedures as they were looked at as technicians rather than professionals and so compelled to teach to a prescribed syllabus that promoted apartheid and Western ways of thinking (Dahlstrom, 2002).

Formerly known as German Southwest Africa, Namibia was colonized by Germany under Otto von Bismarck starting in 1884 (Berat, 1990). South Africa took control of the German colony in 1915, during World War 1. Under the terms of the League of Nations, South Africa assumed responsibility for its administration in 1920. In 1946, South Africa declined to give up its previous mission to become part of a United Nations Trusteeship arrangement, which called for increased international oversight of the territory's governance (Fokken, 2012). Pressure to grant Southwest Africa independence was intensified against South Africa in the 1960s. The Odendaal Commission after Frans Hendrik Odendaal established the Commission of Enquiry in 1962 in response to mounting international pressure to justify its annexation (Goldblatt, 1980). The year 1990 began with the start of the transition in February, and on March 21, 1990, Southwest Africa proclaimed independence and was given the new name of Namibia (Fokken, 2012).

Forms of teacher training had been separated according to race, namely Black, Coloured (Mixed), White and Indian or Asian population groups, based on the Christian National Education curriculum which had an overall aim of instilling the ideology and segregation practices of apartheid (Angula & Lewis, 1997; Pomuti & Weber, 2012). It did not acknowledge or make provision for IK integration in the classroom, leaving teachers with no understanding of the potential of IK to be incorporated into Mathematics classrooms. Teachers require training to immerse them in indigenous cultures and so acquaint them with a broad perspective of IKS and structures that cover a plethora of contents and contexts that incorporate mathematical artefacts (Chahine, 2013; Mudzamiri, 2019).

Without training, teachers cannot develop effective teaching methods or use appropriate teaching aids in the classroom (Mandikonza, 2019; Ronoh, 2017).

After independence in 1990, the Namibian government chose to eliminate the South African teachers' training programmes through a National Education Certificate for Primary and Lower Primary Teacher Certificate (Dahlström, 2002; UNESCO, 2010). Simultaneously, the Namibian government, with the help of the Swedish government, introduced a new education programme known as the Basic Teacher Education Diploma (BETD) (Arreman, Erixon & Rehn, 2016), planned to reduce the high number of inadequate and under-qualified teachers in schools. However, the new programme, which the administration claimed to be progressively viable, clashed with a forerunner, the Integrated Teacher Training Programme (ITTP), and still did not offer satisfactory preparation of teachers or change the acquired issues, including IKS integration in the education system (Arreman, Erixon & Rehn, 2016; Dahlstrom, 2002; Kambundu, 2005).

Over time, Namibia revised the education curricula and standards for schools and the teaching profession were developed (Arreman, Erixon & Rehn, 2016; UNESCO, 2010). The Education Act of 2001 was thoroughly reviewed based on geographic, cultural, social and political contexts (Biraimah, 2016). The Namibian government formulated a range of educational laws, plans and policies (UNESCO, 2002), with the most relevant strategies, policies and legal documents including *National Research, Science, and Technology Policy* (1999), *The Namibia Vision 2030* (2004), the *Fourth National Development Plan* (2012), *the Research, Science and Technology Act* (2004, in effect from 2013), and the *National Programme on Research,*

Science, Technology and Innovation (NPRSTI, 2014). These aimed to support the Constitution, promote the development of diversified, competent and highly productive human resources and to build a knowledge-based society. Additionally, they advocated identification of methods of infusing indigenous knowledge content, methods and teaching aids into the secondary school curriculum (Chinsebu, 2015; MoEAC, 1999; UNICEF, 2011).

In an effort to build a knowledge-based society embedded in IK values, national workshops and the Strategic Plan of 2017/18- 2021/22 of the MEC in Namibia embarked on the formation of a draft policy and bill on the recognition, promotion and protection of IKS. This was a response to a call made by the Government of the Republic of Namibia (2001) after they had identified a need for cultural policy to adopt a comprehensive approach for schools to ensure that IK was firmly embedded in the curriculum across the educational system. However, the policy was not accompanied by a set of implementation guidelines on the integration of IKS. As a result, there was a high need to strengthen the Continuous Professional Development (CPD) which is aimed at supporting teachers' learning from the initial hardship, to enhance their professional competencies and to maximize their potentials in the area of IK integration (MoEAC, 2002; Nakambale, 2018; University of Namibia Continuous Professional Development Unit (UNAM CPD Unit, 2012). This study makes use of basket weaving as an example of how *ethnomathematics* can be integrated in the school curriculum. Constructing a basket is a small bio-engineering project that requires mathematical thinking and related skills (Jungic, 2019) which teachers can acquire from communities that have long been practising them and observing, discussing, and interpreting the activity (Demmert, 2001). In satisfying the epistemology underpinning this study I have adopted a creative approach, adopting an

analytical practice to interpret meaningfully the outcomes guided by the five criteria of autoethnography: (a) substantive contribution to understanding social life; (b) aesthetic merit of the text in terms of being artistically shaped and satisfyingly complex;(c) reflexivity as the author's subjectivity of both a producer and a product of the text;(d) impact fullness in terms of emotional and/or intellectual capacity of the text to generate new questions or move the reader to action; and(e) expression of realities as fleshed out lived experiences (Richardson, 2000). Together with other researchers (Ali & Davis, 2018; D'ambrosio, 2020; Gerdes, 2012, Gould, 2014; Mosimege, 2012; Peñas, Garciano & Verzosa, 2021), I believe that the mathematical thinking and mathematics-related skills involved in the construction of baskets can be transferred from community members and integrated in the mathematics curriculum, a process of knowledge transfer that has hitherto been ignored. The Aawambo is a subgroup of the Bantu people who have retained their cultural practices, including basket making (see Section 1. 7). I promote mathematics teachers' capacity development by identifying what content of the curriculum can be linked to basket making, particularly measures to implement guidelines and strategies that integrate IK in the mathematics curriculum.

1.2 Statement of the problem

The degree to which the Mathematics curriculum can be adjusted to accommodate IK remains a concern in Africa as researchers call for a curriculum that is culturally sensitive and responsive to the needs and the aspirations of the people (Ogunniyi, 2018; Rosa & Orey, 2011; Sparrow & Hurst, 2012). A group of researchers have researched the integration of IK, including basket making, in the classroom but with little success (Ezeanya-Esiobu, 2019; Mawere, 2015; Ronoh, 2017). In addition, a variety of mathematical aspects that are involved in basket making are limited to a number of mathematical concepts and not utilised in the

mathematics classroom (Onstad, Kasanda & Kapenda, 2003). The non-integration is attributed to teachers' lack of skills, knowledge and attitude to apply IK contextually (Ministry of Basic Education, Sport, and Culture {MBESC}, 2002; Onstad et al., 2003), with no CPD offered through in-service training (UNAM CPD Unit, 2012). Hence, this study explores the mathematics embedded in basket making, a cultural activity by the Aawambo people, which might help in the promotion of effectiveness of integration of indigenous knowledge in the Mathematics classroom.

1.3 Research Questions

The study seeks to answer the following questions:

- ❖ What geometry is found in basket making of Aawambo ethnic group in Oshana Region?
- ❖ Which geometrical content at the junior secondary level is applicable to basket making practised by the Aawambo women?
- ❖ How can the Mathematics teachers integrate geometrical constructs embedded in basket making by Aawambo women into the teaching and learning process of Mathematics?

1.4 Significance of the study

The present study may enable Mathematics teachers to use Aawambo weaving methods as a supplementary instructional method, especially in the application of Mathematical concepts in word problems. Thus, this study may offer culturally relevant teaching approaches through teachers' continuous development, which could be integrated into the Mathematics lessons. It is hoped that the present study will assist in the rediscovery of the power and beauty of the

nearly forgotten and devalued cultural mathematical activity of the Aawambo. The inclusion of real-life cultural contexts could present opportunities for curriculum designers, material developers and policymakers to demand the use of local resources, especially in rural areas. In addition, it may serve as a motivation to Mathematics teachers in applying local knowledge in mathematical activities.

1.5 Limitations of the study

Problems encountered in carrying out of the present study are as follows: I made use of a purposive sampling technique. This was necessitated by many of the Aawambo cultural activities such as basket making not being sustained to date. Only a few people have continued practicing traditional basket making (Aludhilu & Bidwell, 2018). Inconsistency among basket makers as they provided opposing and mismatching information, making it difficult to determine how both could be verified and validated. The nature of questions I asked during the interviews was to some extent subjective so, it was a challenge to determine the accuracy of responses.

1.6 Delimitations of the study

According to Theofanidis and Fountouki (2018), delimitations are restrictions or boundaries actively put into place by the researcher in terms of the study's duration, population size and type of participants. The present study was restricted to the Aawambo cultural mathematical activity of basket making in the Oshana Region. In addition, its focus on the mathematical

content at junior secondary level is applicable to strategies Mathematics teachers may add onto the known strategies to integrate IK in Namibia.

1.7 Definitions of terms

To avoid ambiguities that may arise in the study, the following key terms are defined based on the context of this study:

Aawambo

Aawambo is a Bantu ethnic group native to Southern Africa, primarily modern Namibia, who reside on the flat sandy grassy plains of northern Namibia and the Cunene Province in southern Angola (Shigwedha, 2004; Kaakunga , 2020). In the context of this study, the Aawambo are one of the ethnic groups that have retained their cultural practices, notably basket making.

Basket making

Basket making refers to the process of weaving or sewing pliable materials into three-dimensional artefacts, (Agrawal, 2016; Mejorado, 2022). In the context of this study, it refers to the weaving of baskets by the Aawambo women.

Culture

Culture refers to a set of norms, beliefs and values that are common to a group of people who belong to the same ethnic group (Hammond, 2000). In addition, culture is defined as all the ways of life including arts, beliefs, norms of behaviour and institutions (Nurbaeti, Sowanto, Mikrayanti, Sarbudin, & Edison, 2019). In the context of this study, it refers to the customs and

social behaviours of the Aawambo people.

Ethnomathematics

The mathematics which is practiced among identifiable cultural groups, such as national-tribal societies, labour groups, children of a certain age bracket and professional classes (D'Ambrosio, 1990). Correspondingly, ethnomathematics is defined as the study of the relationship between mathematics and culture (Marcia, 2019). In the context of this study it is the Mathematics being practiced in the basket making by the Aawambo women.

Indigenous knowledge

Indigenous knowledge, abbreviated as IK, is the unique knowledge confined to a particular culture or society (Senanayake, 2006, Shinana, 2020, Kakambi, 2021). In the context of this study it refers to the cultural knowledge applied by Aawambo women in the basket making process, which might help in the promotion of effectiveness of integration of indigenous knowledge in curriculum implementation. In this study Indigenous knowledge is used interchangeably with ethnomathematics.

Indigenous Knowledge Systems

Indigenous Knowledge Systems (IKS) are complex sets of knowledge, skills and technologies existing and developed around specific conditions of populations and communities indigenous to a particular geographic area (Noyoo, 2007; Shinana, 2020; Shinana, Ngcoza & Mavhunga, 2021). In the context of this study, IKS constitute sets knowledge that are integrated into the

basket making that the Aawambo people have developed over time and continue to develop.

Indigenous knowledge culture

Indigenous knowledge culture can be defined as a network of knowledges, beliefs, and traditions intended to preserve, communicate, and contextualize indigenous relationships with culture and landscape over time (Bruchac, 2014; Kakambi, 2021).

1.8 Chapter Summary

This chapter introduced the study on the mathematics embedded in basket making by the Aawambo women in the Oshana Region. It presented a background to the existence of indigenous knowledge that can be integrated into the school curriculum. I outlined how mathematics education in Namibia has undergone several reviews and reforms with attempts to integrate IKS in school curricula. It has emerged that teacher training does not thoroughly prepare teachers for IK integration, hence their incapability to do so.

CHAPTER 2

LITERATURE REVIEW AND CONCEPTUAL FRAMEWORK

2.1 Introduction

This Chapter is divided into four sections, the first of which addresses the existence of indigenous knowledge in Mathematics, contestation of indigenous knowledge into the curriculum and socio-culturalism. The literature on existence of Mathematics and contestation provides information to establish familiarity with the current research and offers a foundation for this study. The second section addresses types of geometrical mathematics embedded in basket weaving activities, pointing out what is unknown, contradictions and similarities about basket weaving in different countries and its application to the mathematical content at Namibian junior secondary level. The third section presents the strategies used in CPD programmes, necessary for capacitating teachers on knowledge about the integration of IK in the Mathematics curriculum, whilst the fourth presents the conceptual framework for this study.

2.2 The existence of indigenous knowledge in mathematics

To demonstrate the diversity of mathematical systems, scholars have traced the historical cycles of mathematics' development from antiquity to the present (Gerdes, 1994; Huylebrouck, 2006; Burton, 2011; Meyer & Aikenhead, 2021). Huylebrouck (2006) and Burton (2011) specifically mentioned that before the agricultural revolution, native cultures measured food ingredients, made clothes, found geographic locations, played games, counted arrows, and used

numbers to express ideas to one another. Farmers had to devise methods for counting their livestock, using basic geometry to plan a town's layout, determining who owned what property, forecasting when flooding would happen, and explaining the night sky. To perform various calculations, they had to develop an administration-oriented Mathematics system (Mosimege, 2000; Zaslavsky, 1999), which resulted in the accumulation of mathematical experiences over time. This was included in the definition of Mathematics provided by cultural anthropologists, which linked Mathematics to any culture and, by extension, to the Mathematics taught in schools today (Guus, Liebenstein, Slikkerveer & Warren, 2016).

A study by Fouze and Amit (2019) on geometrical shapes in Bedouin women's traditional dresses from the Negev area in southern Israel showed symmetrical designs that indicated a complex and precise spatial perception and high level of skill developed over generations. This study is one of several attempts to connect geometric elements of traditional embroidery and ethnomathematics (Maxwell & Chahine, 2013). Like this, Nurbaeti, Sowanto, Mikrayanti, Sarbudin, and Edison (2019) examined the geometric patterns and patterns found in the Tembe Nggoli, a type of woven fabric used by the Mbojo tribe. From these examples, mathematical concepts such as translation, reflection, dilatation, as well as the rotation in patterns of triangles, rectangles, parallelograms and octagons emerged. These geometrical forms can be used as a source of learning to enhance the understanding of students and community of the relationship between their cultures and Mathematics (Nurbaeti, et al., 2019). The existence of ethnomathematics has led to the establishment of schools of thoughts regarding which knowledge is useful in general and also in the Mathematics school curriculum.

2.3 The perspective of Universalism versus Multiculturalism in education.

Knowledge can be placed in two categories, namely universalist and multicultural. Christensson (2020) defines universalism as an ideology and perspective which believes that there is only one truth that all people should follow. It is presumed to be superior to Western knowledge because it is rooted in scientific knowledge that depends on scientific inquiry employing objectivity, empirical evidence, and rationality (Chikunda & Ngcoza, 2017). According to Siegel (2012) and Snively and Corsiglia (2014), there is only one truth in universalism, and it is characterised in the form of theories which are testable and genuinely predictive.

On the other hand, multiculturalism is defined by Jacobs (2015) and Klein (2011) as the contextualisation of knowledge accumulated over time and passed from generation to generation. Stanley and Brickhouse (2015) describe it as an anthropological ideology and perspective which argues that there is not just one truth or culture which is superior to another. The school of thought is based on the principles of diversity, inclusivity, equality, resource, and overcoming barriers (McCormick, 2014).

2.4 Contestation of indigenous knowledge in the curriculum

Although IKS continue to exist, several researchers not only challenge their validity but also their integration in school curricula, especially as whether they are useful to education (Botha, 2012; Jacobs, 2015; Ronoh, 2017). This is evident in the debate between universalism and multiculturalism as scholars fail to reach consensus on methods to validate traditional

knowledge. Most indigenous peoples transmit their knowledge through traditional ways of knowing, most typically through narratives, carved and painted objects (Bruchac, 2014; Basso, 2015). Horsthemke and Schafer (2007) dispute the idea that IK is owned since cultural possession seems deceptive and only serves to further marginalise alternative knowledge systems. According to Horsthemke and Schafer (2007), there are difficulties in integrating IK since it might be difficult to find and recognise the scientific skills ingrained in cultural practices and since certain talents are not culturally specific. IK is out of date, degenerate, degrading, and out of step with modern thought (Onwu, 2009).

Since the goal of Mathematics education is for learners to grasp related ideas, the application of IK centres on the employment of techniques that emphasise the transmission of mathematical facts rather than reasoning (Botha, 2012). In a similar vein, Webb (2013) objects to the inclusion of IK in the curriculum, arguing that it is illogical, unrecorded, and verbally delivered, forcing teachers to follow the text and overlook its application. On the other hand, it was stated by Brayboy and Castagno (2008), Cobern and Aikenhead (1998), and Mavuru and Ramnarain (2020) that excluding some types of knowledge from the curriculum will erect obstacles and prevent learners from having access to ethnomathematics teaching methods in classrooms. Khupe (2014) showed in her study on the use of IKS in Mathematics teaching that it enables teachers to draw on cultural knowledge, which has a positive impact on learning. Khupe (2014) went on to say that the colonial masters misunderstood IK and saw it as unscientific, a viewpoint that some people considered to be ignorant (Shiza, 2007; Kakambi, 2020).

Mhakure and Otulaja (2017) stressed the importance of teaching that integrates multi - cultural artefacts and advocated for culturally responsive pedagogies that integrate learners' world views into Mathematics lessons to facilitate understanding in their study on the application of IKS in Mathematics learning. Seehawer (2018) proposed that even though IK and Western knowledge are distinct scientific fields, they can work in tandem to achieve a shared objective because they both make equal contributions to our understanding of the world. Consequently, teachers are able to harmonize the application of both in Mathematics teaching and learning within their classrooms (Hashondoli, 2020).

2.5 Integration of IK in the Mathematics curriculum

Several scholars encourage the integration of IK in the school curriculum as it has the potential to promote participation, increase interest in Mathematics and help in the development of mathematical concepts. It preserves IK and the recognition of community teachers' cultures that are embedded in mathematical practice (Kibirige & Van Rooyen, 2007; Mapara, 2009). According to Mukwambo, Ngcoza and Chikunda (2014), it enables learners to recognize their identities and so have a sound educational basis. For indigenous learners this has numerous socio-psychological ramifications since they would start to respect their own expertise and link it to other knowledge systems.

Emeagwali (2003) recommends striking a balance between Western and indigenous knowledge systems whilst Agrawal (2014) and Drew (2005) believe that knowledge can be tapped from the community and not only from laboratories as in Western systems. Incorporating IKS into

the established educational system broadens the scope of academic knowledge, therefore systems from the West and Africa could coexist in an academic setting (Shinana, 2020; Shinana, Ngcoza & Mavhunga, 2021). By incorporating a diversity of ideas, academia develops a more cohesive body of knowledge, regarded by Jegede and Aikenhead (1999) as harmony between universalism and multiculturalism in the formal school curriculum and syllabus. Aikenhead explains that using both curricula will allow teachers to instruct learners using resources available in their immediate vicinity. Also, learners will be able to connect what they have learned in school with what they have experienced in life, thus improving meaningful and productive learning (Achimugu & Adib, 2014). The process involves introducing them to their natural and social contexts while guiding them from what they already know to formerly unknown territory (Chauraya, 2015). According to Cobern and Loving (2016), this procedure will guarantee more efficient learning, be a more comprehensive method of knowledge acquisition, and will be simple to execute. Hewson (2013) noted that formal education is no longer limited to what is taught in a classroom but should consider all of the learner's daily experiences such as basket weaving and clothes embroidery.

Mukwambo, Ngcoza and Chikunda (2014) found that the integration of IK in Mathematics has the potential to decolonise African educational systems. Since many are generally regarded as unscientific, the decolonisation of Western education could assist in the implementation of IKS that meets the needs of an African child (Mazrui, 1998). Nevertheless, it is crucial to take into account the epistemological difficulty of integrating the two bodies of knowledge given the nature of both ethnomathematics and Mathematics. The pedagogical implications of IKS in Mathematics teaching are to decolonise concerning the nature Western knowledge that impedes

the integration of IK as different divergent opinions of Mathematics influence how it is taught in schools (Abonyi & Adibe, 2014). Currently, policy documents in schools require that teachers integrate IK in school subjects, including Mathematics (Pinxten & François, 2017). Teachers must be provided with teaching supports and aids to enable them to use content knowledge and link it to ethnomathematics in the classroom (Kibirige & van Rooyen, 2018). Teachers' preparedness to do so in the teaching and learning of geometry is also questioned by Mapara (2009), whilst Massarwe, Verner and Bshouty (2017) argue that adhering to the Curriculum and Assessment Policy Statement (CAPS) in schools is not enough to make teachers competent to integrate IKS in Mathematics.

2.6 Mitigating strategies to integrate indigenous knowledge in the classroom

When teachers integrate IK into Mathematics lessons learning is relevant and meaningful to learners and helps them appreciate its potential applications. Possibilities should be created to help them develop their own knowledge and more opportunities should be given for them to obtain other perspectives on phenomena (George, 2016; Jegede & Aikenhead, 1999). The following themes emerged from the literature:

2.6.1 Local resources should be utilised in classrooms

According to Jegede and Aikenhead (1999), local resources should be utilised in classrooms, including local materials and people. For instance, local engineers, biologists, geologists, environmentalists, nurses and basket makers can be invited to schools to talk about the importance of IK integration in society and how it can co-exist with Western knowledge (Da

Silva, Pereira & Amorim, 2023; Barnhardt & Kawagley, 2020; Semali, 2004). The limitations of both can be demonstrated particularly the romanticized, skewed vision of Western knowledge that further deprives the pupils of crucial concepts available in IK.

2.6.2 Teachers' capacity building on use of indigenous knowledge through workshops

Khupe (2016) argues that capacity building is a suitable strategy to enhance the integration of IKS in the teaching of Mathematics in schools. Various forms of staff development, such as workshops and in-service training can be adopted, and teachers supported in collaboration and development of their own strategies for the inclusion of IK. This capacity building can be achieved through staff development programmes such as workshops, seminars and conferences. For effective integration in the teaching of Mathematics, all teachers should undergo the programmes to equip them with pedagogical content knowledge and ability to design a comprehensive lesson plan (Kind, 2009). The knowledge acquired from staff development programmes would help them identify IK appropriate to their lessons.

2.6.3 Launching community consultation on indigenous knowledge

George (2016) states that community consultation on IK is an effective strategy that enhances its integration in the Mathematics curriculum, and necessary to effect realistic policy changes based on local and cultural practices. Thus, stakeholders such as parents, traditional leaders and Mathematics teachers should be instrumental in shaping a comprehensive IK policy. Similarly, Aikenhead (2011) found that the strategy works best when the nature of the IK to be incorporated into a Mathematics curriculum and pedagogy is identified, with consultations yielding better results through campaigns for stakeholder familiarisation on policy and

implementation in the classroom. Mathematics teachers need to be given the opportunity to air their views on the ways to best incorporate IK and so inform policy and practice.

2.6.4 Documentation of indigenous mathematics knowledge

Lee, Yen and Aikenhead's (2011) study in Taiwan stated that the Ministry of Education, Art and Culture which oversees curriculum development should work together with teachers to record indigenous practices for possible infusion into policy. Further, Lee, Yen and Aikenhead claim that Mathematics textbooks need to provide examples of the contributions of ethnomathematics that enable indigenous peoples to live in environments over a long time. Similarly, the development of written texts and material that integrates ethnomathematics through gaining a good understanding of it would enhance incorporation into school curriculum. Concurringly, Hashondili (2020) also found a need for the publication of books and learning materials on numerous traditional learning activities, so that they can be accessible in schools. Hashondili (2020) argues that the documented information should be home-grown and Mathematics teachers invited to make contributions to the generation of such literature so that IK is culturally and contextually appropriate. The literature provided should be for both for teachers and the learners, in the form of appropriate storybooks.

In summation, it is evident from literature that conducting workshops and conferences on ethnomathematics in the school curriculum, launching of ethnomathematics consultation and campaigns in the community, and the funding of research in ethnomathematics need to be prioritized, and documentation of such indigenous mathematics knowledge used as strategies

for integration in schools. Based on this literature, this study aims to capacitate teachers through workshops, with particular focus on Namibia.

2.7 The Namibian stance on indigenous knowledge

In Namibia, the National Commission on Research, Science and Technology (NCRST) has funded a project to document IKS and their application across the 14 regions, whilst the establishment of a national IK database is being carried out by the two national universities, namely the University of Namibia (UNAM) and Namibia University of Science and Technology (NUST) (NCRST, 2021). According to Shinana, Ngcoza and Mavhunga (2021), funding research in ethnomathematics should be prioritized in the country to provide important direction on how teachers can proceed with its integration in the school curriculum.

In an effort to capacitate Mathematics teachers with professional knowledge that improves the teaching of Mathematics, the Namibian government devised initiative programmes such as the Mathematics and Science Teachers Extension Programme (MASTEP). The programme provided an opportunity for up skilling of Mathematics who otherwise were unqualified to teach Mathematics. MASTEP had a great impact on the teachers' content knowledge and improved their classroom instructional methods through workshops and conferences (Kakambi, 2021). However, the programme was not centred on integration of IKS in the teaching of Mathematics in schools.

As mentioned in Chapter One (page 5), the Namibian curriculum has undergone recent changes which require Mathematics teachers to use IKS (MEAC, 2002), but not all have been able to adapt. It was thus important for these teachers to be provided with professional development

platforms, such as workshops, group reflections and conferences, to afford them an opportunity to share their knowledge on ethnomathematics and, for example, basket weaving and how it can be integrated. Another study by Haras#Gaes (2005) indicated that the cultural activities and artefacts of Damara culture are embedded in many mathematical concepts and processes, such as clothes design and its exploration of mathematical concepts associated with geometrical shapes, tessellation, and various types of symmetry. Geometrical forms were found in the work of wood and ivory carvers, potters, painters, weavers, mat and basket makers, whilst geometry, symmetry and transformation were covered by the junior secondary mathematics curriculum (Haras#Gaes, 2005). Whereas Onstad, Kasanda and Kapenda (2003) linked abstract school subjects, local culture and everyday experiences in the Oshana region. Onstad *et al.* identified mathematics used by people in Northern Namibia, with focus on educational use of ethnomathematics and the benefits of its use in the teaching of school mathematics. Though the findings indicated that basket weaving is embedded in ethnomathematics, as depicted in the shapes of circles, the study did not aim to identify content that could be matched to themes and topics presented in the mathematics curriculum nor the strategies to effectively capacitate teachers. In conclusion, the few studies in Namibia found cultural activities embedded in geometrical shapes but exposed a dearth of literature on how ethnomathematics could be integrated in the country's educational system. There is need for studies that examine training in IKS integration so that teachers can acquire the necessary knowledge on how cultural mathematics resources can be tapped and integrated in the classroom.

2.8 Types of Mathematics embedded in basket weaving activities

This section reviews studies that focused on geometrical mathematical concepts which are rooted within basket weaving activities. Geometry shows how shapes are formed, the position of angles, properties of shapes and ways they are constructed. Similarity, congruence and the way a given object is shaped and undergoes transformation are geometrical concepts that are depicted in basket weaving and discussed below.

2.8.1 Geometrical transformation

Focussing on the ethnography of mathematical concepts in the cultural activities at the Basotho Cultural Village, Mosimege and Lebeta (2015) aimed to identify the use of mathematical geometry in the daily activities of indigenous basket weavers. Using the decorative pattern methodology, the findings indicated that the basket weaving process is rooted in rotational transformation. According to Mosimege and Lebeta (2015) rotational transformation refers to a transformation obtained by rotating a figure around a fixed point (turning a figure about a point). It also revealed that the decorative triangles and squares on woven baskets reflect rotational transformation from one point to another for decorative purposes. There is noticeable evidence that mathematical concepts in basket weaving reflect rotational symmetry which is relevant to the teaching of geometry in schools. The study concluded that the incorporation of mathematical traditions into the curriculum could contribute to the elimination of individual and socio-psychological blockage and the related cultural impasse.

In a similar study, Chahine (2016) focused on the plane and decorative patterns used to identify reflection transformation in the woven baskets. Chahine (2016) defines reflection is a

transformation which produces the mirror image of a figure (flipping a figure across a line). The study concluded that transformation is one mathematical concept found in basket weaving that should be integrated in the classroom.

Atmosfera (2019) conducted a study on the mathematical structures of woven baskets crafts of Lagangilang in Abra, Philippines to identify the mathematical concepts, shapes, and designs present in the woven basket crafts, to determine the mathematical structure of their patterns and to associate meanings and mathematical implications of the designs. The findings were that geometrical transformation in basket weaving reflects enlargement and concluded that teachers are appropriately placed to indigenize mathematics knowledge and experiences inside and outside the early formal classroom. Enlargement transformation denotes a type of transformation that changes the size of a shape or object (Atmosfera, 2019). Therefore, the study recommended that Mathematics teachers improvise foreign materials with the indigenous basket resources to close the already widening gap on matters of indigenization of basketry in classroom instruction.

The increase in size of a decoration pattern methodology on a woven basket form an enlargement of geometrical transformation, therefore, the dilation or increase in size methodology provides a useful insight into an effective way of developing pedagogical content knowledge of the geometrical transformation found in basket weaving.

Bose and Talledo (2015) focused on geometric transformation of the basket weaving in Abra to identify the categories of geometrical transformation, finding indicated that basket weaving

depicts transformation. According to Bose and Talledo (2015), translation transformation refers to transformation that slides a figure a given distance in a given direction. The sliding of decorated pattern was used to identify the translation geometrical transformation.

The Shuttleworth Foundation (2016) focused on the Mathematics of Zulu baskets design in South Africa to identify geometry in basket weaving and to offer suggestions on how it could be integrated in teaching and learning in the classroom. The findings were that geometrical transformation in basket weaving reflects shear. Shear refers to the stretching of a given object or shape to the extent that it looks like it increased its size (Atmosfera, 2019). The study concluded that traditional activities contained mathematical elements which, if investigated, might play an important role in the classroom.

2.8.2 Geometrical terms and relationship

This section gives an overview of geometrical terms associated with basket weaving arising literature namely; lines, parallel and intersecting lines, angles, similarity and congruence.

2.8.2.1 Lines

An ethnographic study in Mozambique by Cherinda (2013) focused on the identification of the types of geometrical terms and relationships found in basket weaving. The study employed the weaving morphology or structure to identify geometrical line on woven baskets. The findings of this study revealed the stripe decorated patterns that runs on the basket to form a linear geometrical term. It concluded that mathematical concepts of geometrical shapes found in basket weaving should be integrated in Mathematics teaching and learning.

2.8.2.2 Parallel and intersecting lines

Vithal (2012) focused on indigenous mathematical knowledge in education in South Africa, finding that the strips used in basket weaving depict the geometrical terms of parallel lines which are found on the rim. The straight line goes in the same direction as parallel lines in the woven basket. He further stated that plaited straight line formed by weaving fibres meet a point to form the mathematical concept of intersection. Thus, Vithal (2012) speak of two lines crossing each other as intersecting lines. On other hand, Mosimege and Lebeta (2015) defines parallel lines as two lines in the same plane that do not intersect. However, the study did not specify how ethnomathematics can be brought to the classroom, a shortcoming that this study sought to address through continuous professional development. The study recommended that the South African Department of Education call for teachers to play an important role in linking what happens in the community to various curriculum requirements.

2.8.2.3 Angles

A study conducted in Madagascar by Gould (2014) focused on baskets for the Mathematics classroom, aiming to identify relationships between solid angles and angles in the sides of a basket that meet to form it. Gould (2014) defines an angle as two rays that have a common endpoint called the vertex of the angle. The morphology or structure of strip of the plaited fibre on the basket was used to identify the angle in woven products, with long strips wrapped around a circular rim at 60° angles to form two strips to weave at 120° angles.

The angles found in basket weaving also form a right angle while the strips in the third direction are parallel to the plane of the rim and the sides of the basket are perpendicular to the base,

with the strips continuing diagonally up the sides in a natural fashion. The study concluded that the basket weaving strip pattern form geometrical angles and he decorative patterns with a vertex with two arms or parallel form an angle.

2.8.2.4 Similarity and congruence

Mosimege (2012) sought to identify geometrical concepts found in basket weaving. It used the decorative strip pattern to identify the similarities and congruency found in decorative structure. Similarity refers to two or more figures having the same shape but not necessarily the same size (Mosimege, 2012). On the other hand, congruent is a geometric figure having the same size and shape; all corresponding parts of congruent figures have the same measure (Bose & Talledo, 2015).

The relationships between areas of similar triangles, with corresponding results for similar figures were also discussed and recommendations made for educational stakeholders to accept collaboration with local artisans to harness the indigenous basket resources to enhance conceptual understanding in geometrical similarity and congruence.

2.8.3 Symmetry

From literature, two types of symmetry have arisen namely; axial symmetry and rotational symmetry. This section gives a brief discussion on the two types mentioned above.

2.8.3.1 Axial symmetry

A study by Alakanani and Liu (2013) of teaching mathematical concepts through basket weaving examined the relationships between Mathematics and cultural identity in Mozambique. The findings indicated that basket weaving activities depict the mathematical concepts of symmetry which comprise axial symmetry in the crossing of lines at the centres of the products. Axial symmetry denotes a symmetry around an axis, an object is axially symmetric if the appearance is unchanged if rotated around an axis (Alakanani & Liu, 2013). Similarly, a study by Mosimege and Lebeta (2015) in South Africa used the diagonal lines which start from the circumference of a circular basket and pass through the centre to the other side, meeting in diagonally at the centre to form an axial symmetry. The diagonal methodology and the crossing of line at the centres of woven basket were the methods used to identify the type of Mathematics employed.

2.8.3.2 Rotational symmetry

A study of basket weaving in Mozambique, Gerdes (2014) explored concepts and practices in the cultural context and offered contributions to understanding mathematical reasoning in diverse cultural practices through geometrical exploration. The possible educational implications of mathematical concepts found in women's basket weaving included mathematical concepts of rotational symmetry.

Rotational symmetry of a shape explains that when an object is rotated on its own axis, the shape of the object looks the same (Dabula (2011). The study employed the rotation of a plain and decorated shape until it returns to its original position to identify the rotational geometrical

symmetry found in basket weaving. The regular geometrical shapes such as triangles, squares and rectangles, which are rich with symmetrical concepts, were used to explain the concepts of rotational symmetry. In a related study, Dabula (2011) has also identified mathematical concepts associated with basket weaving using decorative pattern or structural methodology to achieve rotational symmetry. The decorative pattern or structure methodology used by Dabula (2011) complements Gerdes (2014), who used plain pattern of the plaited fibre methodology. The two studies demonstrated rotational symmetry as both used the rotation of a plain and decorated shape until they return to their original position.

2.8.4 Geometrical construction

This section gives an overview on the concepts geometrical construction that have emerged from literature namely; constructing angle bisectors and perpendicular bisectors using straight lines.

2.8.4.1 Constructing angle bisectors

Madusise (2016) focused on the use of cultural activity in the teaching and learning of mathematics in basket weaving in Southern Africa to determine mathematical concepts incorporated in the patterns of products in Angola, Botswana, Lesotho, Malawi, South Africa and Swaziland.

The parallel patterned lines and perpendicular lines that cut across the woven basket formed the angle of bisection, with a diverse number of mathematical ideas such as geometrical

construction. According to Madusise (2016), angle bisector refers to the dividing of a given angle into two equal angles.

Gibbs and Sihlabela (2008) have examined the geometrical figures of constructing angles of bisectors similar to the ones identified in using the same methodology of parallel strips. The methodology used to identify the angle bisectors in basket weaving products is similar to that of Madusise (2016), with both using parallel patterns lines and the perpendicular line cut across the product to form an angle of bisection.

2.8.4.2 Perpendicular bisectors using straight lines

Bazin and Tamez (2016) studied the geometrical concepts found in basket weaving and how they could be integrated in the classroom. Employing the decorated strips on the woven basket to identify perpendicular bisectors, they found the geometrical construction of perpendicular bisectors using straight lines. Definition of perpendicular angle bisector by Gerdes (2014) denotes a ray known as a bisector that divides an angle exactly in half to create two equal angles. Put more simply, it's a line that passes through the intersection point to split another line segment in half at a right angle. The derived concepts could be incorporated into a school's Mathematics curricula at different levels. It was determined that indigenous basket weaving could be used to teach Mathematics at all levels, from primary to higher institution of learning. The study recommended that the mathematical concepts in basket weaving be utilised to prepare future teachers in using cultural mathematical concepts to deliver the curriculum, and decide which methods of teaching geometry can be used in the integration of IK in the classroom. Similarly, Gerdes (2014) points out that basket weaving activities use Mathematics

concepts of perpendicular bisection and straight or decorative patterns. Bazin and Tamez (2016) concur that decorated parallel strip methodology on a woven basket shows a perpendicular line that bisects the angle. Both studies show decorative patterns and strips form a perpendicular bisector on a woven basket, clearly show how ancient techniques of how perpendicular bisectors are presented using straight lines. My study expands on the work of Bazin and Tamez (2016) and Gerdes (2014) in an attempt to discover common geometric concepts, such as perpendicular bisection and symmetry, in various weaving processes.

2.8.5 Geometrical shapes

This section gives an overview of several geometrical shapes featured in basket making that have emerged from literature namely; circle, square, triangle, rectangle and hexagon.

2.8.5.1 Circle

In Namibia, Onstad, Kasanda and Kapenda (2003) linked abstract school subject, local culture and everyday experiences in the Oshana Region to identify mathematics used by people in Northern Namibia. Their study focused on educational use of ethnomathematical ideas and the benefits of including them in the teaching of school Mathematics, using the circular tray of woven basket methodology to identify that the shape was a circle. According to Bazin and Tamez (2016), circle is the set of all points in a plane that are a given distance from a given point. Nkopodi and Mogege (2012) also elaborated on the exploration of mathematical concepts found in basket weaving products using the coiled structure to reflect a circular shape, as opposed to the circular tray methods noted by Onstad, Kasanda and Kapenda (2003). The circular tray structure and coiled or spiral (circumference) methods form a circular geometrical

shape, hence, a woven basket is a set of all points in a plane that are at a given distance from a given point.

2.8.5.2 Square

Gerdes (2015) identified four corresponding straight lines or points on a woven basket as forming the shape of a square produced in Mozambique. According to Gerdes (2015), square is a regular quadrilateral (all sides and angles are congruent).

2.8.5.3 Triangle

In Mozambique, Cherinda (2012) related educational exploration of traditional basket weaving techniques to the mathematical concepts of geometrical shapes in decorative patterns. The plane structure and decorative pattern were used to identify triangles from the angles on the sides. According to Gerdes (1996), triangle denotes to a polygon with three sides. Similarly, Gerdes (1996) examined the type of geometry found in basket weaving using the corresponding point of the three lines which pointed as vertices in a triangular shape on woven baskets. The three plain strips and decorative pattern lines and the three lines which meet at vertices form a triangle shape as a result of the vertex (vertices) where two-line segments come together.

2.8.5.4 Rectangle

In Cameroon and Zaire, Clements and Sarama (2013) identified the mathematical concepts of shapes in decorative patterns and mathematical implications of designs in basket weaving. They found rectangle decorative shapes used by weavers to adorn the basket, with an intersection of long horizontal straight line and short vertical lines used. Clements and Sarama

(2013) define rectangle is a quadrilateral in which all the angles have the same measure (90 degrees). The strip decorative pattern method formed rectangular shapes and it was concluded that a combination of Mathematics, art and culture could help teachers integrate concrete, abstract ideas and creative elements in the classroom.

2.8.5.5 Hexagon

A study carried out in Ghana by Ali and Davis (2018) focused on harnessing indigenous basketry resources for geometrical mathematics. The purpose of the study was to identify geometrical shapes found in basket weaving and offer suggestions on how they could be used to enhance the teaching of geometry in the classroom. Hexagonal shapes formed decorative patterns on the basket, with a spiral consisting of a zigzag band. According to Cherinda (2010), hexagon is a polygon with six sides. Similarly, Cherinda (2010) used the intersection of oblique line methodology to show the formation of hexagonal shapes.

2.9 Summary

The role and consequences of indigenous knowledge in education, specifically mathematics education, have been highlighted in this chapter. Numerous researchers and academics have demonstrated interest in the development of mathematical concepts with respect to the IKS perspective. Examples were cited to show its existence and recognition by various nations. The Namibian educational system is to a greater extent negating ethnomathematics integration in the school curriculum and little literature exist. Different geometrical mathematical terms have emerged from the literature, showing Mathematics embedded in basket making that can be linked to the junior secondary syllabus and the integration methods that can be used in

mathematics classes. The next section discusses CPD, a programme given to teachers as in-service training to enhance their knowledge whilst they are working. It is aimed at equipping teachers with tools and resources necessary to produce quality instruction (Brodie, 2013).

2.10 Continuous Professional Development in the context of indigenous knowledge systems

Mhakure and Otulaja (2017) demonstrate that knowledge from basket weaving activities contributes to IK teaching approaches to Mathematics that draw on the learners' cultural knowledge. However, researchers established that teachers are not able or all willing to integrate ethnomathematics in school curricula (Mothwa, 2017, Jacobs; Khupe, 2016). Mothwa (2017) claims that the teachers' pre-independence education, which was Eurocentric and denigrated IK at face value as unscientific, is to blame for their lack of training. This was made worse by the top-down curriculum of the time and the dearth of IK integration mentoring that went along with it (Cronje, 2015).

As a result, the curriculum was created to meet the expectations of the designers rather than to address the needs of the learners. Shizha (2017) discovered that despite being expected to incorporate ethnomathematics into their lessons and classrooms, Zimbabwean teachers had unfavourable opinions of it. The teachers served as custodians, shielding Western knowledge from IK, rather than integrating IK. The effective provision of teachers' professional development occurs when they are involved in intervention workshops that allow them to share ideas that improve their pedagogical content knowledge (PCK) of the integration of ethnomathematics in the classroom.

It is crucial that teachers receive training through in-service programs on how to create teaching activities and teaching tools so that learners can understand the connection between Mathematics and IK and how it applies to their everyday lives (George, 2016; Shinana, 2020). The intention is to give teachers a lasting and useful grasp of ethnomathematical concepts and to enable them to apply the knowledge they have gained from these training opportunities in the classroom. Eun (2017) noted that seminars, workshops, and group reflections provide argumentative activities for Mathematics teachers' professional development. During CPD, teacher group reflections facilitate social interactions that afford Mathematics teachers and IKS holders the opportunity to share their experiences, resulting in knowledge development. Subsequently, these could then lead to teachers learning new knowledge that would assist them in integrating IKS in teaching practice. The CPD of Mathematics teachers could be conducted with the help of cultural historical activity theory (CHAT) and pedagogical content knowledge theory (Sannino, Engeström, & Lemos, 2016; Shulman, 1986). A CHAT model focuses on the dynamic relationships among individuals, goals, tools, community members and mediating factors that are elements of any human activity (Koszalka & Wu, 2004). According to the CHAT paradigm, learning involves continuing interaction with both the environment and other people. Individual students build their knowledge by drawing on prior historical experiences and the context in which they are learning. Technology is a tool for actively involving them in the learning process, and one that mediates learning activities with which to build individual knowledge. It is influenced by the norms of the community and interactions with it (Carstens, Mallon, Bataineh & Bataineh, 2021). The CHAT paradigm therefore presupposes those interactions between users, technology, and environmental elements within a context leading to outcomes (knowledge) being generated. Understanding the interaction process of the activity

within the naturalist environment is the subject of CHAT assessment study. Drawing relevance to this study, the CHAT principle of expansive transformation offers teachers professional learning through engaging in the learning actions of questioning, analysing, modelling, examining, implementing, reflecting and consolidating (Morselli, 2019).

Cultural Historical Activity Theory (CHAT) and Pedagogical Content Knowledge (PCK) Theory

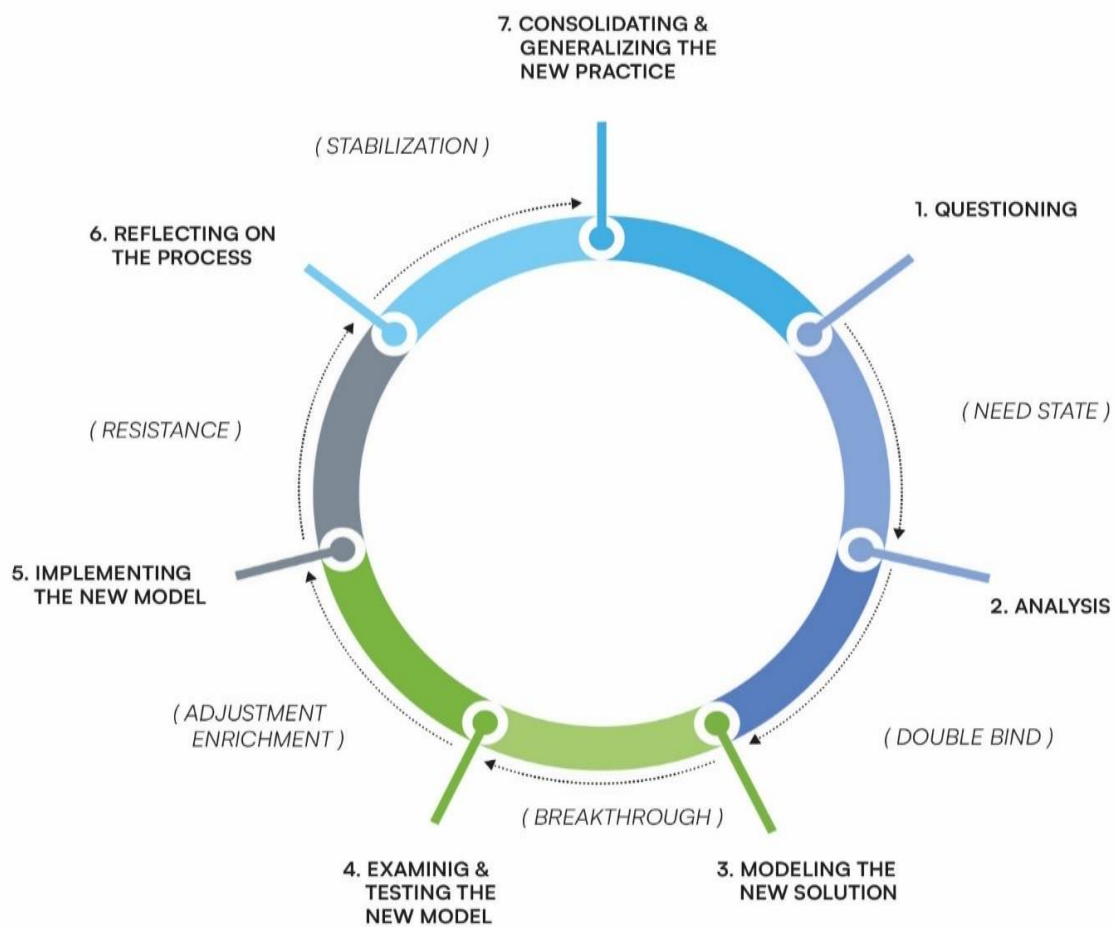


Figure 1: Sequence of learning actions in an expansive cycle (Source: Morselli, 2019, p.41)

Figure 1 presents the sequence of expansive learning in relation to the PCK which was employed in this study to show how the Mathematics teachers could acquire geometrical content knowledge and the methodologies of identifying geometrical concepts. PCK is an academic construct that was first introduced by Shulman (1986). It is based on the idea that teaching is more than just imparting mathematics content knowledge to learners in the hopes that they will retain it for future use.

Rather, it is thought to be the understanding that teachers get through practice and time about how best to teach specific subjects to learners in ways that will improve their comprehension. Shulman (1986) noted that PCK consists of distinctive bodies of knowledge for teaching that represent “the blending of content and pedagogy into an understanding of how particular topics, problems, or issues are organised, represented and adapted to the diverse interests and abilities of the learners and presented for instruction” (Shulman, 1986 p.8).

While Shulman (1986) asserts that teachers also possess Subject Matter Knowledge (SMK), PCK enables self-evaluation of the current mental state with regard to a set of mental cognitive states brought about through thoughtful consideration of beliefs and culture. It takes work to transform the content so that learners can understand it before this knowledge is ready to be taught. This aligns with Vygotsky's theory of the zone of proximal development (ZPD), which is defined as "the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration" (Vygotsky,1978p.86). It also means that the knowledge must be modified to fit the learners' level and learning abilities.

This model was utilised to analyse how the mediatory tools employed in this study improved the teaching of ability and capabilities and in the following areas using the concepts of learning mediation and ZPD:

- a) How to integrate indigenous knowledge to teach concepts of the Mathematics curriculum;
- b) How the tools enhanced mediation of scientific process skills;
- c) How the tools promoted the acquisition of higher order thinking; and
- d) How the acquisition of these skills further influenced the teachers' PCK.

According to Shulman's theory, PCK is a skill used while teaching as well as a body of knowledge used in preparation and delivery of a subject in a particular classroom setting (Gess-Newsome, 2015). Teachers would be able to learn appropriate pedagogical content and methodologies for integrating relevant IKS Mathematics into the classroom by attending the intervention workshop on how IKS should be integrated into the classroom (Loughran & Mulhall, 2006). As a teaching theory, PCK is utilized in this study to modify the SMK and conceptual teaching strategies of Mathematics teachers. This is illustrated by its nature, which was previously discussed. After taking in this collective PCK, the teachers reflect and make sense of it in order to present their own PCK. A teacher's personal PCK is created, moulded, and polished over time through formal education, on-the-job training, and professional sharing, claim Carlson and Daehler (2019). It was intended for this study's participants to have the chance to enhance their own PCK through social interactions that happened during the intervention workshop (Vygotsky, 1978).

The CHAT concept of subject was integrated by referring to the community in which the Mathematics teachers lived and worked, as custodians and exponents of IK, that is, the Aawambo basket weavers. The division of labour was integrated to show how the community took up different roles during the workshop training. For instance, while the junior Mathematics teachers are traditionally known as the practitioners mandated to transmit knowledge to society, in this study it was the members of the community of Aawambo basket weavers who were experts and/or authorities in their craft. I applied the ideas of CHAT Theory to offer intervention workshops for engaging in collaborative learning, asking teachers to participate in group reflection. These aimed to enhance interaction between the teachers and basket weavers and create opportunities for social learning.

In the CHAT Theory, I integrated the cultural tools, symbols, and artefacts found in basket weaving to support their learning, including their indigenous language, woven products and the methodologies which they used to decorate them. The CHAT lens was used to understand the expansive learning opportunities created through these workshops, with the participants referred to here as ‘learners’ (of Mathematics) and ‘experts’ (in basket weaving). The theory is applicable as it advocates social interaction of the subjects (the community) and objects (baskets) that lead to expansive learning and a shift in junior Mathematics teachers’ SMK and the instructional methodologies of PCK. Teachers could thus facilitate knowledge sharing of the Mathematics embedded in basket weaving whilst being equipped with the methodologies of identifying the geometry involved. During the workshops the discussion became multi-voiced and subsequently involved social learning, modelling and experimenting with new ideas.

2.10.1 Continuous Professional Development Approaches

This section outlined different CPD approaches that could be used by teachers to enhance their knowledge on IK integration in the curriculum, namely; Seminars, Workshops and Group reflections.

2.10.1.1 Seminars

A gathering of people to discuss a stated topic (Mukhopadhyay & Pandey, 2015), the seminar provided a formal broader platform on which teachers could present papers, exchange ideas and discuss various topics among each other and other resource personnel. These frequent meetings' interactive format offered a forum for participation in curriculum and material development as well as the testing of teacher-useable, accessible resources (Wilson, 2014). The CHAT theory behind group seminars of basket weavers and co-learners, namely the Mathematics teachers, facilitated argumentation or discussion by establishing claims resulting in the flow of knowledge to teachers (Morselli, 2019; Sannino, Engeström & Lemos, 2016). In addition, the group seminar and discussion facilitated the generation of agreed knowledge, thereby leading to a consensus point which allowed teachers to acquire IKS and learn how to integrate it in Mathematics teaching (Augustsson, 2021).

2.10.1.2 Workshops

A professional development tool that directs teachers towards an improvement in lesson delivery, the workshop transferred knowledge to novice teachers through the sharing of tasks or information sharing (Morales, 2017 & Yamagata-Lynch, 2010). Studies have shown that if teachers attend workshops that provide them with direct experiences that lead them to believe

they can master a domain, their personal competence level will rise (Bandura, 1997; Pintrich & Schunk, 2002). The activity systems of workshops boosted knowledge production which could then be assimilated by Mathematics teachers for IKS integration in schools over time, based on their interaction with the basket weavers. The workshop as an activity aimed at producing transference of IKS expertise from the basket weavers and continuous professional development of the Mathematics teachers (Englund, 2018).

The discussion between the two groups as co-learners resulted in transfer of information and facilitated the generation of a wide range of viewpoints that led to “*multi-voicedness*,” evidence the IK holders and teachers were acting in different contexts, and both groups could create and represent their viewpoints on IKS integration (Bal, Afacan, & Cakir, 2018; Morselli, 2019). In this process Mathematics teachers learned knowledge from the knowledge gatekeepers (Augustsson, 2021).

2.10.1.3 Group reflection

The engaging of Mathematics teachers in group reflection on basket weaving activities helped them acquire knowledge of the integration of Mathematics that is found in basket weaving (Kaptelinin, 2016; Morales, 2017; Stetsenko, 2015). In order to establish claims and counterclaims and come to a consensus or shared point of view, the individuals discussed their opinions in a small group (Ronoh, 2017; Tekkumru-Kisa & Stein, 2017). In order to help Mathematics teachers learn about IKS integration in the classroom, the goal was to come to a shared group understanding of the problem at hand.

The group reflection as the “*activity*” of CHAT theory facilitates a group of people coming together to discuss an idea with the intention of sharing information for using IKS to teach the Mathematics curriculum (Englund,-2018). It brought “*multi-voicedness*” on how IKS should be integrated in schools and which aspects of it should be integrated (Morselli, 2019). The multi-vocalism of viewpoints facilitated knowledge transfer from basket weavers to Mathematics teachers as co-learners (Augustsson, 2021).

2.10.2 Summary

In summary, the continuous professional development approaches on the integration of IKS in the curriculum have been highlighted in this section. Numerous researchers have demonstrated that teachers can be capacitated to use them in Mathematics through workshops, seminars and group reflections. I deduced that if the CPD approaches are utilised the integration of IKS into the Mathematics curriculum would be effective.

2.11 Theoretical framework: Vygotsky’s sociocultural theory

This research is based on Vygotsky's (1978) sociocultural theory, which suggests that social development and interpersonal interactions are related. According to this theory, cognitive functions start out as real interactions with people on an inter-psychological level and then progress to an intra-psychological level when new information is processed. According to McRobbie and Tobin (1997), people create interpretation on a community idea when they combine new information with what they already know. In other words, the new information's meaning is obtained by integrating it with previously acquired knowledge.

The premise is that cooperative learning, such as that which occurs during collaboration workshops, is the most effective way for learners (in this case, teachers) to learn (Goos, 2004). Mathematics teachers learn and internalise new concepts, psychological tools, and skills through group interaction with more skilled individuals, such as Aawambo basket weavers and teachers as learners. Employing Vygotsky's socio-cultural theory, I focused on three concepts, namely: social interaction, mediation of learning and the zone of proximal development.

2.11.1 Social interactions

Vygotsky (1978) describes 'social interaction' as the learning that takes place with more knowledgeable others (MKOs) such as parents, teachers, and peers. According to Vygotsky, it can result in development, thus, in the context of this study, it results in the acquisition of geometrical concepts found in basket weaving and the instructional methodologies of identifying each one. The professional development on geometry and methodologies of identifying the concepts occurs in a social set up, and as Rubtsov (2016) argues, it is through social interaction that what was not developed may be developed through proper guidance. The workshops, seminars and group reflection are regarded as a social set-up that facilitates learning for use in the CPD for IK integration in junior secondary Mathematics.

2.11.2 Mediation of learning

According to Ramasike (2016), mediation is a tool for cognitive change. Based on Vygotsky's ground-breaking research from 1978, Thompson (2017) divides mediatory tools into three groups: The more knowledgeable person serves as the human mediator in this scenario. The mental mediator consists of the skills and system that the more knowledgeable person models

for the less competent person during social interactions. The external mediator is made up of the technical tools used in the process of social interaction. As the mediators, the basket weavers were in charge of translating and explaining the actions they took on the baskets, as well as the reasons behind their specific actions. This gave teachers the opportunity to connect the information from the demonstration to the craft of basket weaving. Additionally, the workshop's usage of psychological instruments like the indigenous language Oshiwambo raised participation (Naidoo, 2010; Sedlacek & Sedova, 2017). Within the framework of this investigation, the workshop interventions furnished teachers with opportunities for learning.

2.11.3 Zone of Proximal Development

Using Vygotsky's (1978) framework, teachers' ZPD was viewed as a learning space between their current level of teaching knowledge, which included theoretical and pedagogical content knowledge and skills, and their future (possible) level of knowledge, which would require assistance from others. According to Vygotsky, learning can result in cognitive development and is mediated within the ZPD. The acquisition of geometrical mathematics in basket weaving strengthens Mathematics teachers' skills in geometry subject matter knowledge which are connected to the junior mathematics curriculum (Kuhlane, 2019). Junior Mathematics teachers' subject matter knowledge on geometrical topics and associated concepts might also be strengthened (Stott, 2016). Shabani (2016) asserts that the use of mediatory tools, such as artefacts (woven basket products) and mentors (Aawambo basket weavers), positively affects the ZPD of math teachers. The models utilized in teacher professional development are consistent with Vygotsky's theory, as explained by Eun (2017) and Shabani (2016). For example, the concept of 'mentoring' which takes place during the workshops, seminars and

group reflection is aligned to his idea of the MKO mentoring the less competent, here the junior Mathematics teachers. The professional development sought through ‘training’ which engaged teachers in social interaction with Aawambo basket weavers created an opportunity to learn and build on their knowledge. The enhancement of learning results in extension of the teachers’ ZPD if teachers acquire the methodologies of identifying the geometry found in basket weaving (Shabani, 2016). The sharing of knowledge on the development of a lesson that integrates IKS aims to reach the ZPD regarding the integration of IKS into the classroom. The reach of Mathematics teachers on the ZPD equips them with knowledge on how the IK found in basket weaving could be implemented in the Mathematics school curriculum.

2.11.4 Summary

In conclusion, this section examined Vygotsky’s socio-cultural theory, the theoretical and analytical frameworks on which this study was built on. It was considered appropriate for my research because teachers as learners have varied backgrounds. The mediation of the learning environment occurred in a social setup in which teachers socially interacted, sharing knowledge about the mediation of IK. The theoretical framework was appropriate because teachers require teachers’ professional development that can be enhanced through social interaction and so prepare them for integration of ethnomathematics in the curriculum.

2.12 Conceptual framework of this study

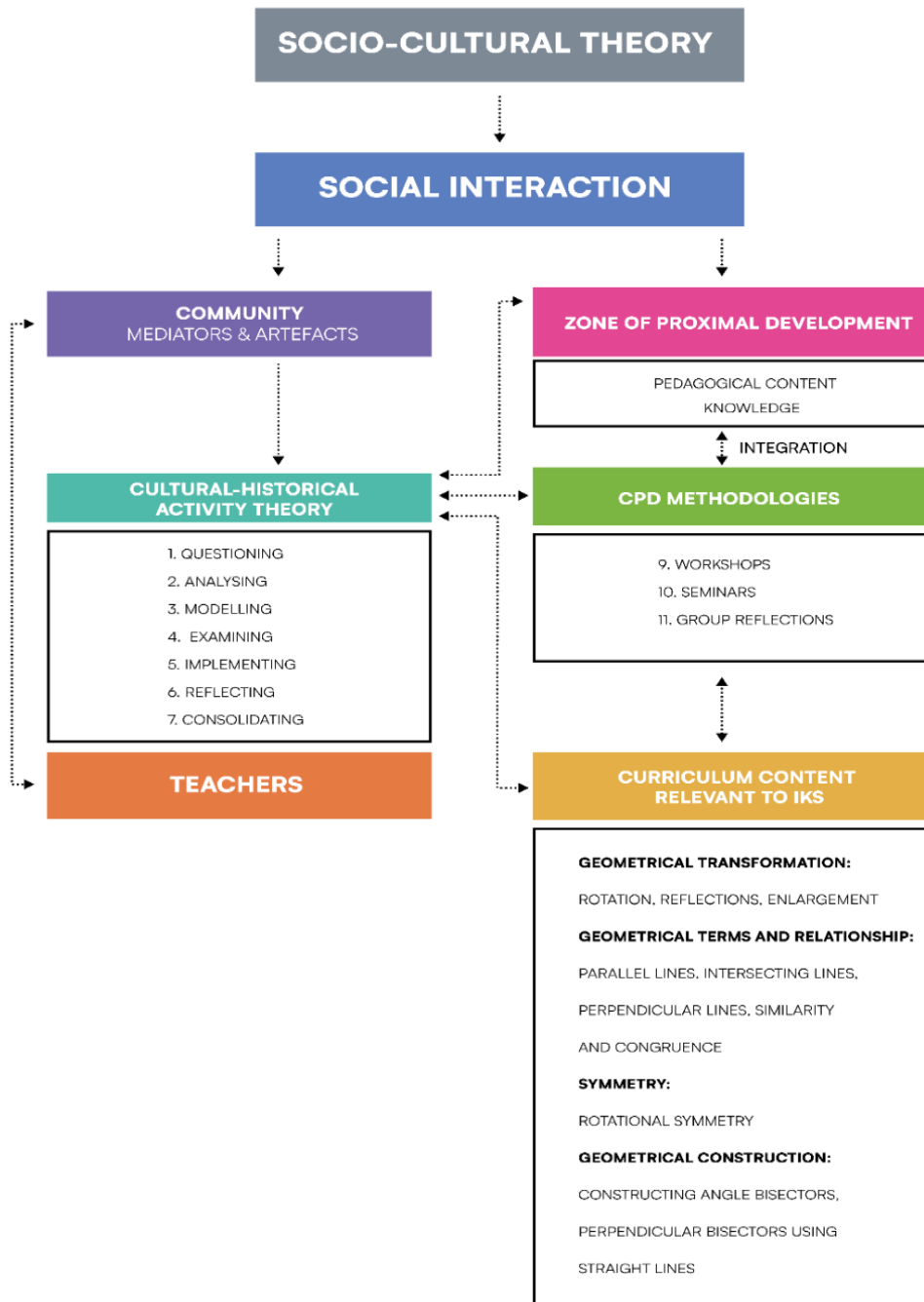


Figure 2: Ethnomathematics integration framework

Figure 2 depicts the conceptual framework of this study, explained systematically as follows:

2.12.1 Social cultural theory

Socio-cultural theory posits that learning in a social context occurs through social interaction with the community (Mahn & John-Steiner, 2012) as indicated in Figure 2 where teachers and the basket weavers' social interact. It is important in this study because the concept of 'mentoring' is aligned to Vygotsky's idea of community experts. Through social engagement, Mathematics teachers interact and so provide training sessions that create an opportunity to learn.

2.12.2 Community

As indicated in as indicated in Figure 2, Knowledge from the community can be incorporated into the school curriculum, particularly the Mathematics curriculum as the community refers to school teachers and the Aawambo basket weavers. Since Mathematics teachers are part of the community and actively involved in its dynamics, content originating from them is easier to understand when attempting to improve the way in which ethnomathematics is incorporated into the curriculum. It establishes the subject matter and delivery strategies, both of which are ingrained in the culture of the populace. Certain communities have unique teaching methods, like basket weaving, that must be used to meet these standards. These are the means by which IK is passed down from generation to generation.

2.12.3 Curriculum content relevant to ethnomathematics

The community can provide the much-needed IKS-relevant mathematical concepts such as geometrical transformation, geometrical terms and relationship, symmetry and geometrical construction, constructing angle bisectors and perpendicular bisectors, which can be linked to content emerging from literature.

2.12.4 Methodologies of continuous professional development

The Mathematics teachers' IKS pedagogical skills would be enhanced by incorporating indigenous methods which were indicated on as indicated in Figure 2 and these include the use of workshops, seminars and teachers group reflections. Their professional development would occur through questioning, analysing, modelling, examining, reflecting and consolidating. The use of workshops and seminars is of importance in enhancing the integration of ethnomathematics into the classroom because the methods allow for the sharing of knowledge through social interaction.

2.12.5 Zone of proximal development

The ZPD is a domain in which improved learning can take place. The Mathematics teacher, with the assistance of a MKO, is capable of achieving what he or she could not achieve alone. According to Figure 2, the acquisition of such of relevant IK contributes to the teacher's ZPD, necessary to integrate IK Mathematics concepts into the classroom without the need of support or assistance. The attainment of the ZPD is important as it helps Mathematics teachers to incorporate the desired competencies of both their communities and development. With time, teachers will be able to solve the problem without mediation as the ZPD is an area in which

Mathematics teachers should encourage collaboration with knowledgeable community members for guidance on curriculum implementation in local schools. When teachers do not have adequate knowledge on how the IK should be integrated, they would return to community to tap the knowledge and take it into the classroom.

2.12.6 Integration

Integration is the capacity of teachers to implement ethnomathematics effectively in the classroom. As indicated Figure 2, the integration of relevant ethnomathematics into the curriculum occurs if the task is successfully mediated into the ZPD of Mathematics teachers. In turn, teachers would integrate the relevant IKS Mathematics within their ZPD.

2.13 Chapter summary

This Chapter discussed the existence ethnomathematics, its integration into the curriculum, the adaptation and adoption of theories to make meaning of the study. The Chapter further discussed the types of geometrical mathematics embedded in basket weaving activities. Furthermore, it expounded on the types of geometrical shapes found in basket making and their application to the mathematical content at the junior secondary level. The literature review focused on the continuing professional development (CPD) required to identify the most effective ways for Mathematics teachers to learn and advance their understanding of the integration of IK in the mathematics curriculum. In order to better understand how this intervention improves teachers' knowledge of IKS integration in school curricula, as well as to

guide the design of the professional development for teachers, the theoretical and conceptual framework was discussed. The research methodology is discussed in the following Chapter.

CHAPTER THREE

RESEARCH METHODOLOGY AND DESIGN

3.1 Introduction

The previous Chapter (Chapter 2) presented and discussed the types of geometrical Mathematics embedded in basket weaving activities. Furthermore, it explicated on the types of geometrical shapes found in basket making and their application to the mathematical content at the junior secondary level. The literature focused on the continuing professional development (CPD) required to identify the most effective ways for Mathematics teachers to learn and advance their understanding of the integration of ethnomathematics in the curriculum. The Chapter answered the following research questions: What geometry is found in basket making of Aawambo ethnic group in Oshana Region? Which geometrical content at the junior secondary level is applicable to basket making practised by the Aawambo women? Chapter 3 address the following research question: 3. How can the Mathematics teachers integrate geometrical constructs embedded in basket making by Aawambo women into the teaching and learning process of Mathematics? This Chapter presents an outline of the research design, research participants, the research instruments and the data collection procedures. Issues of ethics are also discussed towards the end of the Chapter.

3.2 Philosophical perspectives

The term ‘philosophical perspectives’ denotes a set of overall theoretical assumptions about the nature of the world and how one comprehended it (Maxwell, 2018; Vidich & Lyman, 2015). Research philosophies are categorised into three dominant perspectives, namely, the *positivist*

(naturalism), *interpretive* (induction/emic) and *critical*. Presuming that social reality is shaped by human experiences and social contexts rather than being monolithic or objective, this study applied an interpretive paradigm (ontology). According to Bryman (2015), it is therefore best studied within its socio-historic context by balancing the diverse participants' subjective interpretations, or epistemology.

3.2.1 Ontology

The basic tenet of the social constructivist paradigm is that reality is socially constructed. The fact that reality is socially constructed implies that there are many ways of seeing the world and, through the course of study, perceptions may shift. I discovered that there is no objective reality that can be known; rather, there are multiple realities (Cooper and White, 2012; Creswell, 2020; Guba and Lincoln, 2018; Lapan, Quartaroli & Riemer, 2019). The social constructivist methodology disputes the existence of objective reality, instead insisting that realities are social constructions that take place in the mind and that several constructions exist in relation to different individuals (Denzin and Lincoln, 2018 p. 110.) Meanings and understandings are plural and individual people view and interpret reality through their own lenses (Creswell, 2020 p. 15).

Further, Creswell (2020) emphasises that “*humans engage with their world and make sense of it based on their historical and social perspective – we are all born into a world of meaning bestowed upon us by our culture*” (p. 9). Thus, I sought to understand the context or setting of the participants through visiting their village context and gathered information personally. I

also interpreted women's ways of creating knowledge to enhance my own experiences and educational context as a Mathematics teacher.

In elaboration, Matthews and Ross (2018 p. 28) offers the following explanation: Knowledge is seen to be derived from everyday concepts and meanings. As the social researcher I entered the social world in order to grasp the socially constructed meanings and then reconstructs them in social scientific language with regards to the type of mathematics embedded in basket weaving. Also, Tracy (2016 p. 3) emphasises that human activity is not regarded as a tangible material reality to be discovered and measured; rather, it is considered to be a "*text*" that can be read, interpreted, deconstructed and analysed. With this context, I aimed to gain a holistic understanding of concepts.

3.2.2 Epistemology

Social constructivists believe that knowledge is socially constructed in the research process and that the duty of the researcher is to understand this complex experience from the participants' point of view (Mertens, 2010p. 249). Meaning, I and the subject influence each other. Accordingly, I chose a more personal and interactive method of data collection namely, interview, observation, field notes to provide opportunities for basket weavers and junior mathematics teachers views to be heard. As qualitative researcher I focused on the specific contexts in which people live and work in order to understand the historical and cultural settings of the participants (Creswell, 2020p. 18). I therefore asked broad and general questions, which facilitated basket weavers and junior mathematics teachers to construct meaning out of

situations while we interacted. I listened carefully to the narrations of the basket weavers and junior Mathematics teachers in their natural settings.

Huber, Caine, Huber, and Steeves (2013 p. 217) observe that participants in human research are no longer treated as static, a-temporal and decontextualised. On a more fundamental level, I conducted my interviews leaning on the idea propounded by Packer (2011p. 42) that interviewers need to be flexible and responsive, treating the basket weavers and junior Mathematics teachers as fellow human beings who had some knowledge to share without realizing its value. As such, I showed sensitivity and reciprocity when interacting with junior mathematics when collecting data on the geometry embedded in basket weaving and how the relevant IK mathematics could be integrated into the curriculum.

3.2.3 Methodology

This research is a qualitative study guided by the Social Constructivist Paradigm, fundamentally assuming that human beings create knowledge through social interactions (Denzin and Lincoln, 2011p. 19). Individuals strive to understand the world in which they live and subjectively develop meaning out of their experiences. The meaning created varies greatly from person to person so that the researcher must unpack a complex multiplicity of views (Creswell, 2009: 8). I used open-ended questions in narrative interviews in this study to facilitate basket weavers and junior mathematics teachers' expression of their views. Creswell (2020 p. 116) asserts that: Ontological and epistemological views in the constructivism paradigm disallow the existence of an external objective reality independent of an individual from which knowledge was collected and gained, instead each individual construct knowledge

and his/ her experience through social interaction. Therefore, I gained a greater understanding of a phenomena through detailed description of basket weaving processes and the type of Mathematics embedded in basket weaving. In addition, I gained knowledge on how the relevant mathematics concepts could be integrated into the Mathematics curriculum. More importantly, I needed to understand the complex world of lived experiences from the point of view of those who live it (Cohen et al., 2018). In addition, the social constructivist paradigm, researchers are concerned with interpretation, illumination and meaning, through which they gain knowledge. I answered the research questions through the description and explanation of events and the collection of participants' beliefs, experiences and understandings. I generated a model by analysing the collected data. Since human beings create knowledge through social interactions, knowledge is continuously constructed and reconstructed, depending on different cultural contexts.

3.2.4 Axiology

Axiology has to do with the role of values in research (Creswell, 2020; Killam, 2013). Killam (2013) further highlighted that basic beliefs about what is ethical are embedded in the research paradigm and guides the researcher's decision making. In the current study, it was very important to consider human values of both basket weavers and teachers during the data collection process. This was ensured by minimizing risks or harms of the participants, by making sure that the data was collected in a socially just, respectful and peaceful manner.

3.3 Research design

This is a qualitative study using an ethnographic research design to understand the relationship between people and their cultural environment (Neuman, 2011). Following the use of interviews, observations and archival research (Creswell, 2020) it examined the school curriculum and consequently considered transformation of Mathematics teachers. I used an interpretivist paradigm to comprehend and create new meaning based on respondents' own perceptions of reality. This offered a framework in which to explore and comprehend people's ideas, meaning-making, experiences and perspectives (Bailey, 2019; Cohen et al., 2018). Key ideas generated by the interpretive philosophy together form the backdrop for interpretive methods (Denzin & Lincoln, 2018). I applied an interpretive philosophy to demonstrate how human create artefacts in forms of objects constituting what is meaningful to them during the basket making process. However, I am aware that the baskets can present different meanings to other people as knowledge is situated and contextual and might change over time, therefore, interpretation and understanding of this knowledge is subjective and influenced by lived experience.

Using content analysis, knowledge gained was compared to the content in the Namibian curriculum, with commonalities and variation of content established to prove the existence of Mathematics in basket making that could be linked to the national curriculum. Interviews were conducted with basket weavers, with observations and field notes taken concurrently. Recordings were taken during interviews and photographs taken, after which, a Focus Group Discussion was conducted with the Mathematics junior secondary teacher for validation of obtained data. Findings obtained from each phase of the research were infused into the

intervention programme aimed at equipping teachers with the necessary skills to integrate IKS in the school curriculum.

3.4 Research participants

I used a purposive sampling technique to select basket weavers and junior Mathematics teachers as participants, the rationale being that the number of Mathematics teachers is too great to include all (Richards & Morse 2013), so only relevant ones were purposively identified by the qualities they possessed, notably knowledge, skills, availability and ability to help in answering the research question (Merriam & Tisdale, 2016). Competencies of the basket weavers were measures on the merit that they must achieve to weave basket, which includes; preparing harvesting and weaving tools, sourcing and preparing raw materials, weaving basket and attaching accessories, inspecting and re-inspecting products and applying remedial actions if necessary.

I selected two basket weavers to provide me with information regarding how the palm fibres were collected from the forest, prepared and dyed prior to the basket weaving process (Mills & Birks, 2014). They were deemed appropriate as they were competent in designing complex patterns to portray the multiple decorations that were later used by teachers to identify the geometry found in basket weaving.

I selected junior Mathematics teachers based on the criterion that they had been teaching junior Mathematics for more than ten years. The basket weavers and junior Mathematics teachers were intentionally selected based on their characteristics, knowledge and experiences (Merriam

& Tisdale, 2016; Glesne, 2016). The four junior secondary Mathematics teachers were selected to help the researcher identify the geometrical concepts found in basket making, to assess the weavers' skills and methodologies and so establish how this IK could be integrated in the classroom. For purposes of anonymity, I used pseudonyms to conceal the identities of the participants for ethical reasons (Bryman, 2015). The Aawambo basket weavers were: Ms Ester and Ms Nangula. These participants were chosen on the basis of important practicalities, notably their willingness to participate, availability and the distance between their residences and the study site (Cresswell, 2020). In the second phase of data collection, the participants consisted of four junior secondary Mathematics teachers from the Ompundja Circuit in the Oshana Educational Region, Mr Matheus, Ms Elizabeth, Mr David and Mr Angula.

3.5 Research instruments

This section provides an outline of the research instruments used in this study namely: interview guide, observation checklist, focus group discussion guide and field notes tools. Multiple research instruments were used for triangulation, to enhance the validity, reliability, and richness of the research findings, as well as to provide a more comprehensive understanding of a research questions (Creswell, 2015).

3.5.1 Interview guide

I employed semi-structured interviews to collect data from the basket weavers on their background, skills, methodology and skills in knowledge acquisition and transferability. The interview guide ensured that the researcher collected similar types of data from all knowledge

holders (Bailey, 2018), a term used in the study in addition to craft workers, artists and designers (Erickson, 2018; Marshall & Rossman, 2020).

3.5.2 Observation checklist

I used the direct observation checklist in order to observe the traits and behaviours of the basket weavers, the presentation of artefacts, including the patterns, their sequence, the methodology used in basket weaving and the skills employed (Sangasubana, 2018). Direct observation is used to acquire information (Erlingsson & Brysiewicz, 2018; Marshall & Rossman, 2020). The observation checklist was used to answer the question on the geometry found in basket making of Aawambo ethnic group in Oshana Region.

3.5.3 Focus group discussion guide

A guide helped me prepare to run an effective Focus Group Discussion (FGD), including organisation, roles and responsibilities, as well as question that helped with the planning, monitoring and evaluating of the obtained data (Maxwell, 2018). Using FGD, I investigated the junior secondary Mathematics teachers' perceptions', questions, and suggestions on how to integrate geometrical constructs embedded in basket making into the teaching and learning process of Mathematics. Erickson (2018) claims that, a focus group interview is a qualitative data compilation technique that collects research findings through the rational questioning of respondents simultaneously in a formal or informal condition. I used a Focus Group Discussion to determine knowledge about IK possessed by teachers, sensitization about the value of basketry in the curriculum and use of local materials around them in the Mathematics classroom (Miles & Huberman, 2014).

In this study, one group of four junior Mathematics teachers met within a period for one day. The focus group interview discussion sessions took an average of 60 minutes and were audio recorded with prior permission of each participant in the group. Focus group discussion was designed to answer the following questions from junior Mathematics teachers: What geometry is found in basket making of Aawambo ethnic group in Oshana Region? Which geometrical content at the junior secondary level is applicable to basket making practised by the Aawambo women? How can the Mathematics teachers integrate geometrical constructs embedded in basket making by Aawambo women into the teaching and learning process of mathematics? I recorded the data using an audio recorder. According to Merriam (2009) and Check and Schutt (2012), data recording is a process that involves the recording of information using a ‘machine’ during the process of the interviews. I always verified that my audio-machine was recording at the same time encouraging the participants to speak audibly so that all that they said was recorded.

3.5.4 Field notes tool

I used field notes to capture the key conversations and discussion that I could have missed through other instruments. For instance, a ‘critical moment’ is defined as an event which is large or small, intended or unintended, and may have a positive or negative effect on a person’s sense of self (Mills & Birks, 2014). In this study, moments of having conversations while the women continuously weaved shapes on interest to them without losing focus were interesting. An advantage of taking copious notes is that they contribute to data expansion (Onwuegbuzie & Leech, 2018; Sangasubana, 2018), help in understanding perspectives and interpretation of types of Mathematics found in basket weaving, and learning how relevant geometrical concept

could be integrated into the classroom. I used field notes to capture teachers' responses with regards to the geometry found in basket making of Aawambo ethnic group in Oshana Region.

3.6 Data collection process

I collected data sets sequentially, seen by Creswell (2012, p.122) as necessary for conceptualizing in three stages. In the first, I conducted a document analysis, using the outcome to influence stage two, namely, observation and interviews. In stage three, I developed an intervention programme, including workshops, to equip teachers with the necessary skills to be able to integrate IKS. In addition, I captured teachers' reflections.

I conducted a literature review systematically to:

- 1) identify and gain an understanding of the theory and to establish the context. I employed Vygotsky's Socio-Cultural Theory to develop a model that can be used as an alternative to the tradition way of teaching. This model could be used to enhance teaching in schools located in disadvantaged localities.
- 2) identify and gain familiarity of common content found in literature versus the Namibian curriculum. The involvement of knowledge holders eased the process of identification of relevant topics in the curriculum and appreciation of African culture as used to enhance teaching of geometry in Namibia and internationally.

The document analysis aimed at achieving research questions 1 and 2, then I conducted an interview with knowledge holders concurrently with observations. Between these tasks I took notes and photographs. To validate the outcomes at every stage of the data collection I

conducted the FGD with teachers prior to the analysis. Before the research commenced, I visited the sampled schools to familiarise myself with the school and explain the purpose of the study, making necessary arrangements for administration of the instruments and data collection. I described the familiarizing process using an impressionist narrative to give flavour without compromising the conduct of the basket weavers or the school, nor the deontological rules by which I was to abide (Morse, 2018).

After a thorough research on the local customs and traditions, I turned my attention to the basket weaving areas. Not knowing anyone in particular I had the opportunity to familiarise myself with the local culture as an ‘outsider,’ with the advantage of not disregarding or ignoring factors that a local or regular visitor might overlook (Mills & Birks, 2014). These short fieldwork descriptions of sampling procedures reminded me how I regarded the basket weavers daily, coming to the basket weaving work sessions. They were relaxed around me, speaking softly in my ear, gossiping or simply laughing together. The social interaction with the women brought mutual trust to the participants to the extent that they felt free to share with me how basket weaving activities were being carried out (Richards & Morse, 2013).

At the commencement of document analysis, I searched articles from *Google Scholar*, articles published by Namibians on IKS content, and books from libraries to identify the geometry found in basket making in Namibia and beyond. The JSC Mathematics syllabus was reviewed to obtain a common area (intersection) and variation of content found in both literature and the syllabus (See Figure 4).

I began interviewing the basket weavers by asking questions that had been formulated and articulated in the interview guide (see Appendix J). Whilst busy with interviews, observations also took place concurrently. An observation checklist (see Appendix G) was used as a guide to provide a broad social and cultural context of procedures involved in basket making. In the meantime, I took notes of what the women were saying and recorded them to avoid missing important information (Creswell, 2020).

To offer a detailed description of how the baskets weaving product reflected geometrical concepts I took photographs of the artefacts (Shenton, 2004). I captured photographs because they allowed me to examine data closely and reduce my reliance on previous interpretations by allowing for a thorough analysis and comprehensiveness of datasets (Eriksson, 2018) (see Appendix F).

To corroborate research findings obtained from interviews and observations I conducted the FGD with four junior secondary Mathematics teachers (see Appendix D), following the basic components (Snow, Morrill & Anderson, 2017) of explaining procedures, interaction and content. I asked the teachers for permission to record their voices, and as Babchuk, Guetterman and Garrett (2017) recommend, outlined the procedures of the FGD. I presented the concept of IKS to teachers for purposes of familiarization and immersion (*verstehen*), then gathered more data by inducing themes which I later coded. I elaborated on the data from field notes and observations, reflecting on my role as a researcher and creating interpretations (Babchuk & Badiee, 2011). Teachers discussed the concept of ethnomathematics and design of lesson plans (praxis) that could be used as a tool for teaching Mathematics. They were then asked to reflect

and express their opinions on IKs integration in the Mathematics classroom. The research design is depicted in *Figure 3*.

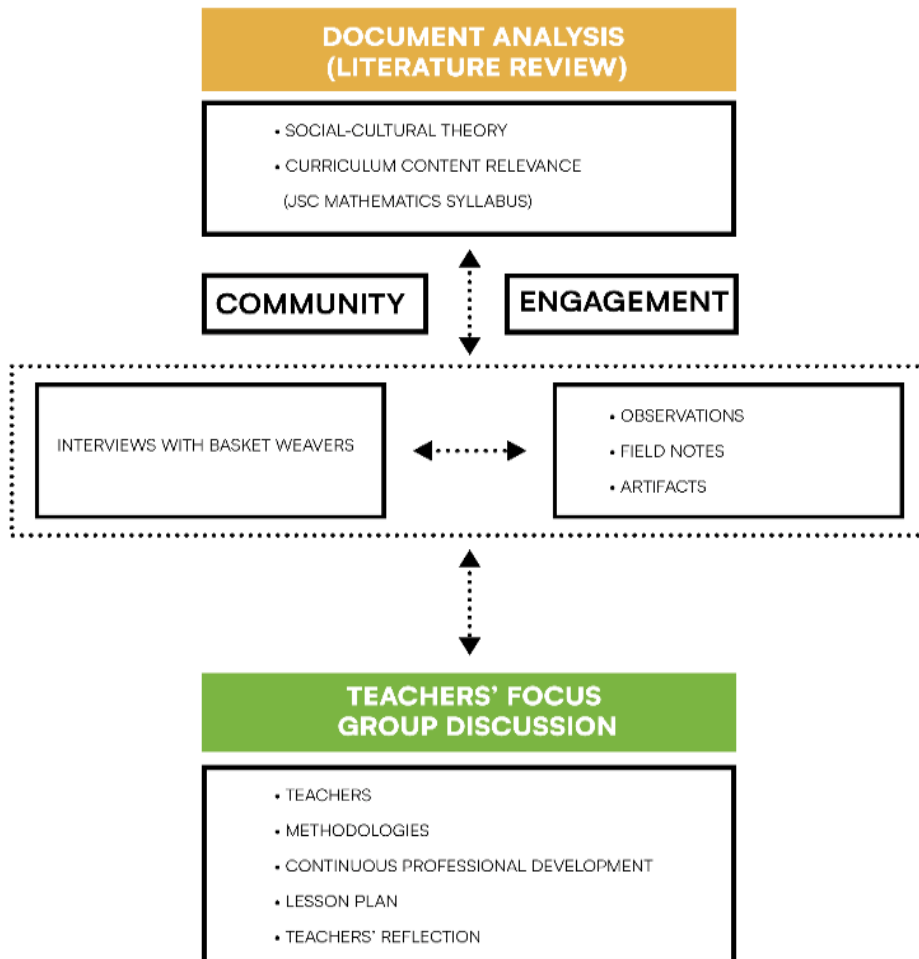


Figure 3: The data collection process for this study

3.7 Data analysis

I employed an interpretive paradigm to source basket weavers' experiences and to ascertain the cultural values linked to ethnomathematics and its relevance to the Namibian Mathematics curriculum. In addition to the outcomes of the systematic review explained in Section 3.6, content analysis was used to compare concepts that existed elsewhere versus the Namibian curriculum.

The common concepts were identified and grouped to establish robust evidence and practices of ethnomathematics in the Namibian curriculum. I analysed the individual data set from knowledge holders to understand their interpretation of the world around them. I generated themes and codes collectively using an axial mode to make sense of their world and establish common practices between them for purposes of validation and consequently share the knowledge with the Mathematics teachers. Data obtained from interviews, observations, field notes and artefacts were analysed inductively. I scanned the data to generate categories and establish relationships between concepts to determine commonalities and variations in opinions of knowledge holders, artefacts and observations. The results from the various methods were crystalized into themes and codes that were used during the focus group discussion. Furthermore, I used the thematic approach during the FGD to build general patterns from the data. I generated new codes as a result of unanticipated moments and added these to the existing codes to bring out new indicators where possible. The validation process was therefore concluded by demonstrating social construction and constructivist criteria including praxis, *verstehen*, trustworthiness and triangulation amongst other ethical criteria (Bryman, 2015).

3.8 Situating myself in the text

I employed an ethnographic research approach because it allowed me to situate myself in the text that formed the research report. In this ethnographic study I employed realist writing where necessary, an impressionist writing method that involves offering narratives of those who have participated in the field (Creswell & Poth, 2019). Here, the overall story of the research report makes visible both the culture being studied and the researcher's way of knowing it as related to the Mathematics curriculum. Due to the intensive engagement of the researcher in this study I used the first-person form when writing the research report (Snow, Morrill & Anderson, 2017). According to Sangasubana (2018), ethnographic writing is best described as evocative, descriptive and lively. Ethnography enforces academic writing but also requires creativity in rendering scenes, sights, smells, feelings, experiences and people in as lifelike form possible (Denzin & Lincoln, 2018), helping to evoke what it was like to be in the field (Erlingsson & Brysiewicz, 2018).

3.9 Trustworthiness of this qualitative research

To enhance the trustworthiness of the findings I engaged in prolonged engagement with the basket weavers and junior secondary Mathematics teachers by interviewing each teacher for 30 minutes over three weeks. This allowed me time to probe for clarification (Creswell, 2012). I triangulated the semi-structured interviews, observations and FGDs which were used to identify the geometry embedded in basket weaving and how they could be integrated into the classroom. Authenticating the contents (content validity) of data collection instruments was a prerequisite, therefore, I needed to check whether every research question would answer the

specified research problem under inquiry (Creswell & Guetterman, 2019). Further, I enhanced the credibility of the study by engaging in thick explanations and descriptions of findings obtained from the participants so as to enhance the credibility of research results (Marshall & Rossman, 2020). In-depth explanations and descriptions are vital in upholding credibility as they assist in expressing the actual conditions that are being scrutinised and the context that surrounds them (Creswell, 2020). I also conducted member checking. Member checking enhanced the trustworthiness and credibility of the research findings, it being the most important provision to reinforce a study's credibility (Lincoln et al., 2018). Checks relating to the accuracy of the data may take place at the time and at the end of the data collection process. I ensured member checking for all transcripts of participants' dialogues.

Additionally, to develop my theories and conclusions evolved during the dialogues, I verified their genuineness by asking respondents to provide explanations for specific patterns I noticed. According to Denzin and Lincoln (2018), "analysis and verification is something one brings forth with them from the field, not something which can be attended to later after the data are collected," they acknowledge the significance of fostering such a formative understanding (p.8). Shenton (2004) pointed out that the researcher cannot just gather data without considering what each piece represents when interpreting field data. I engaged in a detailed audit trail of the entire study for verification of the different stages (Denzin & Lincoln, 2018). The supervisor played a critical role in ensuring that all four elements of trustworthiness (credibility, conformability, transferability and dependability) were maintained throughout by reviewing the instruments.

3.10 Ethical Considerations

Ethical Clearance Certificate (Appendix A) was obtained from the University of Namibia Research Ethics Committee (UREC) prior to the start the gathering of data (Bryman, 2015). I sought approval to carry out the research from the Oshana Region's Directorate of Education, Arts and Culture (Appendix B). Once in the schools, permission was also sought from the respective school principals before talking to teachers. Before conducting the interviews, observation and FGD I received completed informed consent forms from the basket makers (Appendix I) and mathematics teachers (Appendix H).

Written and oral permission was sought from the two Aawambo basket weavers and briefed them in detail about the purpose of the study, the timeframe, interviews and home visits. They were reminded of their right to withdraw from the study at any given point and advised that, if they did so, all the information previously gathered would be destroyed. Some could not participate because of their daily responsibilities which would not allow them to commit to the study. I adhered to all the ethical requirements of the ethics committee. Additionally, to ensure confidentiality and anonymity, the results and the reporting of the findings of the study did not reveal the names of the teachers involved in the study (Creswell & Poth, 2019). I used pseudonyms to report the findings. In addition, participants were informed verbally and in writing about voluntary participation and freedom to withdraw from the study at any time they wished, without penalty (Creswell, 2012).

I promised to share the findings of the study with the basket weavers, Oshana Regional Office and the teachers upon completion of the study. Soft copies of raw data are kept safe in a password-protected computer and the hard copies in a safe. After five years the soft copy was

to be, and shall be, permanently deleted and the hard copies burned (Marshall & Rossman, 2020).

3.11 Chapter summary

In this chapter, I described the methods used to collect and analyse data. The study employed qualitative research using an ethnographic approach. A total of six participants, namely, two basket weavers and four mathematics teachers, were purposively selected. Data was collected using interviews and observations of basket makers, photographing artefacts and a Focus Group Discussion with the Mathematics teachers. To determine the ethnomathematics embedded into basket making, the conversations were audio recorded, transcribed, and then examined. The JSC syllabus's content can be connected to the geometry involved in creating baskets, which supports integration techniques IK. The results and explanations of the study are presented in the upcoming chapter.

CHAPTER FOUR

DATA PRESENTATION

4.1 Introduction

This Chapter focuses on the presentation of research results which I collected from basket weavers and junior secondary Mathematics teachers in the Oshana Region. I analysed the data using qualitative methods involving the identification, coding and categorizing of the primary patterns in the qualitative data (Marshall & Rossman, 2020). After transcription, I performed an inductive data-driven analysis to find the geometry used in basket making and the relevant content to integrate in the Mathematics curriculum at junior secondary level. The Chapter further presents the findings on themes drawn from literature and data emerging from interviews, observations and FGD presented in Chapter 3. The themes are; knowledge possessed by women, content relevant to the junior secondary mathematics curriculum, mathematical content applicable to basket making, teachers' perspectives on IKs implementation and Continuous Professional Development (CPD) and its relevance.

4.2 Demographics of the participants

The study comprised two groups of participants, namely, two female Aawambo basket weavers and four junior secondary Mathematic teachers. Characteristics of the basket weavers and mathematics teachers are presented in that order as follow:

Characteristics of basket weavers

Ms Ester

A 65-year-old female, Ms Ester spoke Oshindonga, one of numerous languages of the Oshiwambo ethnic group. In terms of academics, Ms Ester barely met Standard 5 (Grade 7) and her ability to speak English fluently was an unexpected revelation and during her presentation she did not require a translator. Since she was 15 years old she had been creating baskets, beginning to learn the profession at the young age of eight. She had not taken any professional weaving or dyeing classes but rather had picked up the skills by watching the more experienced women in her community as they wove baskets. In addition to receiving her pension she also made a living by selling handmade baskets.

Ms Nangula

A 60-year-old female, Ms Nangula indicated that she had begun weaving basket at the age of ten and become competent at the age of 14. She was also an Oshindonga speaker and had attained Standard 4 (Grade 6). Both Ms Nangula and Ms Ester had acquired basket weaving skills at a young age and by observing adults. Basket weaving knowledge and skills in decoration of artefacts occurs only after a number of years, after which they are able to create decorative patterns that are challenging to design and require the expertise obtained by years of experience.

Characteristics of junior secondary Mathematics teachers

The second group of participants consisted of four junior secondary Mathematics teachers. Using pseudonyms, Mr Matheus, aged 42, held an honours degree in Mathematics and had 14 years of working experience teaching junior secondary Mathematics. Ms Elizabeth was aged 45 and held an honours degree in Mathematics with 16 years of working experience as junior secondary Mathematics teacher. Mr David, aged 40, held an honours degree in Mathematics with 11 years of teaching junior secondary Mathematics. Mr Angula, 47, held an honours degree in Mathematics with 16 years of teaching junior secondary Mathematics. All four junior Mathematics teachers were from the Aawambo ethnic group.

4.3 Themes and sub themes emerging from the data

This section presents the themes and subthemes that emerged from the data. The themes and related sub-themes are presented in Table 1 to show outcomes of the social interaction construct, namely: Community and Zone of Proximal Development (see *Figure 1*).

Table 1: Themes and sub-themes emerging from the data

THEMES	SUB-THEMES
4.3 Knowledge possessed by women in basket weaving	<ul style="list-style-type: none">❖ Collection and preparation of palm leaf fronds.❖ Preparation of dyes and the dyeing process of the palm leaf strips.❖ Skills on the basket weaving process.
4.4 Types of Mathematics found in basket weaving 4.4.1.1 Geometrical shapes	<ul style="list-style-type: none">❖ Circle❖ Square❖ Rectangle❖ Triangle

THEMES	SUB-THEMES
4.4.1.2 Geometrical Symmetry	<ul style="list-style-type: none"> ❖ Axial symmetry ❖ Rotational symmetry
Geometrical similarities and congruence	<ul style="list-style-type: none"> ❖ Points ❖ Round angles ❖ Straight angles ❖ Right angles
4.4.1.4 Geometrical transformation	<ul style="list-style-type: none"> ❖ Rotational transformation ❖ Reflection transformation ❖ Enlargement transformation ❖ Translation transformation
4.4.1.5 Geometrical Construction	<ul style="list-style-type: none"> ❖ Constructing angle bisector ❖ Perpendicular bisector

i. **Collection and preparation of palm leaf fronds**

The women explained how they sustainably harvested and collected palm leaves fronds from the forest. The collection was in groups to promote social interaction and for division of labour.

- ii. Long knives were used to harvest the leaves and small sized knives to separate the midrib. The women explained the collection and preparation as follows:

“We use long knives to cut young palm leaves” (Ms Nangula, 2021).

“An axe or hoe can also be used for cutting palm leaves” (Ms Ester, 2021).

I observed how Ms Ester and Ms Nangula were carefully cutting fresh tender (green) palm leaf fronds, tying them in bunches and carrying them home. I took note of the way they harvested the leaves as they did not destroy the whole stem but rather left some leaves for next time.

- **Preparation of dyes and the dyeing process of the palm leaf strips**

The dyeing process provided an opportunity to look at the reactants and how they were affected, at the end of the dyeing process (products). The dyeing process is of importance because it provided the junior secondary Mathematics teachers with an opportunity to use and visualize decorative patterns and see how they depicted various types of geometrical concept.

The women explained that fronds are first split into strips before being dried and dyed. The dried leaves were stored in places that did not come into contact with water then washed with plain water and the excess water rinsed. The midrib was removed with the help of a knife and the leaf cut into strips of required size. These strips were then taken for the dyeing process.

The basket weavers explained that palm leaves are dyed in vegetable-based dyes from flower petals and roots, using age-old recipe. The most common dark brown dye is obtained by boiling the finely crushed bark of “*omuve*” (*Berchemia discolor*) together with the palm leaves.

The dye gives an attractive look and shows patterns when woven into baskets. The following statements explain this process:

- **Collection of dying materials**

“*Dye materials are collected from a wide variety of local indigenous plants...*” (Ms Ester, 2021).

“*A bark of the omuve tree (Pterocarpus angolensis) and roots of omudhime bush (Euclea divinorum) are harvested for dying purposes*”. Contrary to the normal practice, sometimes commercial ink is used as expressed by (Ms Nangula, 2021).

“*Commercial ink is used for dying*” (Ms Ester, 2021).

I observed how the basket weavers removed the midrib of the leaf using a sharp knife and thereafter cut the leaf into strips of required size. They simply estimated the required size with their eyes. I took note of the extraction of the bark of “omuve” (*Berchemia discolor*) as it was astonishing and very impressive. This process was carefully done to avoid harming the tree. After the collection of dyes, I observed how the women dyed and crushed the roots and bark of the *omuve* tree and roots of *omudhime* bush respectively. The powders obtained from crushing were then used as a dye. The basket weavers described the dying process as follows:

- **The dying process**

“*Water needs to boil first, add a dye, once the desired colour is visible, palm strips are then added to the vat for the dye to settle on the strips*” (Ms Nangula, 2021).

“*Commercial ink is diluted in water*” (Ms Ester, 2021).

With a slight start of boiling water, the dye is added, once the colour of the water turns

to respective colour the palm strips are added to the vat and left for the dye to settle on the strips. After few minutes the strips are removed and kept for cooling.

I observed and took note of how the women drained the leaves and laid them out on a flat surface to dry. They used a flat sheet to weigh the leaves down and help retain their shape. After the leaves had dried out the women removed the leaves and stored them in a cool, dry place in the storeroom. The women explained the drying process as follows:

- **Drying of dyed palm strips**

“The strips need to be dried before they are stored” (Ms Nangula, 2021).

“Avoid exposing the leaves to direct sunlight or heat for extended periods of time” (Ms Ester, 2021).

The results indicated that both Ms Ester and Ms Nangula had some commonalities in terms of dyeing as they used *omuve* (*Berchemia discolor*) dark for brown and crushed bark of *omuve*, boiled together with the palm leaves.

Even though there were commonalities between their mode of dyeing there was also some discrepancies in term of the way they prepared and dyed the palm strip. Ms Nangula acquired the black dye agent from roots of the *omudhime* bush (*Euclea divinorum*), and purple dye from its fruit, with red dyeing agent obtained from boiling the barks of the *omuve* tree (*Pterocarpus angolensis*). However, Ms Ester’s dyeing mode differed from that of Ms Nangula as it used vegetable-based dyes from flower

petals and roots. They used different dyeing agents because they wished to make their baskets unique in terms of colours that reflected their indigenous knowledge of base weaving and portrayed different decorations.

(iii) Skills to weave baskets

With hot sunny weather I was sitting in the shade with Ms Ester and Ms Nangula to acquire information and understand how weaving was carried out using the palm fibre. Before weaving the basket, water was sprinkled on the strips to keep them moist and avoid breakages while weaving. At the commencement of the weaving process, based on the required size of the basket, the palm stripes were arranged vertically and horizontally interlocking to make a knot at the centre of the basket. Weaving continued in a curved form around the small square or circle which was woven at the centre of the basket, making use of a small bundle of thin palm fibres (*oongoyo*). As the palm approached the end, and a certain length of thin fibre was left, new leaf rods were squeezed in the row to keep the consistency in size of the article made. The coiling technique was used to manufacture a flat basket. Strips were wrapped in and around to create an effect that formed the interior of the coils and excess strips folded and interlocked inside the basket in a manner that the ends were not visible. During weaving a container of water was needed to soak the dyed palm leaf strips. The water in turn was used to moisten the weaving grass and so increase flexibility of the palm fibre. An awl was used to sew the coils together. The following describe the procedures:

- **Weaving technique**

“I tied the knot in order to secure the position where other strips will be attached”

(Ms Ester, 2021).

“I start the basket weaving process with three fibres, and add more new palm fibres when the fibre is nearly to be finished” (Ms Nangula, 2021).

“I wrapped strips in and around to create an effect that forms the interior of the coils using an awl...” (Ms Nangula, 2021).

During the demonstration of weaving techniques, different patterns emerged on the artefacts. The women explained the designing of patterns as follows:

- **Shape and Patterns**

“The designing and the spaces which are left in between the patterns are estimated using naked eyes” (Ms Ester, 2021).

“The odd-numbered decorative patterns on baskets more attractive and need extra competences to maintain the consistency and sameness of the decoration designs” (Ms Nangula, 2021).

“Weaving strands of fibre over and under each other creates a round shape” (Ms Ester, 2021).

I observed how the basket weavers carefully wove strands of fibre over and under each other to create a round shape. A simple coil basket starts out as a thick piece of fibre that is shaped into a basic coil while a thinner, flexible fibre is woven around it. I noted the way the shapes were formed as the weaving process continues. Furthermore, I observed how the women formed different patterns using the dyed strips. Keeping the

rows consistent and creating different shapes around baskets made me want to observe more.

From the data from Ms Ester and Ms Nangula it can be deduced that both basket weavers used a similar weaving approach of decorative patterns when weaving the basket, notably size, plain striped patterns, strip of line, decorated line and patterns that intersected at a point, and decorative patterns that reflected multiple shapes, shrinking and the enlargement of patterns. It was observed that they demonstrated skills and knowledge of basket weaving throughout the process, from collection and preparation of palm leaves through the dying to the end product. Through the creativity displayed it was evident that they were well acquainted with making decorative patterns, shapes, strip lengths, giving the appearance of the basket a consistency in maintaining the rows' sizes and thicknesses.

4.4 Geometry relevant to the Junior Secondary Mathematics Curriculum

This section presents a twofold result emerging from a combination of four methods of data collection: document analysis and interviews complimented by observations and field notes. Results are presented to highlight the geometry found in basket weaving, for instance, geometrical shapes, geometrical symmetry, geometrical terms and relationship and geometrical construction.

4.4.1 Types of geometry found in basket weaving

The results emerging from document analysis and interviews, observations and field notes and teachers' FGD on geometry found in basket weaving were presented under the following sub-themes: geometrical terms and relationship, symmetry, geometrical construction, geometrical shapes. The results show that the following geometrical concepts are relevant to the junior mathematics curriculum in Namibia.

4.4.1.1 Geometrical shapes

The geometrical shapes were presented under the following sub-themes:

- Circle
- square
- rectangle
- triangle
- kite

- **Circle**

Results from this study indicate that the basket weaving activities reflect the mathematical concepts of circular geometrical shapes. I observed the weavers as they carefully wove strands of fibre over and under each other to create a round shape. Mr David and Mr Matheus confirmed the circular shape by stating the methods they used to identify it:

“The basket weaving products depicts the mathematical concepts of circle geometrical shapes” (David, 2021).

“I used the circular tray of woven basket methodology to identify that the shape is a circle” (Matheus, 2021).

The circle shape found in basket making products is evidently observable from the photographs (See Appendix F: inserts 2g).

- **Square**

Results from this study indicated that centre of the woven basket reflects square shapes, as those found in the baskets by the Aawambo women are evidently observable from the photographs (See Appendix E: inserts 2e). In Ms Elizabeth and Mr Angula said:

“I looked at the four corresponding straight line of the same size or length on the basket, it reflects a square shape” (Elizabeth, 2021).

“I used the plain weaving technique and decorated patterns as an approach to identify a square” (Angula, 2021).

- **Triangle**

Results from junior Mathematics teachers reflected the mathematical concept of the triangular shape, as visible on the artefacts produced by the weavers. Ms Elizabeth and Mr Angula depicted the three lines on the baskets that meet to form the triangles:

“I used the plane structure decorative pattern to depict the mathematics concepts of triangle shape” (Elizabeth, 2021).

“The basket weaving activities reflect triangle mathematical shapes and I used the corresponding point of the three lines with vertices point used to identify a triangle shape on woven baskets” (Angula, 2021).

In support, result from observation and field notes revealed that the decorative pattern depicts triangular geometrical shapes and was evident in the photographs (see Appendix F: inserts 2f).

- **Rectangle**

The results of the study reveal that rectangles are one of the geometrical shapes found in woven baskets. Mr Matheus and Mr David explained that:

“The basket weaving activities portrays a rectangle shape which is found at the centre of the basket and from the decorated patterns” (Matheus, 2021).

“In order to ascertain that this is a rectangle, I employed the intersection of long horizontal straight lines and short vertical lines were used to identify the rectangle shape” (David, 2021).

The results from observation and field notes validated that rectangle geometrical shapes concepts, manifestly noticeable in the photographs (see Appendix F: inserts 2d).

- **Kite**

A kite was highlighted as one of the geometrical shapes found in the woven basket. Mr David and Mr Angula explained the methodology:

“The basket weaving products depicts the kite shapes and the decoration’s patterns of the basket to identify the sides of shape that has two pairs of equal length sides and the sides that are adjacent to each other” (David, 2021).

“I also used the intersection of oblique line which is formed as a result of decoration meeting at vertices point to reflect the mathematical concepts of kite shape” (Angula, 2021).

The data set from observation and field notes revealed that the kite shape found in basket making is visible in the photographs (see Appendix F: inserts 2a; 2b and 2c).

4.4.1.2 Geometrical Symmetry

This section presents results emerging from document analysis and interviews, observations, field notes and teachers’ FGD. The geometrical symmetry was presented under the following sub-themes:

- **Axial symmetry**

Results indicate that basket weaving activities depict the mathematical concepts of symmetry which comprises axial symmetry. Mr Matheus confirmed this:

“I used the crossing of line that runs from the centre of the basket to the circumference of woven basket to identify axial symmetry on the woven basket products” (Matheus, 2021).

To validate the results, the axial symmetry was observed as in the pictures (See Appendix F: insert 1f).

- **Rotational symmetry**

Results indicated that the basket weaving activities reflects the mathematical concept of rotational symmetry. Ms Elizabeth remarked that:

“I used the rotation of an object until the decorated patterns goes back to its original position to identify the mathematical concepts of rotational symmetry” (Elizabeth, 2021).

To authenticate the findings, a data set from observation alluded to rotational symmetry as evidenced in the picture (See Appendix F: insert 1a -1e).

In conclusion, the findings highlighted that the use of the crossing of a line that runs from the centre of the basket to the circumference was used to identify axial symmetry on the products. In addition, the circulation of a woven basket returns to its original position to depict the mathematical concepts of rotational symmetry.

4.4.1.3 Geometrical terms and relationship

This section presents, interprets and discusses data on geometrical terms and relationships found in basket weaving activities. The geometrical terms and relationships are presented under sub-themes

- **Lines**

Results indicated that the basket weaving activities reflected linear geometrical terms.

Mr David identified those on baskets:

“I employed the weaving morphology of the decorated patterns of lines, the runs straight across the woven basket, the geometrical concepts of line” (David, 2021).

The mathematics concepts found in basket making products of the Aawambo women

is evident in the photographs (See Appendix F: insert 5e).

- **Parallel lines**

Parallel and intersecting lines

The strips found at the rim of the basket depicted the geometrical terms of parallel (Figure 9). Thus, for example, decoration made up of line AB is parallel to the decorations of line EF. The transversal decorations of line CD intersect and meet lines AB and EF. As a result, angles labelled *a* and *b* are equal as they are alternate angles.

Explicitly the weavers stated:

“I used the straight line that goes in same direction to identify parallel and lines that lie in the same plane and never meet” (Mr. Matheus, 2021).

In addition,

“I also used the plaited straight line formed by weaving fibre met a point to form the mathematical concepts of intersection” (Ms. Elizabeth, 2021).

“I also used the two decorated lines that cross each other to identify an intersecting line” (Ms. Elizabeth, 2021).

The decorations (Appendix F: insert 5a) shows parallel lines on the woven basket that cut across a decorative pattern to produce two angles of the same size, labelled *a*, and *b*.

4.4.1.4 Geometrical similarities and congruence

Appendix F: insert 5c indicates mathematical concepts of geometrical similarities and congruence. Thus, Shape JKLMN is similar to PQRST. The decorations labelled A and B on the basket shows geometrical properties of congruent shapes; with B being congruent to C, and A congruent to D. Based on the interview, Mr David states that:

“I used the decoration pattern, strip pattern on the basket weaving products which are of the same size and shape to identify congruence and same shape and different sizes to identify similarities of decoration structures on woven basket”

- **Points**

Data sets obtained from Ms Elizabeth and Mr Angula indicated that a point is one geometrical concept found in woven baskets:

“I used a dot found on the basket woven product that does not have length, width or height” (Elizabeth, 2021).

“I used a decorated small dot on the basket that has no dimension” (Angula, 2021).

The findings were confirmed by the data set from observation and field notes which indicated that the point concepts were evident in the photographs (see Appendix F: insert 5d).

- **Round angles**

The basket weaving activities reflect the geometrical terms of angle:

“An angle on woven basket is portrayed by the turn or bend between two intersecting

lines that have a common endpoint called the vertex of the angle” (Matheus, 2021).

“In simpler, an angle is formed as a vertex with two arms” (Matheus, 2021).

“A round structure of a decorated pattern or basket artefacts shows a complete revolution which adds up to three hundred and sixty degrees” (David, 2021).

Regarding data from observation, the angle geometrical concepts are evident in the photographs (see Appendix F: insert 5f).

- **Straight angles**

Data reveals that the basket weaving activities mirrors straight angles:

“The basket weaving products reflects the straight geometrical angles. I used the morphology or structure of strip of line to identify the straight angle on basket woven products” (David, 2021).

Thus, one of the straight-line angles formed on a woven basket is marked X on (Appendix F: 5g).

- **Right angles**

Right angles were also identified as one of the geometrical terms found in woven baskets:

“I used the horizontal and vertical lines that cross each other or horizontal and vertical lines that intersect forms right angles” (Elizabeth, 2021).

Regarding results from observation, the angle geometrical concepts are evident in the photographs marked Y (see Appendix F: insert 5b).

In summary, it can be deduced that the weaving morphology of the decorated patterns of lines that run straight across the woven baskets has geometrical concepts of line. Additionally, two straight lines that go in the same direction are used to identify parallel lines. Further, decorative patterns of the same size and shape depict similarities and congruence. The dot found on the woven product depicts a point and the use of the morphology or structure of a strip of line should be used to identify the straight angle. The use of horizontal and vertical lines that cross each other or horizontal and vertical lines that intersect form right angles.

4.4.1.5 Geometrical transformation

This section presents results on geometrical transformations presented under sub-themes:

- **Rotational transformations**

Results indicated that the basket weaving activities of the Aawambo people depict the mathematical concepts of rotational transformations:

“The decorative pattern methodology was used to identify rotational transformation in basket weaving” (Matheus, 2021).

“I used the circulation of decorated pattern around a fixed point and turning a figure about a point” (Matheus, 2021).

The rotational transformation mathematical concepts are evident in the photographs (see Appendix F: insert 3b).

- **Reflection transformation**

Ms Elizabeth mentioned that: *Basket weaving depicts reflection transformation.*

She explained that:

“As a mathematics teacher I used my subject knowledge to find reflection transformation through the decorative patterns which are found on the opposite position of the first decoration and upside of the same size” (Elizabeth, 2021).

Reflection transformation formed by drawing a line of symmetry through point A and C or B and D on the woven basket (see Appendix F: insert 3a).

- **Enlargement geometrical transformation.**

Enlargement transformation was also identified as one of the geometrical concepts found in woven baskets. Mr David explains that:

“When identifying enlargement transformation, I looked at the increase in size or dilation of decorated patterns” (David, 2021).

Enlargement geometrical transformation of decorations labelled A in relation to B on the woven basket (see Appendix F: insert 3c).

- **Translation geometrical transformation**

In reinforcing that basket weaving activities depict transformation, Mr Angula stated that the basket weaving activities show geometric transformation of translation:

“I used the sliding that the decorated patterns exhibit to give distance in a given direction” (Angula, 2021).

The translation transformation concept is depicted in artefacts from the photograph (See Appendix F: insert 3e).

- **Shear transformation**

In supporting that basket weaving activities reflect shear geometrical transformation, Mr Matheus said that:

“The shrinking or stretching the figure of shape from the decorated pattern results in the formation of shear transformation” (Matheus, 2021).

Result from observation indicated that translation transformation is depicted in artefacts in the photographs (see Appendix F: insert 3d).

In summary, the circulation of the woven basket shows the rotational reflection. Decorative patterns of similar size which are opposite to each other depict reflection transformation. Evidently, the sliding decorated patterns exhibit translation and the increase in size of decorative patterns depicts enlargement transformation. The stretching shows a shear transformation.

4.4.1.6 Geometrical Construction

This section presents, data on geometrical construction presented as sub-themes.

- **Constructing angle bisector**

Data from this study revealed concepts of angle of bisector:

“In order to determine that there is angle of bisector on a woven basket I used the parallel lines on the woven basket that cut across a certain decoration pattern to

produce two angles of the same size” (David, 2021).

Consequently, (Appendix F: insert 4b) for example shows how angle ABC is bisected by line BD.

- **Perpendicular bisectors**

Results indicated that the basket weavers’ activities reflect the mathematical concepts of perpendicular bisectors. After probing for more explanation on how these can be identified on woven basket products, Ms Elizabeth replied:

“The straight line that the oblique lines meet at a vertex point results in the formation of perpendicular bisector” (Elizabeth, 2021).

Additionally, the straight lines meeting the oblique lines at a vertex point result in the formation of a perpendicular bisector. Further, the illustration on Appendix E: insert 4a of line AB (formed by the coils and decorations) is bisected by the straight line that the oblique lines meet at a vertex point, X.

In summary, the results showed that the use of parallel line on the woven basket cut across a certain decorative pattern to produce two angles of the same size. Additionally, the straight lines meeting the oblique lines at a vertex point result in the formation of a perpendicular bisector.

4.5 Geometry applicable to basket making

This section presents the results aimed at answering Research question 2: *Which geometry at the junior secondary level is applicable to basket making practised by the Aawambo?* The outcomes of the systematic review explained in Section 3.6 were used to construct a Venn diagram to compare concepts that existed in places elsewhere against the Namibian curriculum.

The common concepts were identified and grouped to establish robust evidence and practices of IK's existence in the Namibian curriculum. The section of this study also justified why ethnomathematics relevant to the curriculum should be integrated into the classrooms.

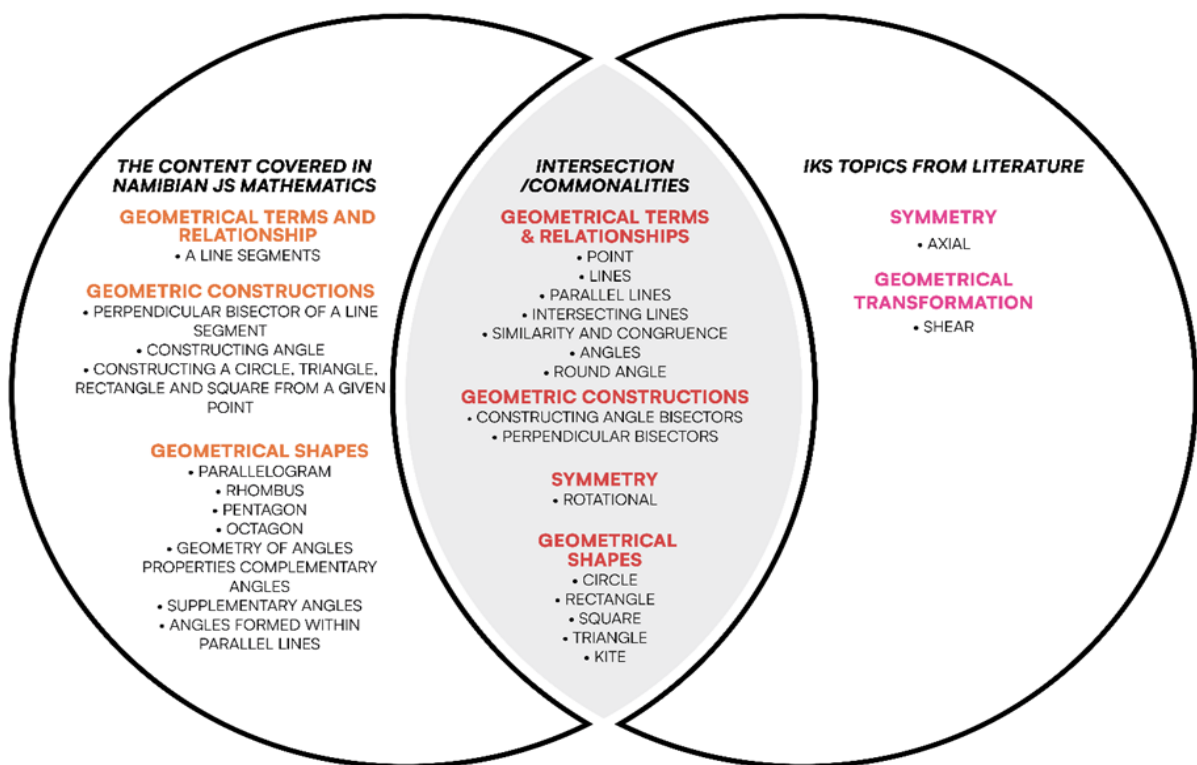


Figure 4: Namibian curriculum and content relevant to geometry

As presented in *Figure 4*, document analysis of ethnomathematics is relevant to the geometrical concepts taught in junior secondary Mathematics curriculum. The figure depicts the geometrical concepts found at the point of intersection are related to junior secondary Mathematics curriculum of Namibia. A dialectical relationship between Mathematics geometrical concepts found in junior secondary mathematics curriculum and IK's content was closely tied. Deducing from this, the geometrical concepts relevant to the junior mathematics curriculum include the following:

- a. the geometrical terms and relationship (point, lines, parallel lines, intersecting lines, similarity and congruence, angles and round angles);
- b. geometrical constructions (constructing angle bisector and perpendicular bisectors);
- c. geometrical shapes (circle, triangle, rectangles, hexagon, kite and square);
- d. geometrical symmetry (rotational) and geometrical transformation (reflection, enlargement and rotation);
- e. geometrical angle and properties (right angle and straight angle).

The ethnomathematics not yet incorporated in the junior secondary Mathematics curriculum comprised symmetry (axial symmetry) and geometrical transformation (shear and translation). In addition, the Namibian geometrical mathematics concepts not found under the IKS relevant mathematics concepts consisted of:

- (a) geometrical terms and relationship (a line segments);
- (b) geometric constructions (perpendicular bisector of a line segment, constructing angle and constructing a circle, triangle, rectangle and square from a given point);

- (c) geometrical shapes (parallelogram, rhombus, pentagon and octagon);
- (d) geometry of angles properties (complementary angles, supplementary angles and angles formed within parallel lines).

The results show that basket weaving portrayed content taught at junior secondary level in Namibia that could be integrated into the mathematics curriculum.

4.6 Teachers perspectives on integration of ethnomathematics

The results show that teachers' perspectives are positive towards the adoption of ethnomathematics and should therefore be integrated into the Namibian curriculum. The outcomes of the FGD showed understanding of the geometrical concepts and junior secondary Mathematics teachers validated the intersection point between ethnomathematics and junior secondary Mathematics curriculum. In doing so, Mr David and Ms Elizabeth supported IK integration:

“We must address and meet the objectives of the policy statement stated by the Government of Namibia since 1990 Namibia that made substantial advances in ensuring an inclusive and equitable education system” (David, 2021).

“IK and Western knowledge System (WKS) are seen as complementary knowledge systems that can be used to promote the learning of mathematics concepts” (Elizabeth, 2021).

“We need to restructure our education system in through decolonizing the curriculum to create a knowledge-based society as per the national benchmark Vision 2030” (David, 2021).

“The Namibian school curriculum calls for home and community to actively support the holistic development of education through fusing the local culture into the curriculum” (Elizabeth, 2021).

The results confirm that although the Namibian policy supports the integration of IK into the education system, the curriculum did not specify it be integrated into the classrooms. In support of the results, Mr David commented:

“Vision Two Thousand and Thirty calls for exploring the field of mathematics curriculum to produce an innovative, educated, and self-sustained society by the year 2030. However, the current curriculum guideline does not specify which cultural knowledge should be used when teachers are conducting lessons in the classroom” (David, 2021).

Making Mathematics relatable to students may be more difficult for teachers now that the curriculum has changed and the topic is more complex than it was in the past. This implies that in order for learners to comprehend mathematical topics, teachers should adjust their methods to fit the needs of their learners. Ms Elizabeth remarked:

“Drawing from my experience and findings from the examination reports, I found it fit to integrate relevant IKS in the teaching of geometrical concepts which are found in basket weaving artefacts which might perhaps help teachers to make learners have a sense of the concepts” (Elizabeth, 2021).

In support of the above statement, Mr Angula suggested that:

“Teachers’ professional development would be a solution to enhance the teacher’s knowledge in IKs for a purpose of quality integration of IKs into the classroom”

(Angula, 2021).

4.7 Continuous Professional Development and its relevance

The Research question 3 asked: *how could teachers integrate the identified ethnomathematical concepts?* One of the crucial parts during the FGD was to determine the validity of the data collected. All the junior Mathematics teachers took part in the validation process, after which an intervention workshop was conducted. They had to discuss the concept of IK and design lesson plans that could be used as a tool for teaching Mathematics. I asked the junior secondary Mathematics teachers on the objectives they wanted to be covered or to learn in the workshop with reference to basket weaving. In their responses, all indicated that they wished to learn about the integration of IK into the classroom.

4.7.1 Workshop on teacher development of lesson plan using IK Mathematics

This section presents results from the FGD (see Section 3.6) featuring the development of a lesson plan in view of a good example of how to integrate IK in the curriculum. Regarding the development of the lesson plan that integrates IK, the Mathematics teachers suggested that the lesson plan contain the following components as expressed under the sub themes:

Topic

“Teachers must provide the topic from the syllabus which needs to be covered”
(Angula, 2012).

“The topic is the first thing that one must think of” (Matheus, 2021).

Teaching resources

“Teachers should use teaching/learning aid of basket weaving artefacts (special resources from the learners’ local environment)” (Matheus, 2021).

“Inviting of knowledge holders to the classroom to present a certain concept on IK can be used as resources” (David, 2021).

Learning objectives

“The teacher must come up with learning objectives of the topic to be covered” (Angula, 2021).

“The basic competencies the learners are expected to have achieved by the end of the lesson must be laid out” (David, 2021).

Introduction

“The teachers should come up with the introduction of the lesson (possibly position for narrating a story relevant to the topic)” (Angula, 2021).

“The teachers must come up with an eye-catching introduction” (David, 2021).

Presentation of subject matter

“Teachers should articulate the presentation of subject matter: (teachers versus learners’ activities: this is the possible portion for IKs basket weaving artefacts, debating cultural beliefs, all expected questions and answers) creating links between abstract geometrical mathematics concepts and IK” (David, 2021).

“The subject matter must be linked to IK” (Elizabeth, 2021).

Assessment

“Use of group work during lesson and continuous assessment to encourage learners on peer learning” (Matheus, 2021).

“Teachers must plan for learners’ homework every day” (Elizabeth, 2021).

Conclusion

“The lesson plan should factor in the conclusion” (Angula, 2021).

“Conclusion must recap on the learners’ link between IK and new subject content knowledge)” (Elizabeth, 2021).

Table 2 (below) shows the lesson plan on teaching geometrical transformation using baskets artefacts (see Appendix E: Exemplar Lesson Plan)

Lesson plan contents	Descriptions of the contents
Topic	- Geometrical Angles
Learning objectives	- Angle properties: Know and understand angle properties to solve problems.
Basic competencies:	- Learners should be able to identify angles: Angles formed on a straight-line Angles at a point. - Angles formed at intersecting lines. - Angles formed within parallel lines intersected by transversal.
Relevant IK:	- Basket weaving
Teaching resources:	- Woven baskets
Introduction:	- The teacher displays all the materials brought to class and ask the learners to identify the traditional practice where they are used. - Learners will be asked to identify the names of the materials.
Presentation of subject matter:	- Cultural artefacts and creating links between abstract mathematical concepts and IK Facilitate the

Lesson plan contents	Descriptions of the contents
	<ul style="list-style-type: none"> - identification of basket woven materials that depict geometrical concepts. - Engage learners in an activity (where possible demonstrate) to identify and discuss the types of mathematics found in given basket weaving artefacts. - Outline the methodologies that facilitates the learners to identify the geometrical concepts in basket weaving. - The teacher helps learner make connection between the observed geometrical concepts comparing with one covered in mathematics curriculum.
Conclusion (recap):	<ul style="list-style-type: none"> - Basket weaving activities depict geometry, symmetry, angles, geometrical shapes and angle bisector.
Assessment:	<ul style="list-style-type: none"> - Write down at least five geometrical concepts which you are observing from the basket weaving product in front of you. - State the reason you have classified the geometrical concepts in those groups.

Table 2: Exemplar Lesson Plan

4.8 Chapter summary

The Chapter presents the results on all phases of the data collection. The results indicate that the basket weavers, referred to as knowledge holders, craft workers, artists or designers, have demonstrated their knowledge and skills during the interviews and observations with reference to basket making. This was visible throughout the process of developing baskets, referred to as artefacts. Through the creativity displayed, the women were well acquainted with making decorative patterns, shapes, strips length, the appearance of the basket, and consistency in maintaining the row sizes and thicknesses. Furthermore, the results indicated that basket weaving activities reflected geometrical shapes, symmetry, terms, relationship and construction. Comparing the above mathematical concepts with the junior secondary Mathematics curriculum, it is evident that basket weaving portrayed content taught at junior secondary level in Namibia that could be integrated into the Mathematics curriculum. In addition, the result revealed the IK practices awareness among the Mathematics teachers, as IK is reflected in the policies. Although the Namibia IKS Policy supports the integration of IKS into the Namibian Education System, the policies and the Namibian curriculum did not specify how the IKS was to be integrated into the classrooms. This prompted the development of the CPD programme among the Mathematics teachers aimed to provide them with the necessary skills and knowledge on IK for curriculum integration purposes.

CHAPTER FIVE

DATA ANALYSIS AND DISCUSSION

5.1 Introduction

This Chapter focuses on data discussion and interpretation of findings attained from the fieldwork. The discussion of the data was based on the themes that emerged from the findings, making it easy for the researcher to comprehend and interpret the findings.

5.2 Demographics of participants

5.2.1 Community

The Department of Basic Education, teacher preparation programs (subject trainers), schools (tool implementers), textbook publishers and authors (tool makers), caretakers, and IK experts made up the community where data was collected. Although Le Grange (2016) states that indigenous people are the experts and caretakers of their own Indigenous knowledge, curriculum developers and the educational system frequently fail to recognize them as such. Because of their assumed misinformation, knowledge holders are consequently frequently excluded from discussions on crucial curriculum issues like the integration of IK. Although information generated from indigenous knowledge is not written down and is instead stored in the minds of community members who are the guardians of this knowledge, Mathematics is a topic taught in schools and may be accessed through textbooks. Teachers are therefore unable to obtain IK unless they figure out how to access community knowledge banks (Hedges, Cullen & Jordan, 2011). This is the reason I asked knowledgeable people from the community to work with me to build the lesson plan in a hands-on manner, teaching basket weaving-related

ethnomathematics. Within the context of this study, breaking away meant letting go of the conventional perspective that sees teachers as knowledge oasis-like areas tasked with educating the community, while community members are seen as uneducated laypeople with nothing educational to contribute (Aikenhead, 1996; Ogunniyi, 2007).

5.2.2 Basket weavers

A total of two basket weavers took part in the study, also referred to as knowledge holders, possessing knowledge, skills, and expertise in basket making. Studies have revealed that the basket weavers are knowledge holders, craft workers, artists and designers (Musiza, 2022). Generally, they those in this study demonstrated sufficient skills to be called knowledge holders as compared to western knowledge holders who establish laws through the application of scientific methods to the phenomenon, beginning with observation followed by a prediction or hypothesis that has to be tested (Chikunda & Ngcoza, 2017). Based on the ongoing verification of both knowledge types (universalism and multiculturalism) through empirical observations, inference and prediction, pattern recognition, and repetition and verification, I believe that indigenous knowledge exists in both the Western and non-Western worlds, and that various forms of IK might continue to exist among Namibia's various ethnic origins.

5.2.3 Teachers

Although the participating teachers possessed the necessary teaching qualification in Mathematics, they lacked skills in IKS integration because this aspect was not covered in the teacher training programme they attended. In the context of this study, teachers knew and covered the syllabus of concepts that demonstrate Western knowledge. To support this

outcome, studies have claimed that teachers are not equipped with knowledge on teaching aids which could support the integration of IKS alongside Western knowledge in the Mathematics classrooms (Greer, de Jong, Schouten, & Dannals, 2018; Ministry of Basic Education, Sport, and Culture (MBESC), 2002; Onstad et al., 2003). In my view, this shows that African teachers are not trained to teach in an Africa setup, even though they may be teaching in rural areas with ample local resources around them. IK integration is usually left to the teachers' discretion (Khupe, 2014, Seehawer, 2018), however, during the FGD of this study teachers demonstrated the necessary mathematical knowledge and skills they possessed. Their attendance of the FGD and vibrant participation could be interpreted as a positive attitude towards the introduction of the 'new concepts' and possibly their willingness to integrate IK in the curriculum.

5.3 Geometry relevant and applicable to basket making

Evidently, the findings show that basket weaving portrayed content taught at junior secondary level in Namibia that could be integrated into the Mathematics curriculum. As highlighted in Chapter 1, Namibia has policies in place that stipulate the importance of IK and the values it may add to education. In an attempt to integrate IK in teaching and learning areas Chinsembu and Hamunyela (2015) write that the challenge lies in identifying the knowledge that could be included in Mathematics, documentation and the locality of IK. Also, while some IK characteristics may be shared by many ethnic groups, variances based on natural settings and social histories are probably present in these setups. Studies from South Africa and Zimbabwe clearly acknowledge how a progressive curriculum makes it clear for indigenous knowledge to be addressed, however, as in Namibia, little guidance is provided to the teachers on how this should be accomplished (de Beer & Mothwa, 2013; Risiro, 2019). These studies revealed the

same challenges that are experienced in the Namibian setup, adding to the list of training of teachers, insufficient IK experts for guidance, teachers' own attitudes and beliefs, assessment challenges, urbanisation and highlighting the absence of pedagogical content knowledge (PCK) among teachers when dealing with IKS (Khupe, 2014; Chikunda and Ngcoza, 2017). For this study, the skills, knowledge, methodologies and eye-catching and flamboyant-looking artefacts involving the designs, patterns and structures, are evidence that knowledge can be tapped from the community as well as from laboratories as perceived by Western knowledge holders (Chikunda & Ngcoza, 2017; Agrawal, 2014, Drew, 2005).

It is significant that the intersection and variations of geometrical concepts found in literature and those from JSC Mathematics syllabus in Namibia could potentially be integrated in the curriculum in an effort to attain policies and national agendas on IKS goals. However, studies have revealed that the implementation strategies remain a challenge (Onstad et al., 2003; Chinsebu & Hamunyela, 2015; Jauhiainen & Hooli, 2017).

5.4 Teachers' perspectives on ethnomathematics

The teachers in this study acknowledged IK to some extent and participated in the core development of the lesson plan as a way to integrate it. This gesture showed a positive attitude and willingness to adopt an IK integrated lesson plan, using the format stipulated in the national mathematics subject policy guide (grades 5-12) of 2009 (MoE, 2015). However, I noted a slight difference to format of the lesson plan whereby teachers suggested that knowledge holders be invited to the Mathematics classroom, with their artefacts, for demonstration and elaboration of the mathematical concepts and skills they possessed.

It became clear that numerous teachers' educational backgrounds ran contradictory to the IK strategy because they were educated during the apartheid era, when IK was despised and thought to be barbaric information unworthy of study. This indicates that although though the Namibian Ministry of Education anticipated the teachers to include IK into their math classes, they were not prepared to do so during their teacher training and had not personally experience integrating it as students. They consequently lack the conceptual tools necessary to evaluate the curriculum and the PCK necessary to integrate IK into their teaching in mathematics (Shulman, 1986). At times they have little information on the local area yet are supposed to be social communicators, as recommended by Aikenhead and Jegede (1999). These inconsistencies inside and between various parts of Mathematics showing calling featured the scholastic struggle between the exercises of the various callings of Mathematics teachers. For instance, Mathematics teachers complained that they were not prepared to integrate IK and did not get assistance from the Namibian Ministry of Education or local specialists accountable for it.

There are no books, manuals or teacher's guides that specifically focus on how to apply indigenous knowledge in mathematics education (Ngcoza & Southernwood, 2015; Balogun, & Kalusopa, 2021). These challenges have shown that there is a conflict between the responsibilities of the Ministry of Education, teacher training institutions, librarians, schools and communities. The gaps identified during this review are considered indicative of the need for teachers to be trained, which informed the workshops held during the larger study.

Although the policy requires teachers to incorporate IK into their teaching, I found that those who participated were not trained in how to do so. In turn they did not go to the Ministry of Education to find out what was in the programme on offer to trainee teachers. This change originates from what Ngcoza and Southwood (2015) portrayed as a contention between curriculum design and execution. It is likewise contended that numerous Mathematics teachers leave teachers training at universities without having knowledge on the integration of IKs into the classroom (Ngcoza and Southwood, 2015; Ogunniyi, 2007). This is steady with the discoveries of Mothwa (2011) and Jacobs (2015), who showed that albeit most teachers in South Africa support the integration of IKs but they do not have PCK to incorporate it, since they are not prepared. Additionally, Ngcoza and Southernwood (2015) likewise expressed that the professional training that teachers get from their higher institution of learning is deficient, conflicting and does not address their issues. As far as IK, I emphasise that this state of affairs implies that Namibian junior Mathematics teachers are supposed to employ teaching materials that they had never utilised previously.

The Ministry of Education in Namibia does not specify what specific topics on ethnomathematics teachers must incorporate into the school curriculum or how IK is incorporated. This obligation to integrate IKs into Mathematics teaching is put on the hand of teachers and textbook authors who are expected to choose the IK they decide to remember for their course readings or examples. Then again, textbook authors, teachers training institutions and schools do not welcome community experts who are the overseers of IKs to share their IK. Thus, IK is not archived, as affirmed by the members, who referred to this absence of writing as one of the significant difficulties that prevented them from coordinating IK. This view

reverberates with the cases made by Botha (2012) that there were no course readings to help teachers in coordinating IK or ethnomathematics. The lack of resources is affecting teaching adversely. I argue that there is sufficient evidence to show that teachers try to integrate IKs, however they do not have the pedagogical content knowledge needed to incorporate it. Teachers who are the curriculum implementers are not involved to conclude what should be included into the curriculum. Jacobs (2015) noticed that the curriculum is given over to teachers like an engineer's original copy to be executed undoubtedly. This resonates with the perceptions made by Mothwa (2011), Jacobs (2015) and Bantwini (2010), who additionally contended that teacher slack support from the Ministry of Education to implement IK based curriculum in schools. Findings show that there is no partnership between the exercises of the Ministry of Education, the teacher training and educational systems. Nonetheless, as currently called attention to, teachers are not consulted as curriculum implementers to give their own contributions of what they thought an IK-based seemed to be (Bantwini, 2010; Jacobs, 2015). All factors considered; the teachers are diminished to simple implementers of the curriculum which they did not partake in.

The educational curriculum is given to publishers who are likewise device creators to write up a consistent textbook, which are endorsed by the Ministry of Education before they are suggested for use in schools. In any case, the IK experts who are the caretakers and specialists in IK are not consulted by Department of curriculum development to contribute their insight into IK which suitable for current curriculum. Subsequently, textbook authors and publishers did not include ethnomathematical concepts when writing textbooks as alluded by the junior

mathematics teachers who accentuates that there are no manuals or books to direct them on the most proficient method to apply the insight of IK.

Even if this IKs integration policy is handed over to schools to be implemented, teachers are not adequately trained to provide the PCK required for doing so, as indicated by the responses of the participants (Pinxten & Francois, 2017). When members of the community are IK guardians and parents of the children who were subjected to the action, they are not advised by Ministry of Education, Arts and Culture, educational institutions or schools for putting their knowledge into raising their children. On the other hand, the Namibian Ministry of Education is responsible for coordinating the curriculum and textbooks. The teacher training institutions, such as universities, did not provide the training of teachers in the integration of IKs into the classroom. As a result, teachers choose what they wanted to teach and could design lessons as they saw fit. The IKS policy stipulates that the teacher receives instructional support and assistance to teach Mathematics teachers can combine with ethnomathematics. Kibirige and van Rooyen (2018) stated that teachers have no knowledge of what teaching can support the integration of IKS and Western knowledge in the Mathematics classroom.

Mapara (2009) also questioned the preparedness of the teachers to incorporate ethnomathematics approaches into the teaching and learning of geometry. In the same line, Massarwe, Verner and Bshouty (2017) argue that curriculum development programmes in schools are not enough to qualify teachers to implement IKS in Mathematics.

The integration of IK in the Mathematics curriculum is a developing peculiarity in many countries which were colonised by western countries. Advocates contend that it enhances effective learning (Aikenhead, 1996; Le Grange, 2016; Ogunniyi, 2007), supported by a plenty of studies carried out in Southern Africa and abroad that affirm that it rouses learners and lifts their confidence, increments cooperation (Ogunniyi, 2018), advances decisive reasoning and makes it simpler for learners to grasp numerical ideas. Research has shown that integrating IK in Mathematics makes the subject really fascinating drawing attention to ethnomathematics and its relevance to teacher upskilling. For example, studies directed by Aikenhead and Jegede (1996) and Seehawer (2018) have shown that learners become more persuaded when teacher uses IK when teaching the curriculum. Considering these discussions, researchers like Mhakure and Otulaja (2017) called for socially responsive teaching methods that integrate learners' perspectives in Mathematics to make it simple for them to comprehend. To meet this, teachers should be social agents. Learner in secondary school schools performed dismally in Mathematics since they neglect to accommodate the IK between their home and school (Cooper, 2011; Aikenhead and Jegede, 1999).

5.5 Relevance of Continuous Professional Development (CPD)

Even though the FGD workshop was only conducted once for data collection purpose, this shows high interests in IK acknowledgement and hopefully transferability. I am unsure about the frequency of Mathematics teachers' workshops conducted in Namibia or the agenda points discussed. I doubt if IKS is at least on the agenda of such platforms. In my opinion, the current curriculum has a potential to aid and support IK integration in Namibia if workshops are conducted. This form of training is similar to that found previous studies by Ogunniyi, (2007),

Ogunniyi and Ogawa (2008), Ogunniyi (2018) and Ogunniyi (2020). Utilisation of argumentation in Ogunniyi (2018) appears to reverberate well with the objective of my review and its attention on supporting junior Mathematics teachers' integration of IK and utilization of effectively available assets. I employed argumentation as a tool to come up with bottom-up approach that decolonise western perspective on knowledge system, the study recommends teachers to tap into the cultural heritage of expert community members who gave practical demonstrations on basket making to support teachers in developing exemplar lessons that integrated IK. Through these functional exhibitions, the junior Mathematics teachers had the option to distinguish the Mathematics ideas implanted in the cultural artifacts of basket weaving. Alternate approaches to knowing were embraced through what Seehawer and Breidlid (2021) alluded to as exchange between information. Put in an unexpected way, IK and Western science are not fundamentally unrelated or oppositional yet rather they can coincide and supplement each another.

That knowledge holders contributed to the core-develop a lesson plan demystifies the concept of the 'knowledgeable others' and 'us.' Involving knowledge holders in educational activities is a valuable act of stimulating and transmitting indigenous perceptions from generation to generation (Assefa & Mohammed, 2022). Through knowledge holders, teachers were able to engage with cultural teachings, experiences, and indigenous languages while co-developing teaching materials. By sharing IK and instructional strategies they were strengthened to integrate IKS in the classrooms. This notion is supported by Brodie (2013), who argued that the importance of co-development of activities with knowledge holders capacitates teachers with IK on the use of local accessible resources that are relevant when there are inadequate

textbooks or teaching resources. Moreover, Ngcoza and Chikunda (2017) contend that co-development of activities with knowledge holders play a major role in changing teaching by moving beyond comprehension of the surface features of a new idea and innovation to a deeper understanding of a topic.

In concurrence with my study's findings, Tekkumru-Kisa and Stein (2017) pointed out that the co-development interaction between knowledge holders and teachers' transformation improves instructional quality in mathematics. Classrooms demand a sustained focus on professional development of Mathematics teachers, and it is against this backdrop that knowledge holders in schools will assist the development and dissemination of indigenous worldviews. Additionally, they will help in fostering an atmosphere of respect and understanding. Parallel to the argument related to the co-development, Mudzamiri (2019) argued that the use of artefacts from knowledge holders can help teachers to grasp mechanical topics more thoroughly by offering mediational tools or scaffolding that is culturally appropriate.

Teachers preferred workshops as a mode of in-service training for ethnomathematics. Studies have shown that if teachers attend workshops that provide them with mastery experiences or direct experiences that lead them to believe they can master a domain, their personal competence level will rise (Bandura, 1997; Pintrich & Schunk, 2002). In agreement with the preferred mode, Mehta, Alter, Semali and Marezki (2013) used video clips that featured stories by individuals that, collectively, represented decades of experience in engaging with indigenous communities in their workshop to capacitate teachers. Mehta et al. believed that the video series could help transform the classroom into engaging with fascinating varieties of

philosophies and epistemologies. In another workshop, conducted by Luwango and Schafer (2013), each teacher executed a critical reflection on the lesson delivered.

5.6 Teachers' reflections on the ethnomathematics workshop

Prior to conducting a workshop on how to develop a lesson plan that integrates IK into the classroom, teachers reflected that they were incapable of developing a comprehensive lesson with it. The junior Mathematics teachers said that the training acquired during their in-service teachers had not focussed on the development of the plan that improves teachers' PCK. The junior Mathematics teachers reported that the co-development workshop has facilitated them to develop a lesson plan that integrated Mathematics from basket weaving products. As a result of their improved understanding of IK and the junior Mathematics curriculum link they were able to plan lessons and be mediated by the IK of weaving baskets from the expert community member's presentation. Using the identified topic, teachers were going to develop more lesson plans on relevant mathematical concepts found in basket weaving when teaching the topics of geometry.

After the workshop junior Mathematics teachers showed they had a comprehension of topic knowledge of ethnomathematics and PCK (Shulman, 1986). They would never again rely upon models given in the school textbooks I yet attempt to teaching junior Mathematics by integration IK using accessible basket weaving products. To reinforce integration of ethnomathematics in the classroom, teachers demonstrated the skills acquired on how to develop lesson plans with aspects of knowledge gained from the community. Additionally, teachers emphasised that inviting IK experts to class sessions enriches the content of the course

and, in turn, encourages the motivation, participation and critical analysis skills of learners, linking theory with the real world and allowing an open dialogue within the classroom. By pondering their past teaching approaches, and as implied over, these teachers showed a huge expansion in both their subject matter knowledge and PCK in the integration of IK in the classrooms.

The junior Mathematics teachers displayed comprehension of IK and its suggestions for Mathematics illustrations, likewise, saying that they had taken in the best way to integrating IK in Mathematics examples. They subsequently reflected with certainty that they would involve the IK information in their future teaching, and they recommend that they would have the option to satisfy the curricular necessities. To validate junior Mathematics teachers' reflections, Jacobs (2015) affirms that created teaching which are IK tapped would be the substance d to resolve issues, for example, the ideas of IK and Western knowledge, how to integrate ethnomathematics in the classrooms.

In CHAT, expansive learning is seen as discovering outcomes in the generation of better approaches for getting things done (Engeström, 2010; Haapasaari, Engeström and Kerosuo, 2016). In this review, it included the establishment of novel answers for the difficulties that confronted junior Mathematics teachers on the integration of IK in Mathematics. Besides, authors like Ogunniyi (2007), Kigozi, Otulaja, Risenga and Dukhan (2021), Hewson (2008) and Paquin (2023) utilised co-development courses to furnish teachers with subject matter knowledge and PCK expected in integrating Mathematics-IKS educational program in the classrooms. Expansive learning was evident as there was a movement in terms of teachers'

knowledge, skills, and attitudes towards the integration of IK (Engeström & Sannino, 2010). The previous studies used workshop because this intervention created opportunities for the teachers to expand their understanding of the nature of IK to integrate in Mathematics teaching. The findings from both the orientation workshop and the demonstration lessons plans' co-development showed that teachers had a wider understanding of IK (Haapasaari et al., 2016; Mothwa, 2011; Ogunniyi, 2007). These examinations have brought about teachers understanding *verstan* and having more noteworthy familiarity with the idea of Mathematics and IKS. They further guaranteed that insights obviously different from review Mathematics and IKS as entirely went against to each other to considering the two to be reciprocal and viable.

In their study, Luwango and Schafer (2013) pointed out the current situation in Namibia whereby professional development workshops conducted for Mathematics teachers mostly focussed on content knowledge rather than on aspects pertaining to critical reflective practice. Parallel to this idea, the concept of development of lesson plans during the Mathematics teachers' workshops created a layout of what they should teach and how to teach for successful integration of IK in the curriculum. I specifically used workshops in order to promote engagement (social interaction) between the teachers and knowledge holders. Teachers could learn from each other as they shared ideas and tapped knowledge from knowledge holders as they interacted.

5.7 Chapter summary

This section focused on data discussion and interpretation of findings which were attained from the fieldwork. From the observations, knowledge discovered through interviews and skill portrayed through artefacts it is evident that knowledge holders possess knowledge that could be integrated into the Mathematics curriculum. The teachers also demonstrated sufficient Mathematical knowledge and skills during the FGD as they were socially interacting with each other during the validation process. Because the teachers did not demonstrate integration skills, this issue was tackled in a workshop that allowed them to develop a lesson plan that could be used as an IK integration tool in the classroom. In this lesson plan, teachers suggested that knowledge holders should be invited to the Mathematics classroom with their artefacts for explanation of IK relating to the topic of discussion.

CHAPTER 6

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

6.1 Introduction

This Chapter presents the summary of the study, draws conclusions and makes recommendations based on the research findings and discussions. It also makes recommendations for further studies.

6.2 Summary of the study

The study attempted to find out the mathematical concepts embedded in basket making by Aawambo women in the Oshana Region in Namibia. After Namibia gained independence, the education system was revised with a focus on decolonising the curriculum through IK integration. Education-related policies advocate IK integration in the curriculum but with no clear guidance or directives on the content to be covered nor the methods to be used to realise this goal. I reviewed the literature on the existence of community knowledge in Mathematics, the debate on the relevance and validity of IK and Western knowledge. I discussed in detail the types of embedded geometric arithmetic and geometrical shapes in baskets and their applications to the junior secondary Mathematics curriculum. In addition, I discussed the importance of continuing professional development (CPD) to learn how best Mathematics teachers can access, improve their knowledge and how to apply indigenous knowledge in Mathematics teaching.

I continued to present the theory and conceptual frameworks to understand how teachers could possibly integrate IK into Mathematics teaching through the initiative of programme design of professional development. Therefore, I explored the following research questions:

1. What geometry is found in basket making of Aawambo ethnic group in Oshana Region?
2. Which geometrical content at the junior secondary level is applicable to basket making practised by the Aawambo women?
3. How can the mathematics teachers integrate geometrical constructs embedded in basket making by Aawambo women into the teaching and learning process of Mathematics?

I employed a qualitative research approach in addressing this practical-knowledge gap explained in this study. Specifically, I employed an ethnographic qualitative research design using an interview guide, an observation checklist, a camera, an audio recorder and field notes. I purposefully selected women with competence in designing complex patterns to portray the multiple decorations and Mathematics teachers who had taught junior Mathematics for more than ten years. I ensured that ethical principles were adhered to for purposes of anonymity, confidentiality, informed consent and protection of research participants from harm.

This finding later aligned by examining relationships between the variables and objectives for the research to add meaning to the conceptual framework of this study. They found that the basket weavers had extensive knowledge with regard to basket weaving activities, portraying complicated weaving techniques and decorative patterns that could not be showcased by someone who is not experienced. The basket weavers demonstrated that being competent they did not need any scaffolding or support when weaving a basket. On the contrary, the study

found that junior secondary school teachers had inadequate knowledge of the integration of ethnomathematics in the classroom.

As mentioned in Chapter 4, the study deduced that the geometrical concepts relevant to the junior Mathematics curriculum included the following:

- a. the geometrical terms and relationship (point, lines, parallel lines, intersecting lines, similarity and congruence, angles and round angles)
- b. geometric constructions (constructing angle bisector and perpendicular bisectors)
- c. geometrical shapes (circle, triangle, rectangles, hexagon, kite and square)
- d. geometrical symmetry (rotational) and geometrical transformation (reflection, enlargement and rotation)
- e. geometrical angle and properties (right angle and straight angle).

The workshop acted as a social unit which consisted of teachers, the community members (basket weavers) and the researcher. I ensured social interaction between junior secondary school teachers and the basket weavers as they shared information on basket making and also among the teachers during the practical demonstration of the co-development of the lesson plan.

The workshop emerged as the most appropriate platform for knowledge transfer, establishing an environment for social interaction and collaborative learning. Significantly, the workshop allowed teachers to reflect upon their experiences as they shared ways they could integrate IK

by co-developing a lesson plan. This outcome is evidence of a contribution to new knowledge with a clear call to mathematics teachers and basket weavers to come up with multi-voicedness on what content and methods to be adopted for IK integration in the Mathematics curriculum.

Figure 5 (below) illustrates my reflection as explained and clearly outlines the model to be adopted for the IK integration in rural schools.

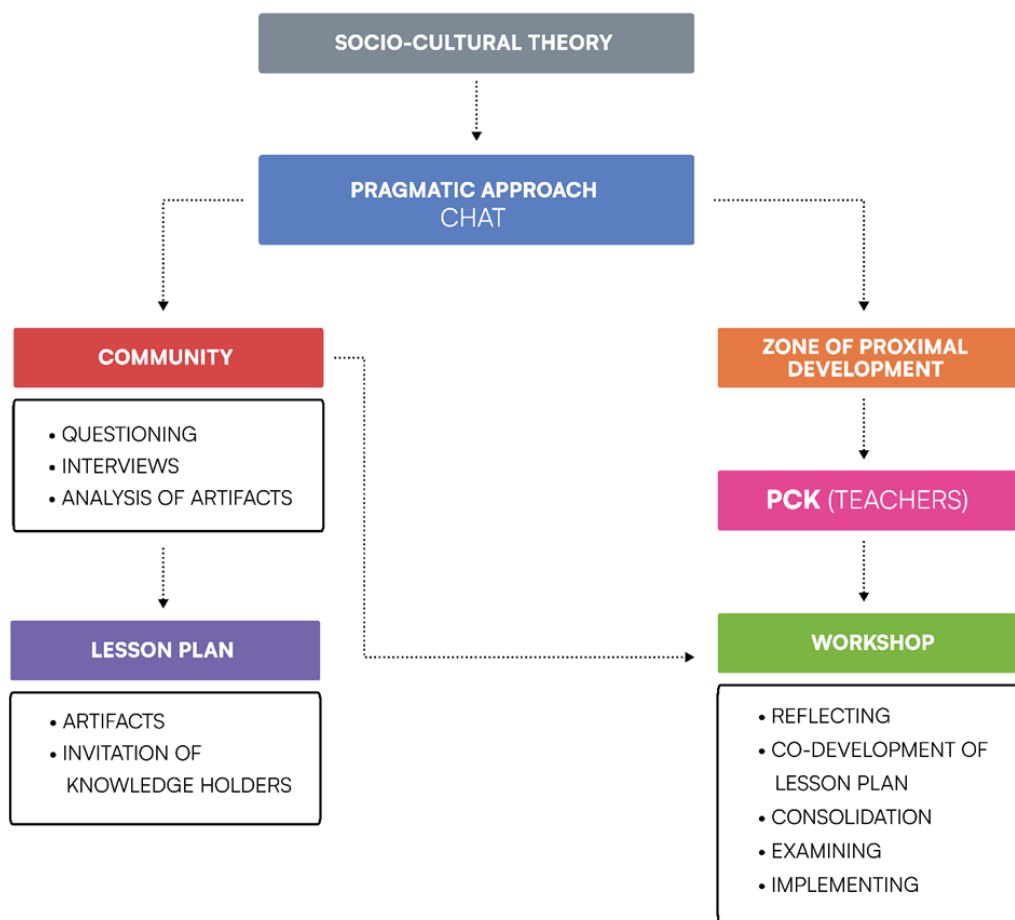


Figure 5: Ethnomathematics Integration Framework: Continuing Professional Development for Mathematics Teachers

6.3 Summary

I conclude that evidently the indigenous knowledge, skills and artefacts observed, geometrical contents were acquired from the knowledge holder to the 'More Knowledgeable Other.' The Geometrical content was shown in the current junior secondary Mathematics curriculum, indicating requirements of international trends to adopt IKS. However, clear guidance on how to integrate ethnomathematics in the school curriculum was missing. In response to this void I have demonstrated my understanding of this thesis through the adoption and adaptation of the social theory framework, intertwined with the ZPD and PCK to suggest ways integration of ethnomathematics could be achieved. However, it is important that this engagement be stated in the lesson plan, assuming that teachers follow the lesson plan to ensure practice.

6.4 Recommendations of the study

The following recommendations emanate from the results of this study:

Recommendations for practice

- CPD workshops for junior secondary Mathematics teachers should focus on the following:
 - The existence of ethnomathematics and its relevance to the curriculum.
 - Strategies to work in collaboration with expert community members as custodians of IK to integrate ethnomathematics in the curriculum.
 - Mapping basket artefacts to the content found at junior secondary Mathematics curriculum.

- Co-development of lessons, including lesson plans that spell out the integration of ethnomathematics applicable to the curriculum.

Recommendations for the Ministry

- I recommend that the Ministry of Education, Art and Culture conduct continuous professional programmes that are based on critical and creative methodologies to encourage teacher participation, collaboration, and enhancement of conceptual learning of ethnomathematics in schools.
- I recommend that the curriculum developers and the Ministry of Education should identify and record the ethnomathematical concepts in baskets to increase the pool of teaching resources.

Recommendations for future research

- The study has opened opportunities for possible further research in other topics such as the co-development of lesson on the integration of ethnomathematics in the classrooms. I recommend that further research be conducted on the co-development of IKS plans on teaching of ethnomathematics.
- The study revealed a need for research that focuses on the documentation of cultural artefacts that could be used to teach junior secondary Mathematics in schools. Therefore, I recommend that future researchers should investigate this area of research.

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Appendix A: Ethical Clearance Certificate



ETHICAL CLEARANCE CERTIFICATE

Ethical Clearance Reference Number: FOF/001/2020

Date: 26 FEBRUARY 2020

This Ethical Clearance Certificate is issued by the University of Namibia Research Ethics Committee (UREC) in accordance with the University of Namibia's Research Ethics Policy and Guidelines. Ethical approval is given in respect of undertakings contained in the Research Project outlined below. This Certificate is issued on the recommendations of the ethical evaluation done by the Faculty/Centre/Campus Research & Publications Committee sitting with the Postgraduate Studies Committee.

Title of Project: ETHNOMATHEMATICS: AN INVESTIGATION OF THE MATHEMATICS EMBEDDED IN BASKET MAKING BY AAWAMBO WOMEN IN THE OSHANA REGION

Nature/Level of Project: MASTERS STUDY

Researcher: SHIMWANDI RUUSA

Student Number: 201026031

Faculty: FACULTY OF EDUCATION

Supervisors: DR E.N. NGOLOLO KAMARA

Take note of the following:

- (a) Any significant changes in the conditions or undertakings outlined in the approved Proposal must be communicated to the UREC. An application to make amendments may be necessary.
- (b) Any breaches of ethical undertakings or practices that have an impact on ethical conduct of the research must be reported to the UREC.
- (c) The Principal Researcher must report issues of ethical compliance to the UREC (through the Chairperson of the Faculty/Centre/Campus Research & Publications Committee) at the end of the Project or as may be requested by UREC.
- (d) The UREC retains the right to:
 - (i) Withdraw or amend this Ethical Clearance if any unethical practices (as outlined in the Research Ethics Policy) have been detected or suspected,
 - (ii) Request for an ethical compliance report at any point during the course of the research.

REC wishes you the best in your research.

REC Chairperson

Prof CJ Wilders: HREC-NH: CHAIRPERSON

A handwritten signature in black ink, appearing to read 'CJ Wilders', is written over a horizontal line.

(Signature)

Appendix B: Approval Letter from the Oshana Regional Director of Education



REPUBLIC OF NAMIBIA
OSHANA REGIONAL COUNCIL
DIRECTORATE OF EDUCATION, ARTS
AND CULTURE
ASPIRING TO EXCELLENCE IN EDUCATION FOR ALL



Tel: 065 - 229800/25
Fax: 065 - 229834
Enquiries: Hileni M Amukana Ref
13/2/9/1

Private Bag 5518
Oshakati

MS' Ruusa Shimwandi
P. O. Box 2115 Windhoek

Cell: 0814981716

SUBJECT: PERMISSION TO CONDUCT A RESEARCH IN OSHANA REGION

Your letter dated 26 February 2020 on the above caption bears reference.

Kindly be informed that permission is hereby granted to conduct research study at Ondbra Combined School and Omuhama Combined School in Ompundja Circuit, Oshana Region.

Research Topic: Ethnomathematics: An investigation of the mathematics Embedded in Basket making by Aawambo Women in the Oshana

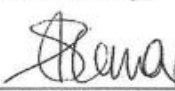
This permission is subject to the following strict conditions; (i) There should be minimal or no interruption on normal working schedule (ii) Ethical issues of confidentiality and anonymity should be respected and retained throughout this activity i.e. Voluntary participation, and consent from participants

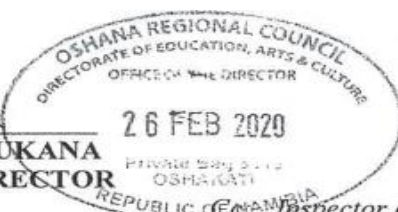
Both Parties should understand that this permission could be revoked without explanation at any time.

Furthermore, we humbly request you to share your research findings with the Directorate of Education, Arts and Culture, Oshana Region. You may contact Ms. Hilma Nuunyango-George, the Deputy Director; Programs and Quality Assurance (PQA) for the provision of summary of your research findings.

We wish you the best in conducting your study.

Yours sincerely,


HILENI M. AMUKANA
REGIONAL DIRECTOR



Inspector of Education: Ompundia Circuit

Appendix C: Letter to the Oshana Regional Director of Education

P O Box 2115

Windhoek

22 February 2020

To: The Director Oshana Education Region

Ministry of Education

P/Bag 5518

Oshakati

Dear Madam

REQUEST FOR PERMISSION TO CONDUCT A RESEARCH IN OSHANA REGION

I am Ruusa Shimwandi, a Masters' degree student at the University of Namibia in Mathematics Education. I am carrying out research on "ETHNOMATHEMATICS: AN INVESTIGATION OF THE MATHEMATICS EMBEDDED IN BASKET MAKING BY AAWAMBO WOMEN IN THE OSHANA". This research will be conducted under the supervision of Dr. Elizabeth Ngololo, a Senior lecturer at the University of Namibia.

I am hereby seeking your consent to approach two (2) Combined schools in Oshana Region as my research sites. The research will include 2 mathematics teachers at each selected school.

Permission has been granted by the University Research Ethical Committee (UREC) and the office of the Postgraduate Studies (PGS) of the University of Namibia (see attached letters).

Full anonymity and confidentiality is assured. I wish to conduct this research between May 2020 and August 2020. The study, the results and the reporting of the findings of the study will not include the names of the schools and teachers that will be involved in the study. Furthermore, the study will not interfere with the day to day functioning of the school.

All face to face sessions with the participants will adhere to the World Health Organisation (WHO) with regard to Covid-19 pandemic. Upon completion of the research, I undertake to provide the Ministry of Education with a bound copy of the full research report.

Should you require further information, please do not hesitate to contact me on +264 814981716 or ruusafilmine@gmail.com

Thank you for your cooperation and understanding and I look forward to a prompt response from your good office.

Yours Sincerely

Ruusa Shimwandi

University of Namibia

St. No. 201026031

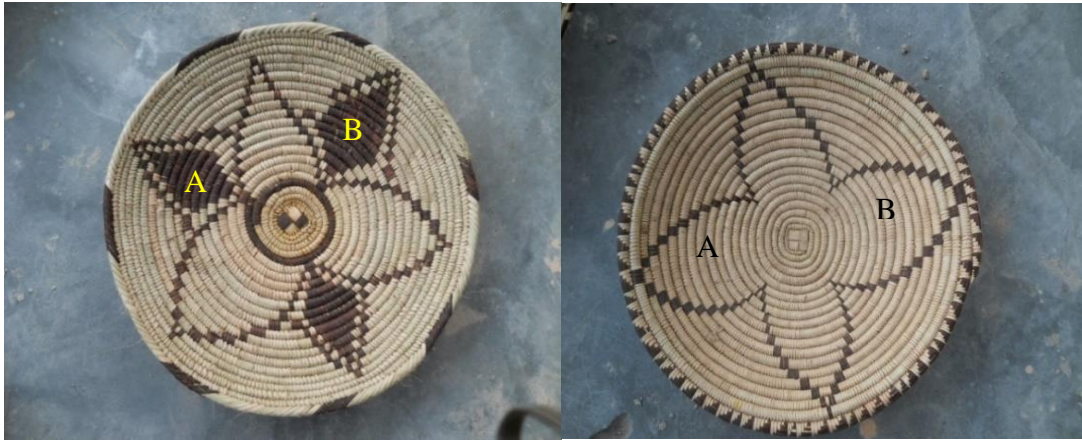
Appendix E: Exemplar Lesson Plan

TEACHER: Ms Elizabeth		SUBJECT: Mathematics	
Date: 21 September 2021			
Lesson plan contents		Descriptions of the contents	
Topic		Geometrical Angles	
Learning objectives		Angle properties <ul style="list-style-type: none"> - Know and understand angle properties to solve problems 	
Basic competencies:		Learners should be able to identify angles: <ul style="list-style-type: none"> - Angles formed on a straight line - Angles at a point - Angles formed at intersecting lines - Angles formed within parallel lines intersected by transversal 	
Relevant IK:		<ul style="list-style-type: none"> - Basket weaving 	
Teaching resources:		<ul style="list-style-type: none"> - Woven baskets 	
Introduction:		<ul style="list-style-type: none"> - The teacher displays all the materials brought to class and ask the learners to identify the traditional practice where they are used. - Learners will be asked to identify the names of the materials. 	
Presentation of subject matter:		<ul style="list-style-type: none"> - Cultural artefacts and creating links between abstract mathematical concepts and IK - Facilitate the identification of basket woven materials that depict geometrical concepts 	

Conclusion: (recap)	- Basket weaving activities depict geometry, symmetry, angles, geometrical shapes and angle bisector.
Assessment:	<p>- Write down at least five geometrical concepts which you are observing from the basket weaving product in front of you.</p> <p>- State the methodology you have used to you have used to classify the geometrical concepts.</p>

Appendix F: Basket weaving Artefacts

1. Geometrical Symmetry



1a: Rotational symmetry

1b: Rotational symmetry (Shimwandi, 2021).



1c: Rotational Symmetry

1d: Rotational Symmetry (Shimwandi, 2021).



1e: Rotational Symmetry



1f: Axial Symmetry (Shimwandi, 2021).

1. Geometrical shapes and properties



2a: Kite (Shimwandi, 2021).



Kites



2b: Kite (Shimwandi, 2021).

Kites



2c: Kite (Shimwandi, 2021).



Rectangle

2d: Rectangles (Shimwandi, 2021)



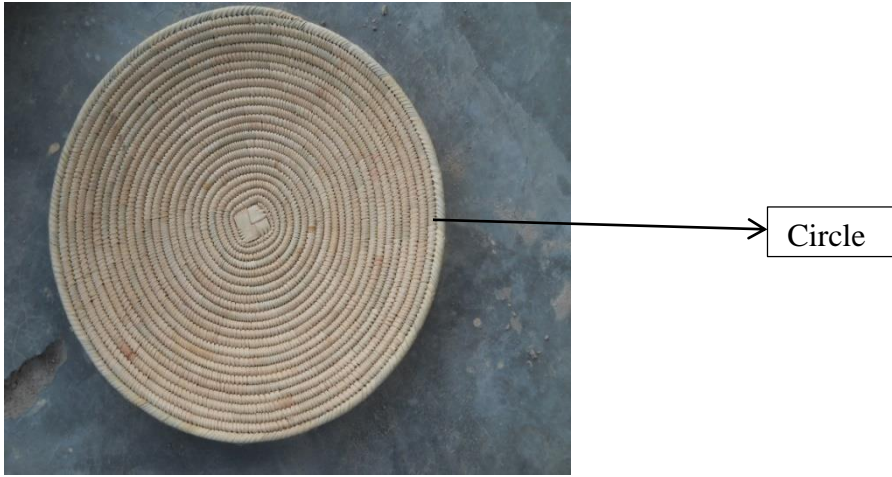
Squares

2e: Square (Shimwandi, 2021).



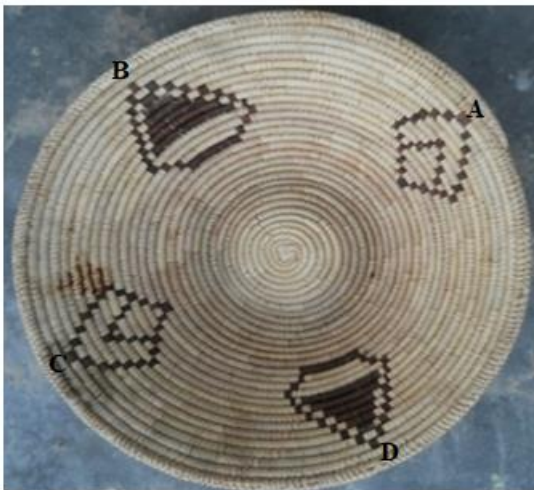
Triangle

2f: Triangles (Shimwandi, 2021).



2g: Circle (Shimwandi, 2021).

2. Geometrical transformation.



3a: Reflection (Shimwandi, 2021).



3b: Rotation (Shimwandi, 2021).



3c: Enlargement (Shimwandi, 2021).



3d: Shear (Shimwandi, 2021).

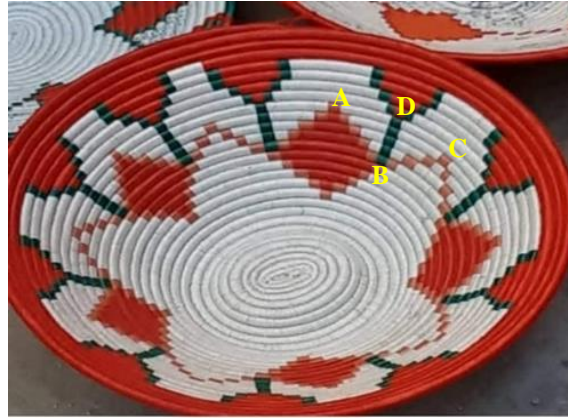


3e: Translation (Shimwandi, 2021).

3. Geometrical Construction

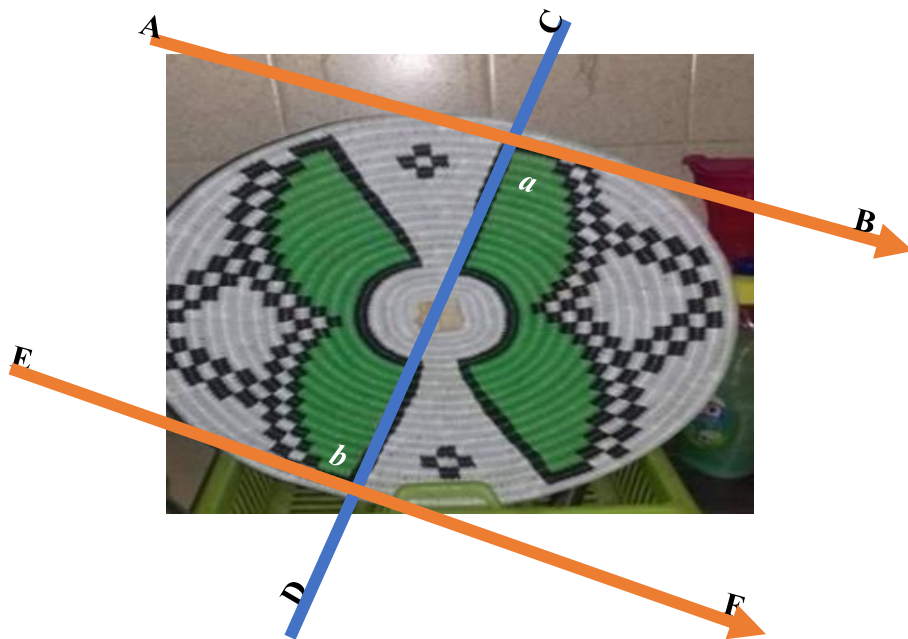


4a: Perpendicular Bisector (Shimwandi, 2021).



4b: Angle Bisector (Shimwandi, 2021).

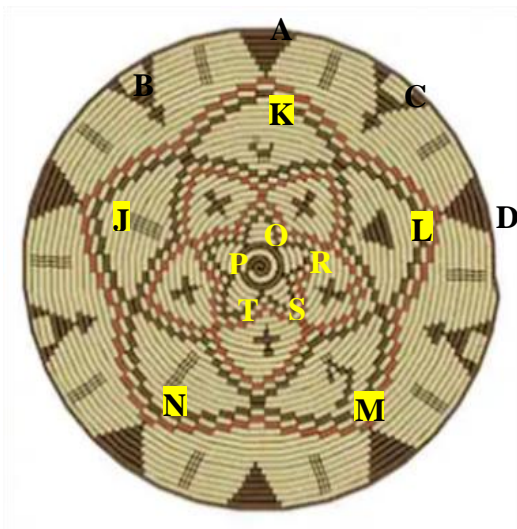
4. Geometrical terms and relationships



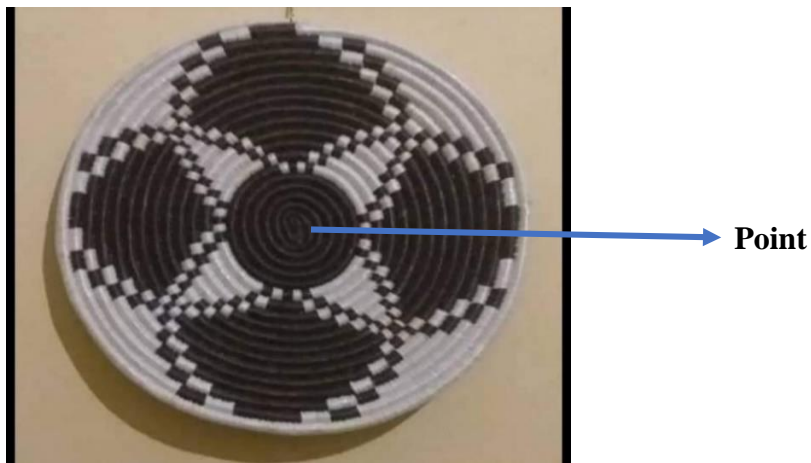
5a: Parallel and intersecting lines (Shimwandi, 2021).



5b: Right angles (Shimwandi, 2021).



5c: Similarity and congruency (Shimwandi, 2021).

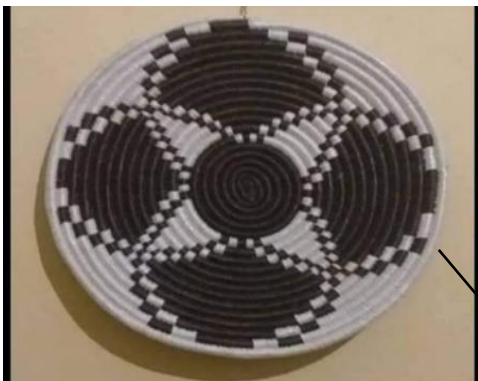


5d: Point (Shimwandi, 2021).



Line

5e: Line (Shimwandi, 2021).



5f: Round angle (Shimwandi, 2021).



5g: Straight angle (Shimwandi, 2021).

Round angle

Appendix G: Observation Checklist

BASKETRY WEAVING OBSERVATION SCHEDULE (BWOC)

Section A: General Information Village: _____

No of Students from the household: _____

Number of weaving experience: _____

Observation checklist: The basket weavers

Description of behavior(s) to be observed	Yes	No
Materials used The basket is presentable.		
Indigenous Knowledge accumulated The weaver use logic when weaving.		
Uniqueness/quality Are the basket rows tight?		
The basket has shape.		
Is there any pattern followed?		
Is there any sequence followed?		
Skills Are the rows lined up smoothly?		

<p>Shapes</p> <p>Does the woven basket have a shape?</p>		
<p>Formula</p> <p>Is there consistency in the row sizes?</p>		
<p>Transformation</p> <p>Repetition of lines to create visual rhythm.</p>		
<p>Skills and Knowledge transferability</p> <p>Demonstrate awareness of meaning of signs, symbols and style.</p>		
<p>Creativity and Perseverance</p> <p>Does the creativity and perseverance of the baskets weaving can be learn through and pass on young children?</p>		

Appendix H: Informed Consent Document for Teachers

The study, conducted by Shimwandi Ndeutenge Ruusa; a graduate student at the University of Namibia, is about Ethnomathematics: An investigation of the mathematics embedded in basketry weaving by Aawambo in the Oshana area.

The interviews and observations are the major part of this study and I accept to be one of the participants to be conducted. I will help the researcher to collect information, to complete the requirements and make contributions to the discussion on the voluntarily basis. I understand that there will be no sanctions for my answers positively or negatively. The researcher will reserve my rights including my name, my answers, and my suggestions by keeping the content confidential.

The interviews will be conducted face-to-face and they will last at least 45 minutes. A tape recorder will be used during the interviews for a recall for the interview information, and only the researcher will have a right to access this information. I have a choice to stop the interviews, to ask questions during and after interviews, refuse to answer questions, and there will be no sanction in the end. I give my permission to be quoted in Shimwandi Ruusa's research publication.

Signature of teacher

Date

Appendix I: Informed Consent Document for basket weavers

The study, conducted by Shimwandi Ndeutenge Ruusa; a graduate student at the University of Namibia, is about Ethnomathematics: An investigation of the mathematics embedded in basketry weaving by Aawambo in the Oshana area.

The interviews and observations are the major part of this study and I accept to participate in this study voluntarily. I will allow the researcher to collect information. I understand that there will be no sanctions for my answers positively or negatively. The researcher will reserve my rights including my name, my answers, and my suggestions by keeping the content confidential.

The interviews will be conducted face-to-face and they will last at least 45 minutes. A tape recorder will be used during the interviews for a recall for the interview information, and only the researcher will have a right to access this information. I have a choice to stop the interviews, to ask questions during and after interviews, refuse to answer questions, and there will be no sanction in the end.

Signature of the basket weaver

Date

Appendix J: Interview guide for Aawambo basket weavers

The aim of this interview is to establish the teachers’ approaches towards mathematics and the use Indigenous Knowledge (IK) in mathematics from the cultural and social constructivism perspectives embedded in basketry weaving as possible teaching materials in topics like sequence, geometry, patterns. The results will be treated as highly confidential and are for research purposes only, so please respond as honestly as possible as the interview will be recorded.

Educational history

What is your education background?

Experience

How long have you been weaving baskets?

Training

How did you learn the traditional skills that you are currently practicing?

Procedure/Technique

Briefly explain the basket weaving process?

Accuracy

How do you obtain equal lengths, symmetry, parallelness, roundness, or squareness in your basket weaving?

How do the weavers determine the amount of material per basket?

Transferability of Knowledge

How do you share your traditional knowledge and skills with your children?

Mathematical Concepts

How would you explain the mathematical concepts and laws found in the basket weaving by Aawambo?

Adaptation to Indigenous Knowledge (IK)

In your view, should the Aawambo cultural activities be integrated into the teaching and learning processes at the junior secondary school level in Oshana? Give reasons for your answer.

Recommendations

Would you recommend the mathematics teachers use the mathematical problem solving skills to address shortage of indigenous knowledge skills embedded in the basket weaving process to teach mathematics lessons at school?

Explain

Pricing of artefacts

How do you determine the price of the final products?

How do you give change to your customer?
